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Dental and Skeletal Development of Children with Low Birth Weight

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Between the dental and skeletal maturity and other maturity indexes a parallelism and an independent variability of the development of the different systems were found. Several authors reported on the parallelism between tooth eruption and body height [2, 16, 20], others on early puberty being associated with an early change of teeth [3, 14]. Some [9] found a loose correlation between dental and skeletal development, — while others [8] a very close one. In a study [11] the correlation between the dental and skeletal ages was calculated in reliance on roentgenograms, chronological age, and the number of permanent teeth; the closest correlation was found between dental and skeletal ages. In another study [12], however, a loose correlation was only established. In contrast, development of the dental and of the skeletal systems were found to vary independently in two studies [4, 16] where groups were formed from examinees displaying parallel advance or parallel retardation in both systems, or advance of one combined with retardation of the other, corroborated by findings of other examinations [10].

The great disparity of the results must be attributed to the inaccuracy and unreliability of the methods used, and perhaps to the questionable reliability of the available standards. The necessity for establishing new, more reliable ones has, therefore, often been stressed. Furthermore, in some studies for determining dental age a single tooth was relied upon such as the M_{2i} [3] or the M_{1i} [5, 11]; in other studies [16] three teeth, in others, eight to ten, were examined.

Considering the high variability of the age of the individual teeth in the same person, the contradictory results are easily understood. This variability is, however, a regular feature of normal dental development [10, 16]. Steel [16] therefore pointed to the necessity of clarifying what elements are the most suitable for characterizing dental age, but with regard to the limited number of his examinees he did not make any pertaining proposal. According to Hotz et al. [8] at 6 to 11 years the second upper incisor and the lower first bicuspid seem to be the teeth most suitable for that purpose; their "normal" material displays, however, a slight retardation as compared with the standards of Greulich and Pyle [6]. According to Steel's data, English children are also retarded as compared with American ones.

In an earlier paper we have reported on the results of a study of a group of handicapped children six to seven years of age [7]. In order to solve certain pending problems, a second cross-sectional study has been made of a similar group of older children.

Material and Method

172 children born with a weight less than 2500 g in the Obstetric Department of Debrecen University between April 7, 1955, and August 4, 1956, were invited for being examined. The examinations were carried out between March 27 and August 13, 1965. Thus, the actual age of the children to be examined varied between 9 and 10 years. Of the 172 invited children 99 reported at the Clinic.

On these 99 children roentgenograms of the left wrist, and intraoral roentgenograms of the teeth were made and body height and weight were measured. Fourty-three pupils of the same age of a Debrecen school served as a control group. This group was considered unselected, although no data were available as to their birth weight. The single criterion for including children into this group was the lack of any long-lasting disease. The sex rate in the two groups was closely similar, with 43 boys and 56 girls; and 17 boys and 26 girls, respectively.

Evaluation of the wrist roentgenograms was made according to the standards of Greulich and Pyle [6]. Ten ossification centres and epiphyses of the wrist considered the most characteristic in that age have been appraised, i.e. the capitate, hamate, distal end of radius, triquetral, first metacarpal, lunate, trapezius, trapezoid, scaphoid, and the distal end of the ulna.

For further computations instead of the ages of the individual bone items their deviations from the chronological age of each child were used.

The intraoral roentgenograms were evaluated according to Moorrees and Fanning [13]. Herewith one obtains directly the difference in development of each tooth from the normal average in proportional units, "standard scores" at any age. The teeth taken into account were the upper and lower first and second incisors, lower left canine, first and second bicuspids, mesial and distal roots of the first molar, and the crown of the second molar. In some children who had lost their lower left first molar, the right one was considered. In this way ten data of the dental system were gained of each examinee. Of the differences of each item from chronological age a mean was computed individually. These means served to express the difference between the dental or skeletal, and the chronological, age of each individual child. With these data the correlation coefficient was calculated. Examinees were not grouped according to sex but the total number was handled as one group, since teeth and ossification centres were compared with standards of the same sex.

In our former paper it was surmised that the most retarded elements would be more suitable than the mean of several items for expressing the developmental retardation of a person. Thus, with the most retarded items the correlation was similarly calculated of the skeletal and dental retardation.

In our first study the values of the single bone and tooth items seemed to scatter on a wider scale than in normal ones. This difference disappeared if the means were taken into account, i.e. when the developmental state of the skeleton or of the dentition was expressed by a single figure. The importance of this has

TABLE I

Distribution of individual skeletal and dental ages

Standard deviation	Skeletal				Dental			
σ	Low birth weight		Control		Low birth weight		Control	
	No	%	No	%	No	%	No	%
> 3	1	1.0	—	—	—	—	—	—
> 2	11	11.0	10	23.3	—	—	—	—
> 1	22	22.0	14	32.5	—	—	1	2.3
0	—	—	3	7.0	—	—	—	—
> −1	30	30.0	8	18.6	27	27.0	26	60.5
> −2	28	28.0	7	16.3	54	54.0	16	37.2
> −3	5	5.0	—	—	17	17.0	—	—
> −4	1	1.0	1	2.3	1	1.0	—	—
> −5	1	1.1	—	—	—	—	—	—

Skeletal system: 1 σ = 10 months
Dental system: 1 σ = 1 standard score

TABLE II

Correlation coefficients between dental and skeletal development

Group	Between mean osseous and dental deviations	Between the most retarded osseous and dental items
Low birth weight	0.48	0.30
Control	0.22	0.14

been pointed out by GREULICH and PYLE [6]. In order to clarify this point, the differences between the most retarded and most advanced items in both systems were calculated in both the low birth weight and the control group.

Furthermore we established the elements which showed the greatest aberration, i.e. items responding most sensitively to the supposed damage to any of the two systems. These items could then serve as indicators of the retardation; and perhaps it would be possible to state in what period of development the retardation becomes the most obvious, or in other words what elements suffer more, those which have been developing for several years more or less uniformly, or those which have undergone a recent spurt in development. To solve this problem, deviations of the same items were summed up in both the handicapped and the normal group and the means were calculated on the one hand, and, on the other, the items of each person were sequence-numbered according to their development and the sequence-numbers were summed up and averaged.

RESULTS

(i) In the low birth weight group, a retardation of dental and skeletal maturity was obvious even at 9 to 10 years of age. The delay was, however,

Table III

Deviations and sequence-numbers of the individual dental elements

No	Teeth	Totalled deviations						Totalled sequence-numbers					
		Low birth weight			Control			Low birth weight			Control		
		Totalled deviations	Mean deviation	Rank order	Totalled deviations	Mean deviation	Rank order	Totalled sequence-numbers	Mean	Rank order	Totalled sequence-numbers	Mean	Rank order
1.	I_{1s}	103	1.04	9	28	0.65	8	354.0	3.6	9	205.0	4.8	8
2.	I_{2s}	61	0.62	10	17	0.39	10	237.0	2.4	10	125.0	2.9	10
3.	I_{1i}	154	1.55	6	41	0.95	3	649.0	6 5	3	305.0	7.1	1–2
4.	I_{2i}	120	1.21	8	34	0.78	5–6	489.0	4.9	8	261.5	6.1	4
5.	C_i	172	1.73	4	34	0.78	5–6	581.0	5.9	5	231.0	5.4	5
6.	P_{1i}	186	1.88	2	35	0.81	4	623.0	6.3	4	221.0	5.1	7
7.	P_{2i}	230	2.32	1	43	1.00	1–2	741.0	7.5	1	283.5	6.6	3
8.	M_{1i} mes. rad.	184	1.86	3	43	1.00	1–2	681.5	6.7	2	305.0	7.1	1–2
9.	M_{1i} dist. rad.	157	1.59	5	32	0.74	7	574.0	5.8	6	224.0	5.2	6
10.	M_{2i}	124	1.25	7	26	0.60	9	565.0	5.7	7	185.0	4.3	9

Table IV

Deviations and sequence-numbers of

No	Bone	Totalled deviations					
		Low birth weight			Control		
		Totalled deviations	Mean deviation	Rank order	Totalled deviations	Mean deviation	Rank order
1.	Capitate	−107	−1.08	9	153	3.55	10
2.	Hamate	−99	−1.00	10	123	3.86	9
3.	Ep. rad.	−519	−5.24	4	−21	−0.48	4
4.	Triquetral	−549	−5.54	3	−46	−1.07	3
5.	Ep. I. met.	−434	−4.38	7	56	1.30	8
6.	Lunate	−1252	−12.64	1	−248	−5.76	1
7.	Trapezium	−613	−6.19	2	−9	−0.21	6
8.	Trapezoid	−501	−5.66	6	−4	−0.09	7
9.	Scaphoid	−305	−3.03	8	−17	−0.39	5
10.	Ep. uln.	−515	−5.20	5	−53	−1.23	2

less marked than at 6 to 7 years of age. From Table I it is clear that the retardation affected especially the dental system.

(ii) As to the parallelism of development of the skeletal and dental systems, i.e. the effect of the supposed damage on the two systems, the correlation coefficients between the mean dental and skeletal deviations, and between the most retarded dental and skeletal items were computed and are summarized in Table II.

(iii) The differences between the age of the most advanced and the most retarded items of both systems in each person were totalled and the means calculated for the handicapped and for the control group. In the handicapped group, the mean difference between the extreme values for the skeletal items amounted to 21 months, while in the control group to 16 months; for the teeth these means were 2.6 and 1.6 standard scores, respectively. Of the differences between the handicapped and control groups, that of the dental items proved to be significant statistically, at the 0.01 level of probability while the skeletal changes were probable only.

(iv) The summarized deviations of the same items and the totalled sequence-numbers are presented in Tables III and IV. Since the numbers of examines differed in the two groups, for comparibility's sake the mean values are given also.

The mean retardation exceeded in all teeth but the upper lateral incisor one standard score in the handicapped group, while in the control group the same degree of retardation was shown by the lower second bicuspid and the mesial root of the first molar. Generally, the lower second bicuspid and the

the individual skeletal elements

Totalled sequence-numbers					
Low birth weight			Control		
Totalled sequence-numbers	Mean	Rank order	Totalled sequence-numbers	Mean	Rank order
427.0	4.3	10	171.5	3.9	9
447.5	4.5	9	184.5	4.1	8
510.5	5.1	7	239.0	5.6	4–7
576.0	5.8	2–3	262.5	6.1	2
539.0	5.4	5	109.5	2.5	10
802.5	8.1	1	334.5	7.8	1
571.5	5.8	2–3	247.0	5.7	3
526.0	5.3	6	240.5	5.6	4–7
481.0	4.9	8	239.5	5.6	4–7
566.5	5.7	4	242.5	5.6	4–7

TABLE V

Rank order of teeth according to mean retardation (Retardation increases from right to left)

Control	P_{2i}	M_{1im}	I_{1i}	P_{1i}	I_{2i}	C_i	M_{1id}	I_{1s}	M_{2i}	I_{2s}
Low birth weight	P_{2i}	P_{1i}	M_{1im}	C_i	M_{1id}	I_{1i}	M_{2i}	I_{2i}	I_{1s}	I_{2s}

TABLE VI

Rank order of teeth according to mean sequence-numbers

Control	I_{1i}	M_{1im}	P_{2i}	I_{2i}	C_i	M_{1id}	P_{1i}	I_{1s}	M_{2i}	I_{2s}
Low birth weight	P_{2i}	M_{1im}	I_{1i}	P_{1i}	C_i	M_{1id}	M_{2i}	I_{2i}	I_{1s}	I_{2s}

TABLE VII

Rank order of bones according

Control	Lunate	Ep. uln.	Triqu.	Ep. rad.
Low birth weight	Lunate	Trapezius	Triqu.	Ep. rad.

TABLE VIII

Rank order of bones according

Control	Lunate	Triquetral	Trapezius	Ep. rad.
Low birth weight	Lunate	Triqu.	Trapezius	Ep. uln.

lunate displayed the most marked mean retardation.

To compare the two groups, the items were arranged according to the mean retardation as well as to the sequence-numbers. Tables V, VI, VII and VIII show the shifts in retardation of the single items of the low birth weight group as compared with the normal one.

As regards the teeth, the retardation of P_{1i}, C_i, M_{1i} dist. rad., M_{2i} and of P_{2i}, P_{1i}, M_{2i} was disproportionally increased in the handicapped group in comparison to the normal children. Among the ossification centres the trapezius and the first metacarpal displayed a similar shift, while the lunate showed the maximum retardation in the handicapped group. The differences in the mean retardations for each item in the two groups are shown in Table IX.

Thus, the first and second bicuspid and the canine were most retarded, lagging behind the control group by more than one standard score. It seemed therefore justified to conclude that it is the canine and the premolars in which the pathological retardation manifests itself most expressedly. These teeth are in the critical rapid developmental stage just at that age and seem therefore to be the most sensitive indicators of the damage and of the retardation in the examined age group. In spite of being in the same rapid developmental stage, the second molar failed to show the same degree of retardation in the low birth weight group, but the peculiar behaviour of this tooth is well-known from the literature [1].

In the skeletal system only the lunate and the trapezius showed a similar behaviour, although here the difference between the handicapped and the control group did not amount to 10 months, i.e. was within one standard deviation.

Thus, we have not been able to decide which elements would be the most suitable indicators of skeletal developmental disturbances in the examined age group.

to mean retardation

Scaphoid	Trapezius	Trapezoid	Ep. I. met.	Hamate	Capitate
Ep. uln.	Trapezoid	Ep. I. met.	Scaphoid	Capitate	Hamate

to mean sequence-numbers

Trapezoid	Scaphoid	Ep. uln.	Hamate	Capitate	Ep. I. met.
Ep. I. met.	Trapezoid	Ep. rad.	Scaphoid	Hamate	Capitate

Discussion

In children 9 to 10 years of age with a low birth weight the retardation of both systems was obvious. These children were unable to compensate their initial lag in development before their 9th or 10th year. The lag was more marked in the dental system; it is thus suggested that the teeth (i) either respond more sensitively to the supposed noxious factor that had been responsible for the low birth weight; or (ii) to the post partum lesions associated with the low birth weight; or (iii) they do not readily compensate the retardation caused by any kinds of factor. That is one of the causes of our having found a moderate correlation only between the two systems, in agreement with other similar studies. In addition, in our material the so-called intervariation [4, 16] was obvious in some instances, i.e. an advanced development of the skeletal system combined with a retardation of the dental one, or vice versa.

TABLE IX

Differences in mean retardation between low birth weight and control group

Tooth		Bone	
Item	Difference (standard score)	Item	Difference (month)
I_{1s}	0.39	Capitate	4.63
I_{2s}	0.23	Hamate	4.86
I_{1i}	0.60	Ep. rad.	4.76
I_{2i}	0.43	Triqu.	4.47
C_i	*0.95*	Ep. I. m.	3.08
P_{1i}	*1.07*	Lunate	6.88
P_{2i}	*1.32*	Trapezius	5.98
M_{1im}	0.86	Trapezoid	4.97
M_{1id}	0.85	Scaphoid	2.69
M_{2i}	0.65	Ep. uln.	3.97

In the control group instead of the expected close correlation between the skeletal and dental data, a loose one was found. This has to be attributed to our having calculated with the deviations from the chronological ages instead of the skeletal and dental ages themselves. Consequently the aberration of the two systems from chronological age in normal children may be of both directions and vary independently, whereas in the low birth weight children the presumed damage exerted an influence on both systems into the same direction. This was the cause of the closer association between their aberrations as expressed by the higher correlation coefficients.

The correlation of the maximally retarded items resulted in an even smaller r value indicating a lack of parallelism of the deviations of those elements which had suffered most from the presumed damaging factor. This finding corroborates the view that these two systems are independent, and may therefore be damaged independently.

The range of the individual dental items' deviation within the same person was significantly greater in the handicapped group than in the normal one. For the skeleton this difference between the groups was just below the significance level. It seems justified to conclude that the increased difference between the extreme values within the same system's single items is a sign indicative of some damage affecting any of the two systems. As the phenomenon was more definite in the dental system, it may be concluded that teeth are probably more sensitive indicators of any damage than is the skeleton. Furthermore, it is not possible to express with a single figure the deviation of biological from chronological age; at least the range between the extreme values even within one system must be given. This difference is apparently also of some importance.

As to what elements are the most suitable indicators of developmental retardation, the conclusion seems justified that in any age those have to be considered which are just in the critically sensitive developmental stage. In the reported material of 9 to 10 years of age it was the canine and the bicuspid, i.e. the teeth displaying a rapid development within a short period. An exception to this rule is the second molar with a proper and peculiar way of development.

From the data of the control group we may conclude that — in agreement with former reports from other countries [8, 16] — Hungarian children display a slight developmental retardation as compared with American standards. It is suggested that the general acceleration of somatic development is more manifest in American children. In all instances, this difference is to be taken into account when European (Hungarian) children are compared with American standards. Therefore, the retardation of our low birth weight group must have been slightly less marked than reported, if comparison is made with regularly developing Hungarian children.

The fact that the deviations of our control group from the standards were found to be greater in, and were uniformly present in all items of, the dental system, proves that the American dental standards of Moorrees and Fanning [13] cannot be applied for the evaluation of European examinees. The skeletal standards of Greulich and Pyle [6], however, are apparently reliable in Hungarian children of 9 to 10 years of age.

As a final conclusion, the necessity is stressed of establishing new skeletal and first of all dental standards for European children.

Summary

Children with low birth weight have been found to be unable to compensate the retardation of dental and skeletal development before the age of 9 to 10 years. Retardation is more marked in the dental than the skeletal system. As compared with American standards, the Hungarian control group displays a slight retardation of all dental items but not of all skeletal ones. At 9 to 10 years of age, dental age is best assessed in reliance on the lower cuspid and bicuspids.

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