Clinical Cephalometric Standards: A Radio-graphic Study of 12-year old British Girls

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INTRODUCTION

MOST orthodontists take at least one • ' cephalometric radiograph of their patients and this most frequently at the outset of treatment. The measurements taken from this initial or "diagnostic ' radiograph if they are to be meaningfully interpreted should be compared with standards relevant for the patient being considered. This means taking into account the patient's race, age, sex, stage of maturity and possibly social class. (Krogman and Sassouni, 1957). It may be that many or all of these factors may influence the interpretation of the standards. Although these measurements are only of limited value, when compared to a longitudinal series, they do describe a child's facial structure in relation to his peers. In this way they can assist the clinician in his diagnosis and in the communication of concepts either between clinicians or between teacher and student. (Horowitz and Hixon, 1966).

From the foregoing the need for and the importance of reliable population standards can be appreciated, and yet the majority of previous attempts to establish cephalometric norms or standards have been criticised for their lack of standardisation of methods and materials. (Krogman and Sassouni, 1957). At the present time there are no suitable standards for British children, let alone Welsh children, of any age group or sex. So in the light of this absence, it was decided that a beginning should be made with twelve year old schoolgirls. At this age the majority of the permanent teeth, except the second and third molars, would have erupted (Miller et al 1965) and furthermore it is a very common age to undertake treatment which will involve the extraction of teeth. Girls were chosen rather than boys because breast bud formation and menarche are two readily recognised signs of puberty and so the girls could be easily related to the growth spurt of adolescence. (Tanner, 1962).

The aim of this study of twelve year old Cardiff girls was to establish standards for some of the most popularly used cephalometric measurements which could be used primarily by orthodontists in Wales but also by orthodontists throughout the British Isles. In addition to this, the height, weight, stage of puberty and socio-economic class of the sample have been described. This information has been included because it was found to have a much greater bearing on the results than had hitherto been thought possible; and because it was felt that should any further studies be undertaken it would help in defining the population and subsequently allow for better comparisons. (Harkness et al, 1970).

Material

The 275 girls used in this investigation were randomly selected from all the twelve year-old girls living within the Cardiff City boundary and who celebrated their twelfth birthday in the same twelve month period. The mean age of this sample was 12.12 years with a standard deviation of 0.28 years. During the initial stage it was possible to identify and exclude all girls who were of non-British ancestry, those that had experienced active orthodontic treatment or those who

were physically or intellectually handicapped. The last group were only excluded after it had been established that they were markedly different from their peers in 9 of the measurements made. (Harkness, 1969). Finally there were 25 girls who refused to participate in the study and 3 girls who had moved from the Cardiff area by the time the examination was made.

In summary the group that was examined consisted of 216 randomly selected twelve year old Cardiff girls who were of British ancestry, had no history of active orthodontic treatment and were not physically or intellectually handicapped. Table 1.

Method

All the girls were examined in the same twelve week period and for each of them the following information was recorded.

1. *Height and Weight:* These measurements were obtained on the same instrument and the same procedure was followed for each girl, e.g. the procedure for height measurements was to orientate the head in natural balance by asking the subject to look at some distant object and then gently straighten her with firm pressure upwards on the mastoids. (Tanner, 1962). All the girls were measured in light clothing with shoes removed. No corrections have been applied to the data to estimate the mean nude weights.

2. *Stage of Puberty:* The information relating to puberty was obtained from a completed questionaire. With this inform ation it was possible to categorise the sample into the following groups;

Pre-puberal — No breast development. Not menstruating. Puberal — Breast development. Not menstruating.

Post-menarchael — Breast development. Menstruating.

3. *Socio-economic status:* This assessment was based on the father's occupa tion and coded using the General Register Office Code. (General Register Office, 1966). The classes were as follows:

I. Professional
II. Intermediate
III. Skilled
IV. Partly skilled
V. Unskilled

4. *Cephalometric measurements:* The lateral cephalometric radiographs were taken with the teeth in occlusion and with the head in an Adams' cephalostat with a mid-sagittal plane — film distance of 13 centimetres and an anode — mid-sagittal plane distance of 152.4 centimetres. (Adams and Brown, 1966). The enlargement was 8.5%. The radiographs were measured in a random order using the method of direct measurement devised by Bjork and Solow (1962). All the con tinuous measurements were taken to the degree or millimetre below and no correction for enlargement was made. Of the 10 measurements made, 8 were angles and 2 were linear measurements. Table 2. For the angular dimensions the following

Table 1. Random Sample of Twelve Year Old Cardiff Girls

Total sample	275
Number refused or absent	28
Number examined	247
Excluded after examination	
Non-British	8
Previous orthodontic intervention	21
Handicapped	2
Number analysed	216

Table 2. Cephalometric Analysis

Angular measurements:	SNa
(degrees)	SNb
	(SNa) - (SNb)
	$\underline{1}$ -MxP
	$\underline{1}$ -T
	T-MnP
	FP-MnP (FMP angle)
	MxP-MnP (MMP angle)
Linear measurements:	OB
(mm)	OJ

reference points and lines were used. Figs. 1 and 2.

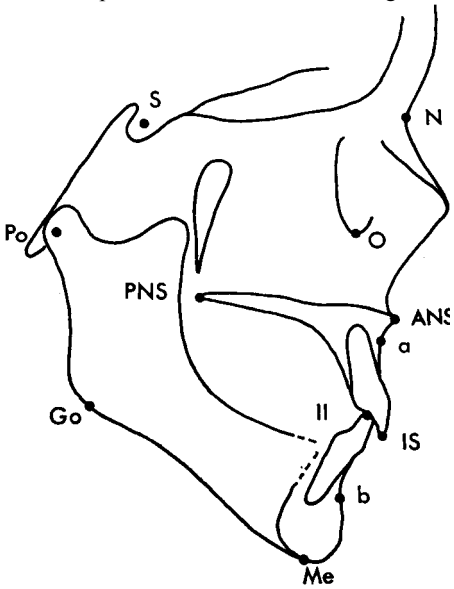

Fig. 1. — The reference points used for the construction of the angles: a-A point; A NS-anterior nasal spine; b-B point; Go-gonion; ll-incision inferius; IS-incision superius; Me-menton; N-nasion; 0-orbitale; Po-pogonion; PNS-posterior nasal spine; S-sella.

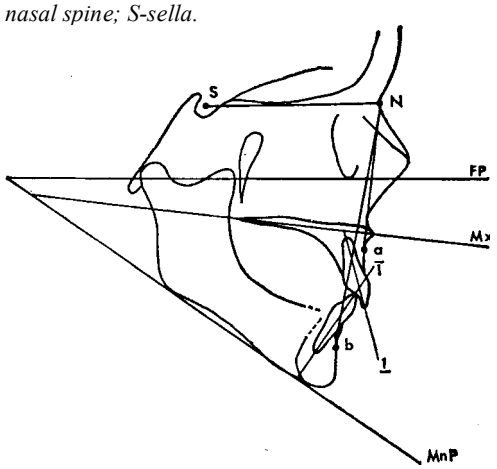

Fig. 2. — The reference planes and the angles measured:

(a) The planes: FP-Frankfort plane T-lower incisor axis; MnP-mandibular plane; MxP-maxillary plane; 1 -upper incisor axis.

(b)_The angles: SNa; SNb; (SNa)-tSNb);_l_MxP; 1_-1; 1-MnP; FP-MnP (FMP angle); MxP-MnP (MMP angle).

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a The deepest point on the anterior contour of the upper alveolar arch

ANS The apex of the anterior nasal spine

b The deepest point on the anteriorcontour of the lower alveolar arch

Go The most posterior intersection of the mandibular plane and the lower border of the mandible

II Midpoint of the incisal edge of the most prominent lower central incisor

S Midpoint of the incisal edge of the most prominent upper central incisor

Me The intersection between the lower border of the mandible and the posterior outline of the symphysis

N The most anterior point of the fronto-nasal suture

O The lowest point of the infra-orbital margin

Po The midpoint between the uppermost parts of the two earpost rings

PNS The apex of the posterior nasal spine

S The centre of sella turcica by inspection

FP The line joining O and Po

1 The line joining II and the midpoint of the root canal nearest the apex

MnP Tangent to the gonial angle of the mandible through Me

MxP The line joining ANS and PNS

1 The line joining IS and the midpoint of the root canal nearest the apex

OP The line through the middle of the cusps of the upper first permanent molars and upper premolars

As well as the angular dimensions, the overbite and overjet of the most prominent upper central incisor tooth were mea-

Table 3 Double The 3	Angles	Determinations Exhibiting	on 50 a	Randomly Significant	Selected Difference	Radiographs'
	Mean diff.	Range Min.	Max.	s.d.	s.e.	Coeff. Var. %
SNb	+0.29	+2	-0.5 -	0.458 0.980	0.065"'"	0.42 2.38 1.68
FMP angle	+0.33	+3.5	1.5 -1.5	0.632	0.139*	
MMP angle	+0.19	+1.5			0.089"	

* P <0.05

***P <0.001

sured on the radiographs. A positive over bite was recorded when the upper incisor overlapped the lower incisor or vice-versa, a negative value if the incisor relationship was either edge-to-edge or where there was no overlap. Similarly if the upper incisor was anterior to the lower incisor the overjet was positive; if it was posterior to or in an edge-to-edge relationship with the lower incisors it was recorded as negative. Fig. 3.

OB The distance between II and IS measured perpendicular to OP

OJ The distance between IS and II, measured parallel to OP

To find the error in the method of measurement double determinations were made of the heights and weights of 40 randomly selected girls and of all the cephalometric variables on 50 randomly selected radiographs from the sample. While the height and weight measurements were repeated on the same occasion the cephalometric variables were re-measured after an interval of at least 7 days. The results of the double determinations for all the variables, including height and weight, indicated a significant difference for only three of the angles:

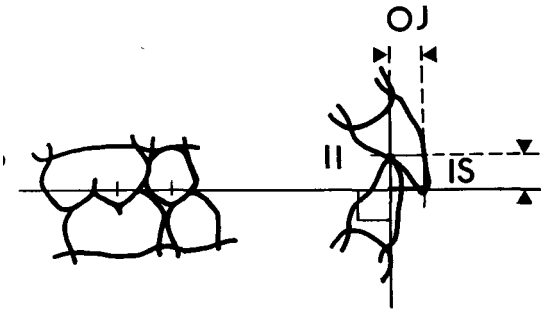


Fig. 3. — The method of measuring the overbite and overjet on the cephalo metric radiographs: 11-incision inferius; **OB** *IS-incision super ius; OB-overbite; OJ overjet; OP-occlusal plane.*

measured; SNb, MMP angle, FMP angle. Table 3. (Harkness, 1969). Differences between individuals in a cross-sectional study such as this are so much greater than any measurement errors, that in most instances, it is doubtful if errors of two or three degrees should be interpreted as meaningful differences. (Hatton and Grainger, 1958; Broadway et al., 1962). In conclusion, the method of measurement used in this study more than meets the requirements of the study. Significant differences were found between two duplicate measurements in three instances, but no importance is attached to these because of the considerable variation of these angles between individuals.

Results

The results in this study were calculated using standard statistical formulae and have been presented as the mean, -range and standard deviation (s.d.) for each of the continuous variables. In addition, these variables are statistically described by values of skewness and kur-tosis and graphically illustrated with the aid of histograms. (Solow, 1966). The figures on top of the bars in the histograms indicate the number of girls in each class interval.

Table 4. The Height (cm.) and Weight (kg.) of 216 Randomly Selected Twelve Year Old Cardiff Girls

	Mean	Range Min.	Max.	s.d.	Skewness	Kurtosis
Height	150.25	133	165	6.73	−0.0129	2.5580
Weight	41.68	25	82	9.02	+1.0816**	4.7128**

**P=0.01

Height and Weight Table 4. Figs. 4, 5

The mean height of this sample is 150.25 cms. and is similar to the mean given by Tanner and his co-workers for London girls of the same age. (Tanner et al., 1966). The mean weight of 41.68 kg. is slightly greater than the value reported by Tanner of 39.6 kg. for London girls. The distribution form of weight shows a marked positive skew with a significant departure from a normal distribution in the values of skewness and kurtosis (P=0.01). The distribution form of height does not show any marked deviation from a normal distribution.

Social Class Table 5

Not unexpectedly there were few girls in the more favoured socio-economic groups, I and II, while the majority of 37.0%, were in group III. A disappointing feature was the large proportion, 30.1%, who gave inadequate information and as a result their replies could not be classified.

Stage of Puberty Table 6

The majority of the girls were in the group with breast development but not menstruating. A large number, 45, however, were uncertain of breast development and have been allocated to the prepuberal group. Only 2 girls were uncertain if they had reached menarche and they have been allocated to the puberal group with breast development.

Cephalometric Measurements Table 7 (a) Angles SNa, SNb and (SNa)-(SNb); Figs. 6-8.

Clearly there is very little difference in the form of distributions of the two angles SNa and SNb; in both cases the standard deviations and values of kurtosis are similar. Their standard deviations are among the smallest of all the cephalo-

Table 5. Social Class According to the General Register Office Code

	I	II	III	IV	V	Not Classifiable
Number	7	24	80	15	25	65
Percent.	3.2	11.1	37.0	7.0	11.6	30.1

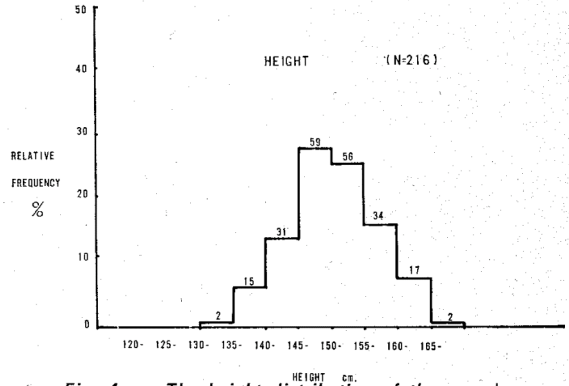


Fig. 4. — The height distribution of the sample in centimetres. Measured with shoes removed.

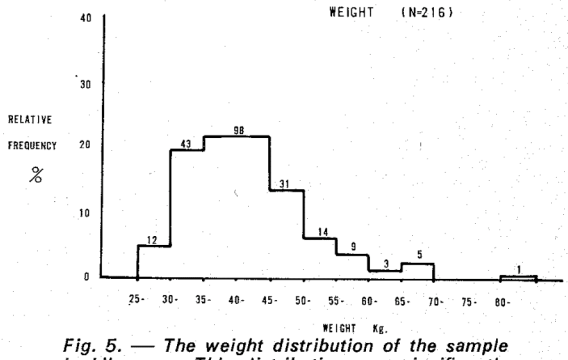


Fig. 5. — The weight distribution of the sample in kilograms. This distribution was significantly different from a normal distribution. (P=0.01).

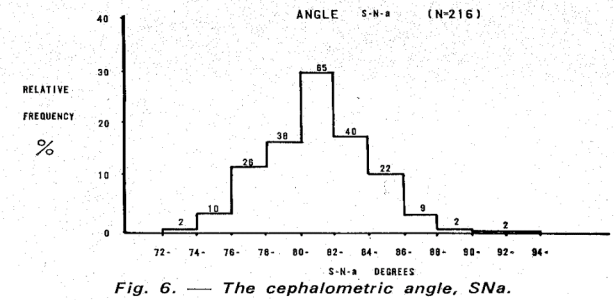


Fig. 6. — The cephalometric angle, SNa.

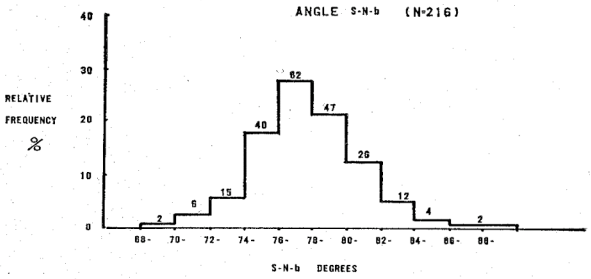


Fig. 7. — The cephalometric angle, SNb.

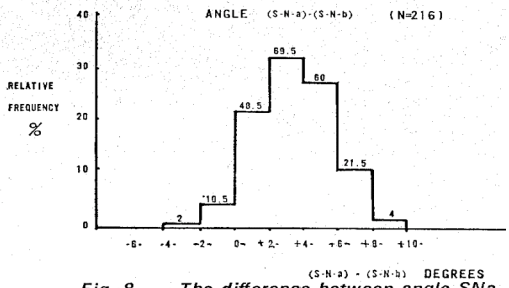


Fig. 8. — The difference between angle SNa angle SNb, with due regard to sign.

Table 6. The Stage of Puberty of the Sample Based on Replies to Questionnaire

Stage	Number	Percent.
Pre-puberal	75	35
Puberal	110	51
Post-menarcheal	31	14
Total	216	100

Table 7. The Cephalometric Variables of 216 Randomly Selected 12 Year Old Cardiff Girls

	Mean	Min.	Max.	s.d.	Skewness	Kurtosis
Angle SNa	80.98	72	93	3.25	+0.3301	3.7086
,, SNb	77.62	68	89	3.18	+0.2642	3.7629
,, (SNa)-SNb)	3.37	−3	+9	2.19	−0.0016	2.8285
,, $\underline{1}$–MxP	108.15	90	127	6.60	+0.1329	3.1230
,, $\underline{1}$–$\overline{1}$	131.63	107	167	9.66	−0.0047	3.2312
,, $\overline{1}$–MnP	94.57	79	110	6.08	+0.1616	2.8768
FMP angle	28.09	11	42	5.51	−0.2466	3.0308
MMP ,,	25.85	14	39	5.17	−0.0325	2.6568
Overbite	3.56	−4	+8	1.75	−0.1982	3.3864
Overjet	3.81	−3	+11	1.93	+0.6472**	5.3866**

**P=0.01

metric variables. The angular difference between angle SNa and angle 8Mb has a mean of 3.37° In calculating this angle, if the actual difference recorded was 1° the true difference could range between 0° and 2°. This discrepancy between the recorded and the true differences was due to the policy of taking all measurements to the last major mark. As a result 50% of the girls with a recorded difference of 1° have been allocated to the class interval 0° - 1 ° and 50% allocated to the class interval 1° — 2° etc.

(b) The incisor inclinations: Figs. 9-11

The upper and lower incisor inclinations to the maxillary and mandibular planes respectively have a similar distribution form in spite of the great difference in their means; 108.15° for 1-MxP and 94.57° for T-MnP. The inter-incisor angle, 1-1 has the largest s.d. of all the cephalometric variables at 9.66° and the range for this angle spreads some 60° from 107° - 167°. Fig. 10. No significant departure from a normal distribution was observed for these three angles.

(c) The plane angles: Figs. 12, 13

There is a small difference between the maxillary-mandibular plane angle (MMP angle) and the Frankfort-mandi-bular plane angle (FMP angle) of 2.24°. Visually the FMP angle shows a slightly more pronounced negative skew than the MMP angle although no significant departure for a normal distribution was recorded. While the mean FMP angle of 28.09° agrees with the most commonly used standards, the mean of 25.85° for MMP angle is less than the generally accepted value of 28°. (Ballard, 1956).

(d) Overbite and overjet: Figs. 14, 15

The mean and s.d. of overbite were approximately the same as the mean and s.d. overjet. While the distribution form for overbite is similar to the other cephalometric variables the distribution form for overjet is leptokurtic and has a significant positive skew. (P=0.01).

Discussion

To our knowledge no other report on cephalometric standards for girls has been based on a sample fully representative of the community. The usual reports are based on data gathered from subjectively selected samples such as those with normal or "acceptable" occlusions or from samples which are ill-defined as to race, sex or age. (Ballard, 1956; Gresham, 1968; lyer and Lutz, 1966). Whereas the study presented here included subjects that belonged to all the Angle's classes of malocclusion, a recent publication which examines the basis of sample selection in thirty-five studies confirms the importance of correct sampling technique to make sure that the samples are truly representative of the community (Peck and Peck, 1970).

The present approach to cephalometric standards, using a stratified random sample, is a new one to orthodontics though well-known elsewhere in biometry. For our part we believe that if the information gleaned from a single cephalometric radiograph is to be interpreted meaningfully some yardstick or standard is necessary; ideally these standards would be based on a survey on a whole population e.g. all the twelve year old girls living in Cardiff, but economy demands and statistical theory allows something less than this ideal. It is, of course, a sample chosen by a careful random •method from a population which can be fully defined.

When defining the group or population

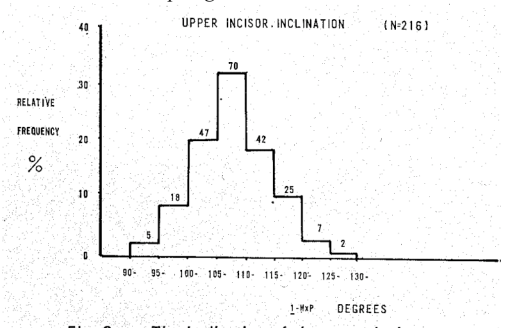


Fig. 9. — The inclination of the upper incisor to the maxillary plane.

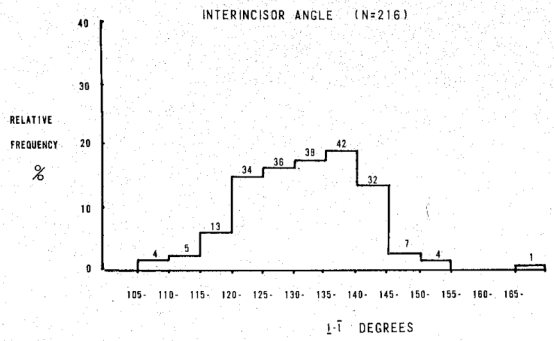


Fig. 10. — The internal angle between the upper incisor axis and the lower incisor axis.

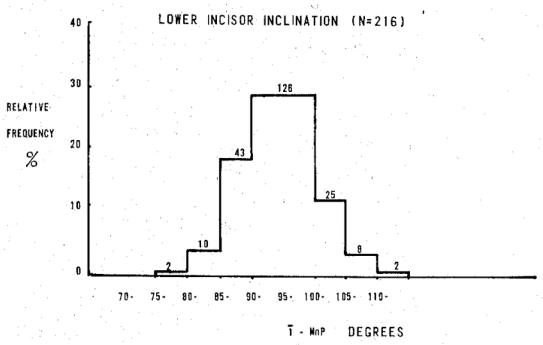


Fig. 11. — The inclination of the lower incisor to the mandibular plane.

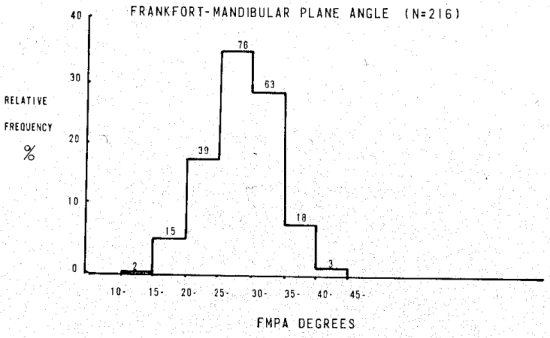
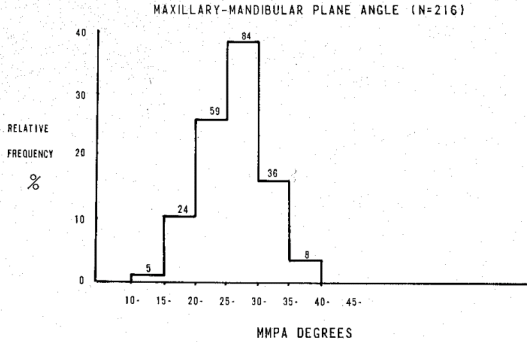


Fig. 12. — The angle between the Frankfort plane and the mandibular plane.



Eig. 13 — The angle between the maxillary plane and the mandibular plane.

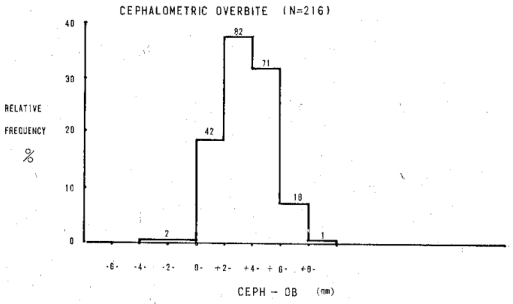


Fig. 14. — The overbite of the most prominent upper central incisor, in millimetres. On average this measurement is 0.5mm. greater than the corresponding measurement made on this sample's study models.

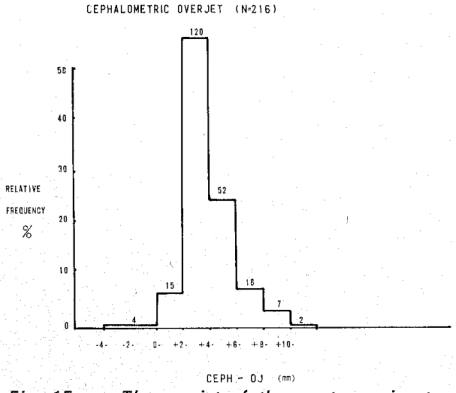


Fig. 15. — The overjet of the most prominent upper central incisor in millimetres. On average this measurement is 0.83 mm. greater than corresponding measurement made on this sample's study models.

to be examined race, age and sex are essentially the minimum requirements, but other factors such as social class may also be important. (Krogman and Sassouni, 1957: Tanner, 1962). Details of height, weight and stage of puberty are also included because of the variations which have been reported from different countries. (Tanner, 1962). By confining our survey to a precise geographical area; Cardiff City; and by examining a large number of girls; 216; we believe that our findings are truly representative of the 12 year old girl population in Cardiff.

The decision to use twelve year old girls for the present study was prompted firstly by the assumption that the majority of those seeking orthodontic treatment were female. Surprisingly, however, investigation of 300 consecutive patients seen in the orthodontic clinic of the Cardiff Dental School and Hospital during 1967-68 showed the percentage distribution between males and females was about the same. Table 8. This suggests the need to undertake a comparable study of boys, but then of course assessment of the stage of puberty would be much more difficult to make. Secondly, because in girls puberty is marked by two easily recognisable signs; the appearance of the breast buds and menarche. The close relationship of these signs to the adolescent growth spurt in height and the growth of the face is valuable information for the orthodontist. (Bambha, 1961; Bjork and Helm, 1967; Nanda, 1955; Tanner, 1962). In girls the peak of this height spurt occurs between twelve and thirteen years. (Tanner et al., 1966).

The cephalometric measurements made in this study were selected because they were among the most universally used measurements and therefore, likely to be of the greatest practical use. (Krogman and Sassouni, 1957). Furthermore, some of the measurements could be compared to clinical assessments and might be of some value to the practitioner without the facilities for cephalometric radiographs.

Table 8. Sex Distribution of 300 Consecutive Patients Who Attended the Orthodontic Clinic During 1967-68

	Male	Female	Total
Total	132	168	300
Percent	44	56	100

One of the most striking observations made during this study was the considerable range of variation of all the variables studied. For example, even the angle with the smallest standard deviation; angle (SNa)-(SNb) had a range from -3° to +9°, and the angle 1-1, which had the largest standard deviation, had a range from 107° to 167°. Of further interest was the form of this distributions for this group of children. All were found to be within the limits of normality except weight and overjet. The latter had a strong positive skew and was leptokurtic. The presence of this significant leptokurtosis for overjet agrees with Bjork (1947), but the reason for the conformity to the shape of a normal distribution generally shown by anthropological variables is not known nor are the reasons for the observed departures from normality. (Solow, 1966).

Comparison of the findings in this study with those of other workers are generally not possible because though similar measurements have taken place, either different methods have been used or the samples have not been comparable. In discussing the means it is important to recognise that they only represent group trends and that no girl in this sample had a "mean cephalometric pattern". Ballard's (1956) study of 250 London schoolchildren represents the only serious attempt to establish cephalometric standards for British children and his findings of 81° for angle SNa, 77.5° for angle SNb and 3.5° for angle (SNa)-(SNb) are approximately the same as in this study. There are, however, several differences in the means of some of the other angles he studied compared to the means found in this study. For example his findings of 28° for MMP angle and 92.5° for *T* - MnP

angle are quite different from the values obtained in this study of 25.85° and 94.57° respectively. It is impossible to draw any valid conclusions from these figures because both the method and the samples may not be comparable. On the other hand, if they are, these small differences are likely to represent statistically significant differences between the samples. Table 9.

SUMMARY AND CONCLUSIONS

The primary aim of this investigation was to establish standards for some commonly used clinical cephalometric measurements from twelve year old Cardiff girls, which could be used for a South Wales population, or even on a wider basis. The findings were based on lateral cephalometric radiographs, height and weight measurements and a questionaire. The sample was randomly selected from all twelve year old girls living in Cardiff during 1968. The findings for the sample of 216 girls indicated a considerable range of variation of many of the cephalometric variables. This variation is statistically described by the ranges and standard deviations of all the continuous variables and illustrated with histograms. Thougn it would be tempting +o make comparisons of the findings of this study with those of other workers, it is felt that they would be misleading. The purpose of this study has been to emphasise the need to employ sampling techniques which reduce the number of variables

Table 9. Comparison of Cephalometric Measurements for British Samples

	Ballard mean	(1956) s.d.	Present mean	study s.d.
SNa	81	3.5	80.98	3.25
SNb	77.5	—	77.62	3.18
(SNa)-(SNb)	3.5	—	3.37	2.19
1 - MxP	109	6.0	108.15	6.60
1- T	130	10.0	131.63	9.66
1-MnP	92.5	6.5	94.57	6.08
MMP angle	28	—	25.85	5.17

such as that of age and sex race, and which assure that the sample is fully representative of the community.

Acknowledgements

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