Acta Med. Auxol. 31 (1): 33-38, 1999

An anthropometric study of cephalo-facial growth among Down's syndrome and normal children

Saiket Deb[1], **Paresh N Sahu**[1], **Thambisetty S Vasulu**[2]
[1] *Department of Anthropology, Sambalpur University, Orissa, India*
[2] *AHGU Indian Statistical Institute, Calcutta, India*

Summary

Variations in cephalo-facial growth among 35 Down's syndrome children (DSP) of an age ranging from 5 to 15 years were studied with respect to six anthropometric characters and were compared with normal children of the same age group to assess the extent of differential growth. A negative correlation was found between age and z-scores, especially for head length, head circumference and maximum facial breadth, which suggests a deceleration of growth among DSP. The comparison of standard growth curves of local school children with those of DSP suggests distinctive patterns of growth especially for head length, head circumference and bizygomatic breadth and the log values of the cephalo-facial characters fall below the 50th percentile for most of the age groups.

Key words deceleration of growth, skewed distribution, common influencing factors, morpho-gene

Several studies investigating the pattern of human growth and its concomitant variables have revealed the influence of genetic, nutritional, socio-economic and environmental factors on populations under different spatio-temporal conditions (1-7) conversely, the patterns of growth in case of abnormal conditions are little understood. While it is known that certain chromosomal abnormalities are associated with a morphological abnormality due to a differential growth pattern, the extent to which these patterns differ from normal growth has been little investigated (8-9). In general, it is known that a gradual increase occurs with age in mean values of cephalo-facial dimensions in children, and this fact is well documented (10-13), whereas the results of anthropometric studies of growth pattern with specific attention to Down's syndrome (children or DSP), a common chromosomal abnormality, are not completely known yet. Studies on DSP reveal certain abnormal characters of brachycephalic to hyperbrachycephalic nature (14) with reduced head length (15). The maxillary growth is reduced in comparison with mandibular growth (16) and hypoplastic development is seen in the mandible with a reduced mandibular angle (17). Percentile values are lower for head circumference and were found to be reduced in the DSP if compared with normal children (18,19) and also the association between mental functioning and structural asymmetry has been investigated (20). To what extent does the cephalo-facial growth pattern in DSP differ from that of normal subjects? Can we assume that the same influencing factors affecting growth in the normal children are also at play in case of DSP? Is the same influencing factors

Received 10.11.1998; accepted 02.12.1998

common to all DSP, irrespective of socio-economic and other environmental factors? Such studies are important to monitor growth in DSP, to devise corrective (clinical, surgical and pediatric etc.) measures and to get a better understanding of human growth and its genetic influences both on normal and abnormal children. This study examines the extent of variation of six cephalo-facial characters between different age groups among DSP when compared with normal children or the extent of deviation in growth patterns of DSP in comparison with normal children's.

Materials and methods

A series of 34 anthropometric measurements were obtained from 35 male DSP belonging to 5-to-15 year age range, for a detailed study. Out of these, the following six cephalo-facial measurements have been considered for the present study. The six measurements taken into account are the following: maximum head length (g - op); maximum head breadth (eu - eu); head circumference (g - op - g); minimum frontal breadth (ft - ft); maximum facial breadth (zy - zy) and bigonial breadth (go - go). The selection of these six measurements was determined by the results of earlier studies (14,20,21) which suggest a more significant dismorphogenesis of cephalo-facial characters than other characters in DSP. The growth status of these characters in DSP is compared with that of suitable normal children. The above measurements were taken by the first Author (SD) following, for each measurement, the landmarks as laid by (19,22,23).

To compare the growth status of DSP with that of normal controls, the raw scores of each measurement were converted into standard z-score with age appropriate standards (24). As no published local growth pattern of regional children was available, another sample of 550 apparently normal and healthy male children between the age group of 5 and 15 years were measured (cross-sectionally) for the study so as to serve as suitable controls.

The deviation in individual measurements (the extent of reduction or increase in linear dimension) when compared with normal controls was classified according to Farkas, Munro and Kolar (14). The abnormal measurements in DSP showing a value less than two-standard deviation and one-standard deviation different from the mean age of the control group were considered subnormal. The extent of the deviation was analyzed in terms of both absolute and signed (relative) values. The absolute value indicates the reduction corresponding to minimum values among the control group.

Association between z-scores for each cephalo-facial variable and age were computed by Pearson correlation coefficient and the significance of r was tested by t-test. To compare the age changes in each of the six cephalo-facial measurements among DSP with respect to the corresponding variation in appropriate age-controlled and cross-sectional control group, the group means of each measurement of DSP were converted into log values and plotted separately against the log values of 5^{th}, 50^{th} and 95^{th} percentile values of normal controls. These were shown graphically.

Results

The mean z-score values for the six cephalo-facial measurements among DSP have been summarized in table I. A high mean z-score was found in three characters: maximum facial breadth (-3.60), head circumference (-3.36) and maximum head length (-2.52) and the lowest was observed in head breadth. But the maximum range of z-score values was observed for facial breadth (-9.70) and the minimum for bigonial breadth (-4.60); however, the three head measurements show an almost equal range. The extent of the deviation in six characters among DSP, expressed in terms of percentages according to standard levels of comparison based on

Table I *Mean z-scores of six cephalo-facial measurements in Down's syndrome*				
Variables		**Mean z-score**	**Minimum**	**Maximum**
Maximum head length	(HL)	-2.52	-7.69	3.82
Maximum head breadth	(HB)	-0.89	-7.41	3.48
Head circumference	(HC)	-3.36	-7.50	0.99
Minimum frontal breadth	(FrB)	-1.40	-5.54	1.38
Maximum facial breadth	(FcB)	-3.60	-9.70	1.88
Bigonial breadth	(BB)	-1.86	-4.60	1.39

Table II *Correlation between z-scores and age in Down's syndrome children*			
Variables		**"r"**	**Significance**
Maximum head length	(HL)	-0.58	$p < 0.001$
Maximum head breadth	(HB)	-0.24	n.s.
Head circumference	(HC)	-0.53	$p < 0.005$
Minimum frontal breadth	(FrB)	-0.35	$p < 0.05$
Maximum facial breadth	(FcB)	-0.29	n.s.

n.s. = not significant

standard deviation has been reported in table III. A majority of DSP shows subnormal values below 2SD levels except for head breadth (9 DSP). The percentage of reduction (below 2SD) in linear dimensions in individual characters varies among the DSP from 74% (maximum) for head circumference (26 out of 35 DSP); 71% for both head length and facial breadth (25 DSP). In case of 1SD level, bigonial breadth shows the maximum frequency of DSP (31%) followed by head breadth (23%).

The association between z-scores values of each measurement with age among DSP is shown in table II. All six values show negative correlation, but only three attain statistical significance, especially for head length ($p \leq 0.001$), head circumference ($p \leq 0.005$) and frontal breadth ($p \leq 0.05$). Figure 1 shows the age specific variation of group means (log values) for each of the six measurements of Down's syndrome plotted against the corresponding age specific variation of the log values of the 5^{th}, 50^{th} and 95^{th} percentile growth curves of the normal control group. The graph indicates that the pattern of growth among DSP is distinctively different from that of normal subjects in all six characters, even though the sample size for DSP is not appreciable. The extent of variation among DSP is different for each character and varies with age. In case of maximum head length, the log values of DSP lie below the 5^{th} percentile except at seven years. In case of head breadth, most of the values are close to the 50^{th} percentile except for 13 to 15 years, where it lies near to the 5^{th} percentile. Concerning head circumference, the age specific growth closely resembles the pattern observed for head length. In case of minimum frontal breadth and bigonial breadth, the age specific mean values of DSP fall

Table III *Summary measurements in Down's syndrome children*					
		< -2SD		**< -1SD**	
Variables		**N**	**%**	**N**	**%**
Maximum head length	(HL)	25	71.43	5	14.29
Maximum head breadth	(HB)	9	25.71	8	22.86
Head circumference	(HC)	26	74.29	6	17.17
Minimum frontal breadth	(FrB)	12	34.29	9	25.71
Maximum facial breadth	(FcB)	25	71.43	5	14.29
Bigonial breadth	(BB)	17	48.57	11	31.43

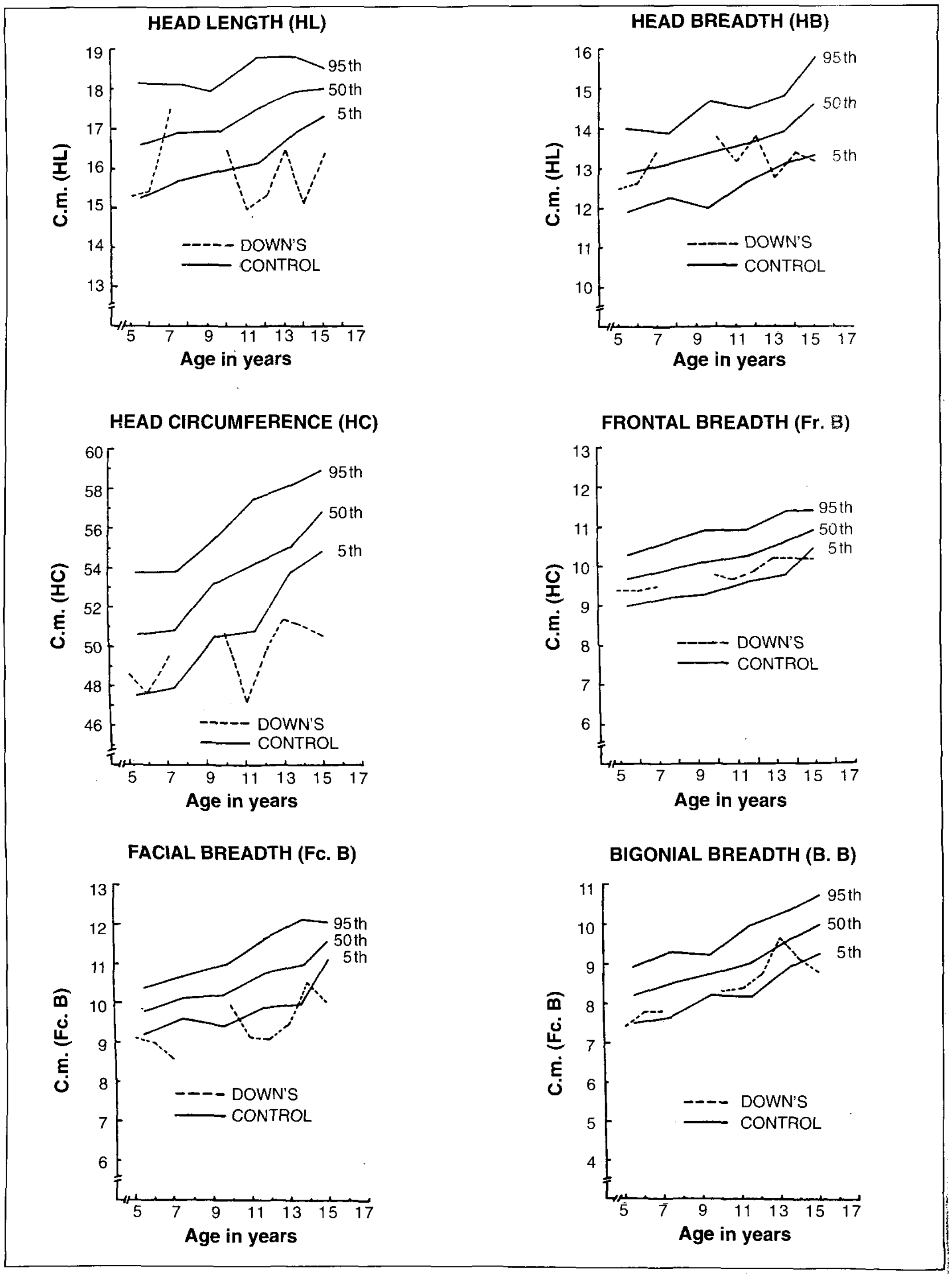

Figure 1 *Variation in cephalo-facial growth in six anthropometric characters among Down's syndrome children between 5 to 15 years of age compared with age - specific standard normal growth curve (5th, 50th and 95th percentile) of control (school children) population.*

between the 50^{th} and 5^{th} percentile curves except for a slight increase (sharp raise) at 13 years of age group, where the corresponding log values almost touch the 50^{th} percentile. As to maximum facial breadth, log values of DSP fall below the 5^{th} percentile, where it shows some deceleration from the 10^{th} year onwards and increases from 12 to 14 years of age to lie close to the 5^{th} percentile.

Discussion

The extent of growth or deviation from the normal growth standards observed in the head morphology of DSP is more or less in agreement with the results obtained in Down's syndrome subjects elsewhere in the world (25). The observed negative correlation between z-scores of cephalo-facial measurements and age among DSP suggests some slowing down (or deceleration) in the growth processes as suggested by Meany and Butler (9). This was prominent in case of maximum head length followed by head circumference and minimum frontal breadth. Since these characters are highly correlated, any change in any one measurement which affects size and shape of the head morphology is reflected in other characters either positively or negatively, due to buffering action. In Down's syndrome, head length disproportionately varies with head breadth and this affects head circumference and possibly other characters including frontal breadth. This possibly implies that one single factor or more factors may be responsible for the deceleration of growth in Down's syndrome. This hypothesis gains credence in view of similar such observations (18), suggesting common factors, which are possibly related to genetic influence associated with chromosomal abnormality. The growth curve shows that these characters fall below the 50^{th} percentile. The result is head shortening and flattened occiput, as suggested by Jaswal and Jaswal (15).

One of the observations made is the wide heterogeneity in the measurements of characters performed, more vertically (lengthwise) than horizontally (breadthwise). Part of this wide variation could be due to sampling, especially, to the sample small size and to the nature of the data obtained. Though the data were collected from school records identified as being related to DSP, owing to the lack of karyotyping data it was not possible to classify them into sub groups according to chromosomal patterns. However, even if this were done, a much larger sample size would be required for the analysis, which might reduce the inconvenience due to sampling. Another possible source of variation could be the mutual correlation between characters, some characters being positively and others negatively associated, resulting in a wide variation between characters. What is desirable is to perform a multivariate analysis, taking into account the mutual correlation between characters, which is expected to show common influencing factors related to the deceleration of growth in DSP. This can also help to search for genetic factors related to chromosomal aberration, or morpho-gene in man.

The pattern of growth and the extent of deviation of each group of DSP are distinctly different from those of the normal control group, despite the small sample size and the lack of data for the eight and nine year-age groups of DSP. The results indicate that the growth process in case of DSP is different for each measurement and between age groups and that it shows a rather skewed distribution. This fact suggests a general pattern of the abnormality of DSP, which would reoccur even if the sample size was increased but it might differ if the different types of DSP are compared separately. This cannot be easily checked on account of the lack of such studies; few such quantitative studies, though available, do not include the above characters and do not help to make comparisons (8,9).

The preliminary study exemplifies the extent of deviation in some cephalo-facial characters, which is distinctly different among a majority of DSP. This quantitative assessment extremely important in surgery, corrective physiotherapy in retarded growth and in pediatric and clinical identification. It may also help to understand the genetics of growth process at the micro level, and the genetics of the population morphology in case of abnormal morphological disposition. The results of the study encourage to undertake these studies possibly with additional characters, preferably taken from a large sample and with the knowledge of karyotyping and other genetic characters.

Acknowledgements

We would like to thank dr P. Bharati for providing us relevant publications and Mr Ajay Das for drawing the figures. We are grateful to Professor K.C. Malhotra, Indian Statistical Institute, Calcutta, for his constant support and encouragement and to the Director of the Indian Statistical Institute, Calcutta for infrastructure and accessory help.

Correspondence *Thambisetty S Vasulu, MD, AHGU Indian Statistical Institute, 203 BT Road, Calcutta-700 035 India.*
e-mail: vasulut@hotmail.com

References

1. Tanner JM, Whitehouse RH, Takaishi M. Standards from birth to maturity for height, weight, height velocity, weight velocity: British children. 1965. Arch. Dis. Child. 1966; 41:454-71; 613-35.
2. Bailey KV. A study of human growth in the frame work of applied nutrition and public health nutrition programme in western Pacific region. Monographs of the society for research into childhood development 1970; 35:40-8.
3. Eveleth PM, Tanner JM. Worldwide variation in human growth. Cambridge: Cambridge University Press, 1976.
4. Tanner JM. Foetus in man: physical growth from conception to maturity. London: Open Books, 1978.
5. Hauspie RC, Das SR, Preece MA, Tanner JM. A longitudinal study of growth in height of boys and girls of West Bengal (India) aged six months to 20 years. Ann Hum Biol 1980; 7:429-41.
6. Beals KL, Smith CL, Dodd SM. Brain size, cranial morphology, climate, and time machines. Curr Anthropol 1984; 25:301-30.
7. Malina RM, Himes JH, Stepick CD, Lopez FG, Buschang PH. Growth of rural and urban children in the Valley of Oxaca, Mexico. Am J Phys Anthropol 1981; 58:221-5.
8. Marshall WA. Human growth and its disorders. New York: Academic Press, 1977.
9. Meaney FJ, Butler MG. Craniofacial variation and growth in the Prader Labhart-Willi syndrome. Am J Phys Anthropol 1987; 74:459-564.
10. Goldstein MS. Development of the head in the same individuals. Hum Biol 1939; 11:199-219.
11. Iyer VS, Lutz W. Cephalometric comparison of Indian and English facial profiles. Am J Phys Anthropol 1966; 24:117-26.
12. Singhrol CS, Mitra M. Cephalo-facial growth of school going girls of Chattisgarh. Ind J Phys Anthropol Hum Genet 1985; 11:141-3.
13. Brown T. Physical growth and adaptation in the tropics with special reference to the cranio-facial structures. In. Prabhu R, Wilson D, Johnson N eds. Oral diseases in tropics Oxford: Oxford Medical Publications, 1991.
14. Farkas LG, Munro IR, Kolar JC. Abnormal measurements and disproportions in the face of Down's syndrome patients: preliminary report of an anthropometric study. Plast Reconstr Surg 1985; 59:159-67.
15. Jaswal S, Jaswal IJS. Malformation of the head in Down's syndrome. Indian Pediatr 1988; 25:373-6.
16. Allanson JE, O'Hara P, Farkas LG, Nair RC. Anthropometric craniofacial pattern profiles in Down's syndrome. Am J Med Genet 1993; 47:748-52.
17. Fischer BH. Vertical development of the jaw in case of trisomy 21: Interaction of form and function. Orhod Fr. 1989; 2: A521-A6.
18. Clementi M, Calzolari E, Turolla L, Volpato S, Tenconi R. Neonatal growth pattern in a population of consecutively born Down's syndrome children. Am J Med Genet 1990; 7 (Suppl.): 71-4.
19. Farkas LG, Anthropometry of the head and face in Medicine. Elsevier: New York, 1981.
20. Malina RM, Buschang PH. Anthropometric assessment in normal and mentally retarded males. Ann Hum Biol 1984; 11:515-31.
21. Meaney FJ, Farrer LA. Clinical anthropometry and medical genetics: A compilation of body measurements in genetic and congenital disorders. Am J Med Genet 1986; 25:343-59.
22. Montagu MF Ashley. An introduction to physical anthropology. 1951; 440-462.
23. Weiner JS Lourie JA. Practical human biology. Springfield. Illinois: Academic Press, 1981.
24. Dawnie NM, Heath RW. Basic statistical methods. 3rd ed. New York, 1970.
25. Vogel F, Motulsky A. Human Genetics. Problems and approaches. Berlin: Springer Verlag, 1982: 40.