

Standardized National Growth Chart of 0–5-Year-old Saudi Children

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Summary

A national survey was carried out to achieve the following objectives: (1) construction of national standards for Saudi children, 0–5 years old, with regard to weight, height and head circumference for males and females; (2) construction of a growth chart for weight, height and head circumference for 0–5-year-old Saudi children that can be used at hospitals and health centres in the Kingdom for routine follow-up of the growth of these children. To achieve these objectives, the WHO recommendations were applied. A total of 24 000 Saudi children, 12 000 males and 12 000 females, were selected randomly representing the five regions of the Kingdom with 200 children in each monthly age group. Demographic data as well as the anthropometric measurements were recorded by well-trained personnel using a pretested questionnaire and new, well calibrated equipment. The current study showed that Saudi boys (0–5 years old) were heavier and taller than Saudi girls in the same age group, and that the median weights and heights of Saudi boys and girls (0–5 years old) were more than those of the Harvard standards. A growth chart was constructed which was suitable for growth monitoring programmes all over the Kingdom.

Introduction

Body measurements of children's weight and height have been widely used for the identification and classification of malnutrition in most of the world.¹

The world 'growth' refers to the increase in the physical size of the body mass.² A growing child is a healthy one,³ and growth and mental developments are indicators of good health and nutrition.^{4,5} Measurements of physical growth is a key element in evaluating the health of children.⁶ Infant growth is related to short-term outcomes including survival, morbidity, and cognitive performance.⁷ The growth curves are intended to serve as a reference point for screening and monitoring, not as an absolute criterion for defining malnutrition or pathology.⁸

Due to the improvement in healthcare over the last hundred years in most western countries, there has been a tendency for children to be bigger at all ages from generation to generation and to mature earlier. This is known as the secular trend. This trend is coming to an end in the western hemisphere but is still operating in developing countries.⁹ There is a worldwide variation in size and shape between children belonging to different populations. These differences are due to differences in their genetic make-up, their requirements, and in the

interaction between the two during the whole period of growth and development.¹⁰

There is some controversy regarding the use of NCHS standards based on the children of the USA, since the reference standard of one country may not necessarily be applicable to another country.¹¹ Not only is the need for the creation of national standards justified¹² but also, over a period of time, the same country needs to revise the national standards.^{13,14} Furthermore, growth standards within the country can be different in different socioeconomic settings.¹⁵

In spite of the significant expansion in the health service in Saudi Arabia over the last 30 years,¹⁶ studies of the growth of Saudi children are still very limited. There are few published studies, we still have little knowledge about the growth status of Saudi children, and national standards for growth are not yet available. However, we are aware that their patterns of growth deviate from the reference standards established in Europe and the USA. One of these studies highlighted the need for national growth standards to assess the growth status of Saudi children.¹⁸ This can not be achieved by a single study in a single region in the Kingdom. Growth measurement studies for Saudi preschool aged children should be done in the five main regions in the Kingdom, choosing the field of study randomly in each region and applying the same protocol in these regions. The data of weight, height and head circumference can then be analysed to obtain the final result of the national growth standards and charts for Saudi preschool (0–5 years) children.

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The most commonly used reference populations for the analysis of group data and the determination of the growth pattern of individual children, used to be the Stuart–Meredith populations, based on data collected on a relatively small number of children in Boston and Iowa during the 1930s and 1940s.⁶ This reference had several shortcomings.

In 1972, the Centre for Disease Control (CDC) recognized the need for a new reference population for use in the analysis of children, both individually and collectively.²⁰ This led to the Committee on Nutrition Advisory to the CDC of the National Academy of Sciences undertaking the task of identifying and recommending a more appropriate reference population for use in nutritional surveillance programmes and in the assessment of the nutritional status of child population.²⁰

Waterlow cross-tabulated height-for-age and weight-for-height.^{23–25} To determine the different types of malnutrition, methods had been suggested for the classification of nutritional status based on measurements of height and weight.^{21,22}

The FAO/UNICEF/WHO Expert Committee on Nutritional Surveillance recommended the use of height-for-age and weight-for-height as primary indicators of nutritional status in children.²²

In 1975, the final NCHS/CDC reference curves were developed using the latest in mathematical and computer technology. Appropriate computer subroutines had been developed at the CDC and widely distributed through the world.²⁰ Later, a World Health Organization Committee suggested using the NCHS/CDC reference data in nutritional studies from both developed and developing countries and included a recommendation that standard deviation scores be used to present population distribution in which a high percentage of values were outside the 5th and 95th percentiles.^{20,22}

The differences between the Stuart–Meredith and NCHS/CDC reference lie mainly in the extreme percentiles, while the medians are similar for height-for-age and weight-for-age. In addition, the NCHS/CDC reference curves are amenable to computer application.²⁰

Materials and Methods

In each region random sampling of 0–5-year-old children was done. In each age group the sample size of males and females was equal. All regional investigators underwent a period of instruction and training prior to the survey, with a view to standardizing the methods. All children under study were weighed and measured once (cross-sectional study) wearing only one piece of underwear. All other clothing including underwear and footwear were removed prior to measurements. The same person weighed the children at each centre. Height was measured after stretching the child as per the training given the staff. For infants and children below 2 years, supine length was measured. Thereafter, standing height was measured (as recommended by Tanner³³ and WHO³⁴).

Standardized equipment was distributed to all health centres participating in the study, only this equipment was used for the measurements needed. They were calibrated at frequent intervals during the study. Beam scales recommended by WHO were used to measure weight.

In estimating sample size the WHO criteria, and Tanner and Healy recommendations were used as reference values and were taken into consideration.^{3,22,26}

According to these recommendations the sample should include at least 200 individuals in each age and sex group. A total of 24 000 healthy Saudi under-fives were included (12 000 boys and 12 000 girls) to cover the 60 monthly intervals needed. These children were distributed across the five main regions of the Kingdom proportional to their population density. As such, the sample size of the Northern region was 2280 children (9.5 per cent of the population), the Southern region 5616 children (23.4 per cent of the population), the Central region 5448 children (22.7 per cent of the population), the Eastern region 3792 children (15.8 per cent of the population), and the Western region 6864 children (28.6 per cent of the population).

Five areas, one from each of the five regions, were selected randomly, the sample for each region was divided into urban and rural groups proportional to the population in each locality.

As health centres are distributed all over the country and cover every district of the cities and villages, they were chosen to be the field of the survey. The number of health centres from each area was determined based on the population density both in urban and rural localities.

After collection of the child's demographic data and examination by a physician, anthropometric measurements were taken and recorded. These included length or height, weight and head circumference. Weight was measured to the nearest 0.1 kg and height and head circumference to the nearest 0.1 cm.

The data were processed using SPSS computer software. The means and standard deviations were calculated and 15 percentiles (3rd, 5th, 10th, 20th, 25th, 30th, 40th, 50th, 60th, 70th, 75th, 80th, 90th, 95th, 97th) of weight and height (length and stature) for each of the monthly age intervals (0–59 months) were calculated. The head circumference means and percentiles were calculated for the first 2 years only (0–23 months). The growth charts were prepared by plotting the selected percentiles by using the graph facilities of the Microsoft Excel package. In addition, percentiles of weight-for-height were also plotted. Smoothing of the percentile curves was carried out by the moving average method.

The results were compared with the NCHS respective percentiles as a reference population.²⁹ The curves comparing the Saudi and the NCHS 5th, 50th and 95th centiles were drawn by the computer depending on the data on the NCHS centile tables of weight-for-age, height-for-age, and weight-for-height²⁹ compared with those of the local national centiles.

TABLE 1
Distribution of the sample according to region

Region	Urban	Rural	Total
Northern	1530	733	2263
Eastern	2436	1315	3751
Central	3823	1540	5363
Western	4374	2508	6882
Southern	2197	3365	5562
Total	14360	9461	23821

Results

The nation-wide anthropometry data from a total of 23 821 (11 913 boys and 11 908 girls) healthy Saudi under-fives were recorded in 109 health centres throughout the five regions of the country during the year 1993–1994 (Table 1 and 2).

The sample size of each monthly age group (0–59 months) was 200 ± 5 per cent. Tables 3 and 4 illustrate the sample size and the means and standard deviation of each monthly age group measurement. The national selected percentile growth charts of weight, height, and head circumference by age for boys and girls are illustrated in Figs 1 and 2, respectively.

TABLE 2
Distribution of the sample from the five Kingdom regions according to population density in the urban and rural localities

Region	Population percentage	Urban/rural ratio	Sample size desired			Selected areas	No. of selected centers	
			Urban	Rural	Total		Urban	Rural
Northern	9.5	2.1 : 1	1542	738	2280	Tabuk	7	4
Eastern	15.8	1.8 : 1	2459	1333	3792	Gatief	9	8
Central	22.7	2.7 : 1	3898	1550	5448	Riyadh	10	13
Western	28.6	1.7 : 1	4353	2511	6864	Jeddah	15	14
Southern	23.4	0.7 : 1	2224	3392	5616	Jizan	12	17

TABLE 3
Mean and standard deviation for Saudi (0–23 months) boys and girls

Boys								Girls							
Age	n	Weight		Height		Head circumference		Age	n	Weight		Height		Head circumference	
		Mean	SD	Mean	SD	Mean	SD			Mean	SD	Mean	SD	Mean	SD
0	208	3.4	0.6	50.6	2.2	34.6	1.2	0	210	3.3	0.5	50	2.1	34.9	1.2
1	210	4.4	0.7	54.6	2.5	36.6	1.2	1	209	4.1	0.6	53.4	2.4	37.2	1.3
2	206	5.2	0.8	57.8	2.8	38.1	1.3	2	199	4.7	0.8	56.5	2.4	38.9	1.3
3	202	6	1	60.6	3	39.4	1.2	3	200	5.4	0.8	59.1	2.6	40.1	1.4
4	205	6.6	1.1	62.9	2.9	40.2	1.3	4	197	6.1	0.9	70.1	2.6	41	1.4
5	202	7.4	1.1	64.7	2.9	40.8	1.3	5	204	6.5	1	62.8	2.8	41.8	1.4
6	195	7.7	1.1	66	3	41.4	1.4	6	206	6.9	1.1	64.3	2.8	42.5	1.4
7	203	8.1	1.3	67.3	3	42	1.4	7	195	7.3	1.1	65.6	2.8	43.1	1.4
8	202	8.5	1.3	68.5	3.1	42.5	1.4	8	198	7.6	1.1	66.8	2.9	43.6	1.4
9	201	8.8	1.3	69.6	3.2	42.9	1.4	9	210	7.9	1.2	68.1	2.9	44	1.4
10	201	9.1	1.3	70.7	3.1	43.3	1.4	10	196	8.2	1.2	69.2	2.9	44.3	1.4
11	203	9.2	1.3	71.8	3.2	43.7	1.4	11	209	8.5	1.2	70.3	3	44.8	1.5
12	199	9.4	1.4	72.9	3.3	44.2	1.4	12	207	8.7	1.3	71.3	3	45.2	1.5
13	194	9.6	1.3	74.1	3.3	44.6	1.4	13	194	8.9	1.3	72.5	3.1	45.6	1.5
14	197	9.8	1.4	75.1	3.3	44.9	1.5	14	194	9.1	1.2	73.6	3.1	46	1.5
15	196	10	1.4	76.2	3.4	45.2	1.5	15	194	9.3	1.2	74.6	3.2	46.4	1.5
16	190	10.3	1.4	77.3	3.2	45.5	1.5	16	199	9.5	1.3	75.4	3.2	46.7	1.5
17	198	10.4	1.4	78.2	3.3	45.7	1.5	17	198	9.7	1.4	76.3	3.3	46.8	1.5
18	205	10.6	1.4	79.1	3.4	45.9	1.6	18	203	9.9	1.4	77.2	3.3	47.1	1.5
19	198	10.8	1.4	80	3.4	46.1	1.6	19	199	10.1	1.4	78.2	3.3	47.3	1.5
20	191	11	1.5	80.9	3.4	46.4	1.6	20	194	10.3	1.4	79.2	3.3	47.5	1.5
21	197	11.1	1.5	81.9	3.4	46.5	1.6	21	192	10.4	1.5	80	3.4	47.6	1.5
22	205	11.2	1.5	82.7	3.4	46.6	1.6	22	197	10.5	1.5	80.8	3.4	47.9	1.6
23	197	11.3	1.5	83.4	3.4	46.7	1.6	23	194	10.7	1.5	81.6	3.5	48	1.6

TABLE 4
Means and standard deviation for Saudi (24–59 months) boys and girls

Boys						Girls					
Age	n	Weight		Height		Age	n	Weight		Height	
		Mean	SD	Mean	SD			Mean	SD	Mean	SD
24	204	11.4	1.6	82.2	3.6	24	205	10.8	1.6	80.6	3.4
25	202	11.6	1.6	83.1	3.5	25	198	11	1.6	81.5	3.5
26	194	11.8	1.7	83.8	3.6	26	195	11.2	1.6	82.2	3.5
27	193	12.1	1.6	84.6	3.7	27	195	11.4	1.7	83	3.6
28	198	12.3	1.7	85.5	3.6	28	191	11.6	1.7	83.8	3.6
29	195	12.4	1.7	86.2	3.7	29	197	11.7	1.7	84.6	3.7
30	204	12.5	1.7	87	3.8	30	198	11.9	1.7	85.4	3.7
31	195	12.6	1.7	87.7	3.8	31	196	12.1	1.8	86.1	3.7
32	192	12.8	1.8	88.6	3.7	32	199	12.3	1.7	87	3.7
33	197	13.1	1.8	89.3	3.8	33	197	12.4	1.8	87.7	3.8
34	202	13.2	1.8	90.1	3.9	34	198	12.5	1.8	88.5	3.8
35	197	13.4	1.8	90.8	3.9	35	191	12.7	1.9	89.2	3.9
36	204	13.5	1.8	91.5	3.9	36	196	12.9	1.9	90	3.9
37	210	13.6	1.8	92.3	3.9	37	197	13	1.9	90.6	3.9
38	199	13.8	1.8	93.1	4	38	196	13.2	1.9	91.2	4
39	198	13.9	1.9	93.8	4.1	39	196	13.4	1.9	92.1	4
40	192	14.1	1.9	94.6	4	40	200	13.6	2	92.7	4
41	196	14.2	2	95.3	4.1	41	200	13.7	2	93.3	4
42	194	14.4	2	96.1	4.2	42	196	13.9	2	94	4.1
43	198	14.5	2	96.7	4.2	43	190	14.1	2.1	94.7	4.1
44	198	14.7	2	97.4	4.2	44	197	14.3	2.1	95.4	4.1
45	197	14.9	2	98	4.3	45	196	14.4	2.1	96.1	4.2
46	195	15.1	2.1	98.7	4.3	46	197	14.5	2	96.8	4.2
47	193	15.2	2.1	99.3	4.4	47	200	14.6	2.1	97.5	4.2
48	196	15.3	2.1	100.1	4.4	48	199	14.8	2.2	98.2	4.2
49	199	15.6	2.1	100.6	4.4	49	204	15	2.2	98.8	4.2
50	196	15.8	2.2	101.2	4.5	50	199	15.1	2.2	99.5	4.3
51	196	15.9	2.2	101.8	4.5	51	196	15.2	2.2	100	4.3
52	196	16.1	2.1	102.3	4.5	52	196	15.3	2.3	100.6	4.4
53	195	16.3	2.2	103	4.6	53	197	15.5	2.3	101.2	4.3
54	194	16.5	2.3	103.7	4.5	54	196	15.6	2.3	101.8	4.4
55	104	16.6	2.3	104.2	4.6	55	198	15.8	2.3	102.4	4.4
56	202	16.7	2.3	104.7	4.6	56	200	15.9	2.4	102.9	4.5
57	200	16.8	2.4	105.3	4.6	57	201	16	2.4	103.4	4.5
58	195	16.9	2.4	105.8	4.6	58	200	16.1	2.5	103.9	4.5
59	198	17	2.4	106.3	4.7	59	199	16.2	2.4	104.5	4.5

A *t*-test between Saudi boys and girls, 0–5 years old, was significant ($p < 0.05$) for weight, height, and head circumference. A *t*-test between urban and rural boys and girls for weight, height, and head circumference was performed; urban children were significantly different from rural ($p < 0.05$). Saudi 0–5-year-old boys were taller and heavier than the girls of the same age group. In addition, urban boys and girls were taller and heavier than their counterparts in rural areas.

Analysis of variance (Table 5) between urban and rural localities within the five regions for boys and girls, weight and height, showed a significant difference ($p < 0.05$). Hence, there is a significant difference in the weight and height between the children of the five urban and rural localities. Details of these differences were illustrated through the Scheffé Multiple Range Test (Table 6).

The male and female children of the Southern region (both urban and rural) were significantly lower in weight and height than the other regions. The region which was second in being significantly lower in weight was the Northern region, except for the weight of urban females. The data for the Western region were in between. For urban male and female children, children of the Eastern region were significantly heavier and taller than children of other regions. The rural children of the Central region, both male and female, were significantly heavier and taller than all others.

A growth chart for Saudi 0–5-year-old males and another for females were developed based on the results of the standardized median, 97th, 75th, 25th and 3rd centile for each of the 60 monthly age groups measured during the survey. In designing the growth charts, the

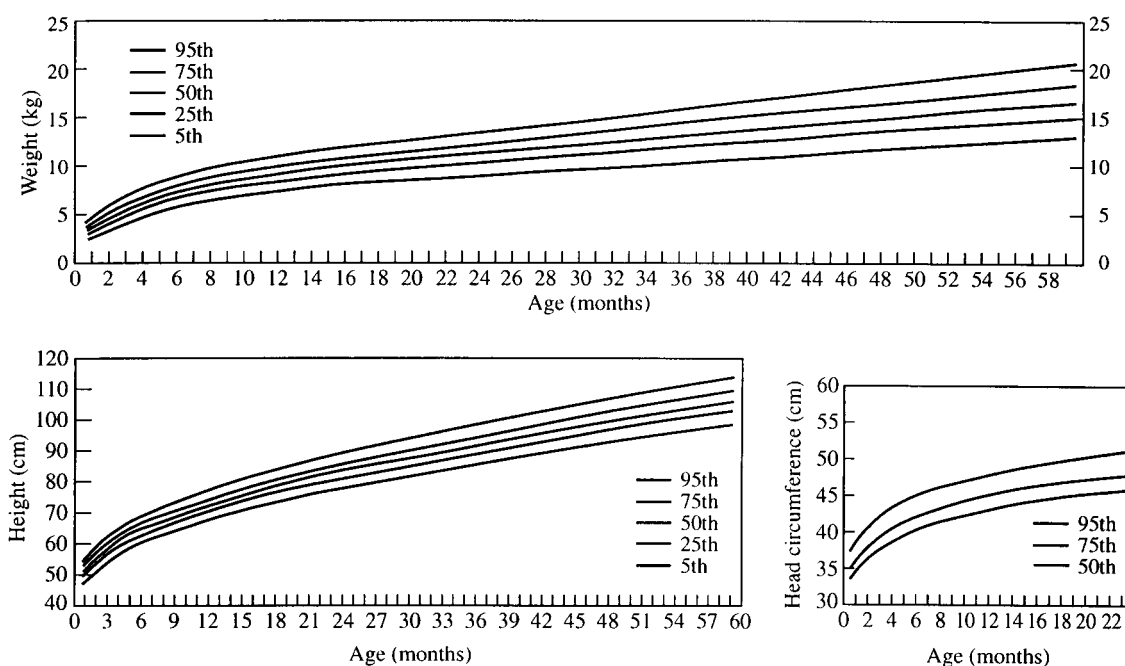


FIG 1. Growth charts for Saudi boys aged 0–59 months

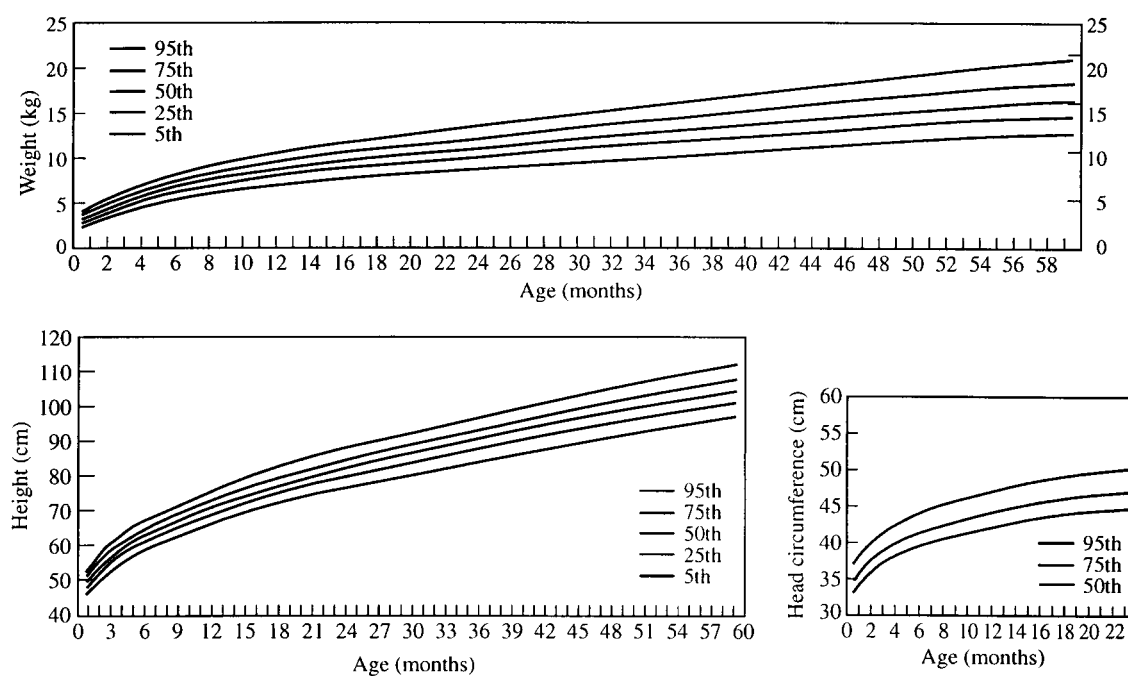


FIG 2. Growth charts for Saudi girls aged 0–59 months

TABLE 5
Analysis of variance between urban and rural localities

	Urban		Rural	
	F ratio	p value	F value	p value
Boys				
Weight	11.85	0.0000	48.08	0.0000
Height	8.04	0.0000	20.33	0.0000
Girls				
Weight	15.41	0.0000	62.05	0.0000
Height	13.47	0.0000	33.55	0.0000

WHO recommendation that states that the charts must include proper identification of the children, was followed.³

Discussion

The current study showed that boys were heavier and taller than girls, a finding similar to earlier studies in Riyadh and Asir regions.^{17,18} The pattern of growth for boys and girls appeared similar at each age group to that of Asir and Riyadh studies.^{17,18} In addition, this study showed that Saudi children under 5 years old were shorter and lighter than the reference population which was also

TABLE 6
Scheffé multiple range test between the five regions

Weight						Height					
Region	Southern	Northern	Western	Central	Eastern	Region	Southern	Northern	Western	Central	Eastern
(a) Boys											
Urban											
Southern						Southern					
Northern	*					Northern					
Western	*					Western					
Central	*					Central					
Eastern	*					Eastern	*	*	*	*	
(b) Girls											
Urban											
Southern						Southern					
Northern	*					Northern					
Western	*					Western	*				
Central	*					Central	*				
Eastern	*	*	*			Eastern	*	*	*	*	
(c) Boys											
Rural											
Southern						Southern					
Northern						Northern					
Western	*					Western	*				
Eastern	*	*	*			Eastern	*				
Central	*	*	*			Central	*	*	*	*	
(d) Girls											
Rural											
Southern						Southern					
Northern						Northern					
Western	*					Western	*				
Eastern	*	*	*			Eastern	*	*	*	*	
(e) Boys											
Rural											
Southern						Southern					
Northern						Northern					
Western	*					Western	*				
Eastern	*	*	*			Eastern	*	*	*	*	
(f) Girls											
Rural											
Southern						Southern					
Northern						Northern					
Western	*					Western	*				
Eastern	*	*	*			Eastern	*	*	*	*	

*p value < 0.05.

noted by the Riyadh study¹⁷ and the study reported from Jordan.³⁰

The currently used growth curves for weight and height at the health centres were compared with the results of this study. Since they are based on Harvard standards it is only possible to compare the median of weight- and height-for-age for boys and girls. This showed that the medians of weight and height for Saudi boys and girls are higher than those of the Harvard standard.

Four studies of Saudi under-fives weight and height measurements had been conducted earlier.^{18,19,31,37} However, comparing these results with the results of our study was not possible, since either the growth charts were given without base line tables or the age grouping was every 3 or 5 months, unlike the present study which was done for each single month. Therefore it is not possible to determine the secular trend of Saudi children at this stage.

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