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Length and weight growth trends for children less than two years old in Zanjan, Iran: Longitudinal modeling

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Abstract

Background: Growth failure in children less than five years old can lead to the serious complications such as increased mortality, learning difficulties or physical disability. The aim of this study was to investigate the non-organic factors affecting the growth trend in less than two years children living in Zanjan, Iran.

Methods: This longitudinal study was conducted on a sample of 3566 children less than two years old in Zanjan. Weight and length growth trends were recorded as ordinal variables and analyzed by longitudinal marginal model.

Results: About 12% (n=289) and 8% (n=212) of children had at least one decline/stagnation in the weight and length growth curve, respectively. Based on the marginal model, the effect of the child's age and residence area on the weight and length growth trends were statistically significant ($p<0.05$).

Conclusion: Given the relatively high prevalence of growth failure among studied children less than two years old in rural areas of Zanjan, raising the awareness of parents in rural areas about feeding and nutritional behaviors of children seems an important issue. Additionally, healthcare providers should mostly focus on monitoring the growth of children older than 12 months.

Keywords: Weight growth trend, length growth trend, longitudinal data, marginal model.

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Introduction

Child growth is argued to be of paramount importance and constitutes one of the fundamental and basic principles of healthy society. Growth failure is a situation that indicates a child is delayed in growth compared to standard anthropometric measures of weight and height for healthy children. Although the discussion of growth failure dates back to a long time ago in medical literature, a comprehensive and precise definition has not been proposed to date to capture its nature. Child growth failure, instead of being a specific disease, refers to a situation in which children suffer from inadequate calorie absorption or the inability to preserve or consume it correctly (1,2).

Generally, the major reasons identified for child's growth failure can be subsumed under two general rubrics, namely, organic reasons such as acute and chronic diseases (infection) requiring medical treatment, and non-organic reasons such as not receiving adequate food, occupational status of the parents and mothers' insufficient knowledge regarding proper feeding of the child. However, in most of the cases, child growth failure is due to non-organic reasons with no underlying disease (2,3).

Growth failure is generally found among children below 5 years of age, specifically among children below 2 years. Failing to treat it would lead to more serious complications such as increased mortality, increased affliction with related diseases, learning difficulties, and intellectual, emotional, or physical disability (2-4). Accord-

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ing to the report released by World Health Organization (WHO), more than 30% of children younger than 5 years old suffer from growth disorders which 80% of them show reductions in length growth and 20% are underweight (5). According to previous studies, the prevalence of growth failure in the third world countries is more than other regions of the world and in the majority of these countries the physical growth of infants and children is lower than the international standards. The result of a national survey conducted in Iran in 2008 suggests that 9.5% of children younger than 5 years old suffer from moderate or intense underweight. This study reported the prevalence of short stature and thinness to be 13.9% and 5.3%, respectively.

One of the effective methods for the identification, management and early diagnosis of growth failure, is periodical monitoring of length and weight and screening for their abnormalities. Growth curve is an effective and common instrument that can be easily used by healthcare employees for monitoring the child's sanitary and nutritional state. The main advantage of the growth curve is visual comparison between child's growth state and universal standards (such as CDC, WHO, and NCHS) (5-9).

In applying the growth curve, the trend and direction of the curve is of paramount importance such that four different conditions occur between the percentiles of 3 and 97. As for the first condition which is construed to be normal, the trend and direction of growth is ascending and parallel to the standard curve. In the second condition, growth curve trend is ascending and less steep in comparison with the standard curve which indicates slow growth. The third state is a flat curve, which is an indication of growth stagnation and the fourth case is descending which shows growth decline. The second to fourth conditions are considered abnormal and need immediate attention and intervention (9).

Given the decisive effect of time on the investigation of growth trend in children, longitudinal models can be effective instrument in examining the growth failure. One of the significant and distinctive features of the longitudinal studies setting them apart from other methods is repeated measurements for different variables during a time span leading to correlation between different observations. Accordingly, using common regression models, in which the independency of observations is presupposed, leads to skewed measures with low accuracy. To put it generally, three methods, namely transition model, marginal model, and random effects model, which take into account the correlation between observations, are used for longitudinal studies (10-12). The present study, using a marginal longitudinal model, aims at investigating length and weight growth trend in children under age two in Zanjan, Iran.

Methods

Data

The population of this longitudinal study included all children born from 2011-2013 in Zanjan, Iran who were at least two years old at the time of the study. Only children less than two years old who were referred to these centers for growth monitoring or vaccination at least 6 times and not having any congenital diseases or complications were analyzed. Finally, 3566 children were selected using two stage stratified random sampling method. First, we considered two strata (rural & urban) then in each of them, health center are considered as a stratum (sampling are conducted from all centers) and finally took random samples from each health center. To measure the weight of the child, a digital scale with an accuracy of 10 gr was used. More than 99% of deliveries took place in hospital and the weight and length of the children in 1, 3, 6, 9, 12, 18, 24 months was measured in health centers by an accuracy of 100 gr.

Data were gathered using researcher-designed form which consisted of the child's residence area (urban, rural), the child's age, child's gender, birth order (first, second, third, fourth and higher), the mothers' education (illiterate, primary/junior high school, high school/high school diploma and academic), mothers' occupation (housekeeper, employee), mothers' age (<20y, 2-34y, ≥35y), children's special health care (yes, no), gestational age and exclusive breastfeeding as the independent variables. Also, children's weight and length growth trends in comparison with the previous referral were considered as dependent variables. The weight and length growth trends are ordinal based on the NCHS standards for height and weight with four categories (7-9). For trends, code 4 shows a curve which is ascending curve and parallel to the NCHS standard growth curve, code 3 shows ascending and less steep curve than NCHS standard growth curve, code 2 shows flat curve and code 1 shows a descending curve. However, the length variable does not consist of code 1 as a descending trend. To guarantee the intra-observer reliability of the data, each growth curve was independently examined by three public health experts and if there was not agreement between their codifications, then the record under consideration was excluded from the study.

Ethical issues

Ethical issues including data fabrication, double publication, and plagiarism were considered and the health centers properly anonymized personal information therefore, no identifying information of participants (e.g., name, email address, video-recording, etc) were used. The study protocol was approved by the Ethics Committee of Tarbiat Modares University (Code: D52/d/3863).

Statistical Analysis

Descriptive statistics (frequency distribution and linear plot) were used to describe the data. Since the length and weight growth trends are qualitative ordinal and longitudinal variables, a marginal model was used to assess the factors affecting length and weight growth trends in children less than two years old. To estimate the parameters of the marginal model, the method of generalized estimating equations (GEE) were used. The analysis was performed using R software and significance level was considered as 0.05.

Results

In this longitudinal study which was conducted on 3566 children younger than 2 years old living in Zanjan, Iran, 59% (n=2111) of the children were lived in urban areas, 51% (n=1804) were male and 81.3% (n=2899) were of the birth order of

Table 1. The frequency distribution of background variables of children less than two years, living in Zanjan, Iran in 2014

Variable	Category	N	%
Residence area	Urban	2111	59.2
	Rural	1455	40.8
Children's gender	Male	1804	50.6
	Female	1762	49.4
Birth order	1	1312	36.8
	2	1587	44.5
	3	521	14.6
	≥4	146	4.1
Mothers' education	Illiterate	171	4.8
	Primary	906	25.4
	Secondary	838	23.5
	High school/high school diploma	838	23.5
	Academic	813	22.8
Mothers' occupation	Housekeeper	2921	81.9
	Employee	645	18.1
Mothers' age (year)	<20	401	11.2
	20-34	2878	80.7
	≥35	287	8.1
Children's special health care	Yes	1597	44.8
	No	1969	55.2

Table 2. The frequency distribution of weight growth trend of children less than 2 years old, living in Zanjan, Iran in 2014 by age range and gender

Gender	Weight Growth trend	Age range (month)						
		0-1	1-3	3-6	6-9	9-12	12-18	18-24
Male	Decline	14(0.4)*	3(0.1)	0(0)	44(1.2)	114(3.2)	36(1.0)	39(1.1)
	Stagnation	39(1.1)	3(0.1)	3(0.1)	108(3.0)	56(1.6)	14(0.4)	57(1.6)
	Slowness	810(22.7)	892(25.0)	1013(28.4)	1659(46.5)	1236(34.7)	314(8.8)	884(24.8)
	Desirable	2703(75.8)	2668(74.8)	2550(71.5)	1755(49.2)	2160(60.6)	3202(89.8)	2586(72.5)
Female	Decline	18(0.5)	3(0.1)	7(0.2)	32(0.9)	111(3.1)	18(0.5)	61(1.7)
	Stagnation	25(0.7)	0(0)	7(0.2)	57(1.6)	61(1.7)	36(1.0)	57(1.6)
	Slowness	342(9.6)	464(13.0)	1052(29.5)	1719(48.2)	1208(33.9)	1245(34.9)	877(24.6)
	Desirable	3181(89.2)	3099(86.9)	2500(70.1)	1758(49.3)	2186(61.3)	2267(63.6)	2571(72.1)
Total	Decline	18(0.5)	3(0.1)	3(0.1)	36(1.0)	114(3.2)	28(0.8)	50(1.4)
	Stagnation	32(0.9)	0(0)	3(0.1)	82(2.3)	57(1.6)	24(0.7)	57(1.6)
	Slowness	578(16.2)	681(19.1)	1035(29.0)	1690(47.4)	1223(34.3)	773(21.7)	881(24.7)
	Desirable	2938(82.4)	2882(80.8)	2525(70.8)	1758(49.3)	2172(60.9)	2741(76.9)	2578(72.3)

* N(%)

Table 3. The frequency distribution of the length growth trend of children less than two years old, living in Zanjan, Iran in 2014 by age range and gender

Gender	Growth trend	Child's Age (month)						
		0-1	1-3	3-6	6-9	9-12	12-18	18-24
Male	Stagnation	28(0.8)*	7(0.2)	3(0.1)	36(1.0)	68(1.9)	89(2.5)	36(1.0)
	Slowness	1347(37.8)	874(24.5)	668(18.8)	859(24.1)	1234(34.6)	1105(31.0)	1637(45.9)
	Desirable	2190(61.4)	2685(75.3)	2895(81.2)	2671(74.9)	2264(63.5)	2372(66.5)	1893(53.1)
Female	Stagnation	39(1.1)	0(0)	11(0.3)	25(0.7)	50(1.4)	39(1.1)	110(3.1)
	Slowness	620(17.4)	86(2.4)	681(19.1)	824(23.1)	1284(36.0)	1833(51.4)	1578(44.3)
	Desirable	2906(81.5)	3480(97.6)	2874(80.6)	2717(76.2)	2232(62.2)	1694(47.5)	1878(52.7)
Total	Stagnation	36(1.0)	3(0.1)	3(0.1)	32(0.9)	61(1.7)	64(1.8)	71(2.0)
	Slowness	988(27.7)	485(13.6)	678(19.0)	842(23.6)	1255(35.2)	1466(41.1)	1608(45.1)
	Desirable	2542(71.3)	3078(86.3)	2885(80.9)	2692(75.5)	2250(63.1)	2036(57.1)	1887(52.9)

* N (%)

one or two. Also, 23% (n=813) of the mothers had an academic degree and 18% (n=645) of them were employees. The mean±SD of gestational age was 38.6±1.26 weeks and mean±SD of exclusively breast fed was 5.7±0.69 months. The frequency distribution of the background variables is shown in Table 1.

Based on the results of Table 2, the prevalence of decline in the weight growth curve for children younger than 6 months was between 1 and 5 out of every 1000 children, while this was 10 and 32 out of every 1000 children with age of 6-24 months. Moreover, the highest prevalence of decline in the weight growth curve was between the ages of 9 and 12 months. The weight growth trend of children is shown in Table 2 by age and gender.

The prevalence of stagnation in the length growth curve for children younger than 6 months was 10 of 1000 children, while this prevalence decreased and varied between 9 and 20 out of 1000 children. The highest prevalence of stagnation in the length growth curve was observed between the ages of 18-24 months. The weight growth trend of children is shown in Table 3 by age and gender.

The results of the marginal model for the length growth trend (Table 4) suggested that the chance of a desirable weight growth trend could be reduced by 8% for a month increase in child's age (OR=0.92, 95% CI: 0.90-0.93, $p<0.001$). Also, the chance of a desirable weight growth trend could be increased by 11% for children whose live in urban area (OR=1.11, 95% CI: 1.05-1.16, $p<0.001$). Finally, the chance of a desirable weight growth trend could be increased by 20% for children whose mothers are employee (OR=1.20, 95% CI: 1.10-1.31, $p<0.001$).

In this study the main effects of the child's gender, the child's birth order, mothers' education, children's special healthcare and exclusively breast fed were not statistically significant on the weight growth trend of children less than two years old.

Table 4. Factors affecting the length growth trend of children younger than 2 living in Zanjan, Iran in 2014 using a marginal model (PA)

Variable	Category	OR (95% CI)	p
The child's age		0.92 (0.90-0.93)	<0.001
Residence area			<0.001
	Urban	1.11 (1.05-1.16)	<0.001
	Rural	Reference	-
The child's gender			0.848
	Male	Reference	-
	Female	0.99 (0.94-1.05)	0.848
Birth order			0.775
	1	1.03 (0.90-1.18)	0.639
	2	1.03 (0.90-1.19)	0.598
	3	1.07 (0.92-1.24)	0.355
	≥4	Reference	-
Mothers' education			0.294
	Illiterate	1.06 (0.92-1.22)	0.410
	Primary	0.99 (0.92-1.08)	0.940
	Secondary	1.08 (0.99-1.17)	0.084
	High school/high school diploma	1.0 (0.93-1.09)	0.900
	academic	Reference	-
Mothers' occupation			<0.001
	Housekeeper	Reference	-
	Employee	1.20 (1.10-1.31)	<0.001
Children's special health care			0.611
	Yes	0.01 (0.96-1.08)	0.611
	No	Reference	-
Exclusive breastfeeding	-	0.99 (0.96-1.04)	0.895
Gestational age	-	0.98 (0.95-0.99)	0.045

Table 5. Factors affecting the weight growth trend of children younger than 2 residing in Zanjan, Iran in 2014 using a marginal model (PA)

Variable	Category	OR (95% CI)	p
The child's age		0.79 (0.78-0.80)	<0.001
residence area			<0.001
	Urban	1.11(1.06-1.16)	<0.001
	Rural	Reference	-
The child's gender			<0.001
	Male	Reference	-
	Female	1.21 (1.15-1.27)	<0.001
Birth order			0.418
	1	0.93 (0.82-1.05)	0.276
	2	0.95 (0.83-1.07)	0.397
	3	0.99 (0.86-1.13)	0.849
	≥4	Reference	-
Mothers' education			<0.001
	Illiterate	1.24 (1.09-1.40)	0.001
	Primary	1.19 (1.10-1.29)	<0.001
	Secondary	1.16 (1.07-1.25)	<0.001
	High school/high school diploma	1.04 (0.96-1.21)	0.324
	Academic	Reference	-
Mothers' occupation			0.562
	Housekeeper	Reference	-
	Employee	1.02 (0.95-1.10)	0.561
Children's special health care			0.004
	Yes	0.92 (0.88-0.97)	0.004
	No	Reference	-
Exclusive breastfeeding	-	0.94 (0.91-0.98)	0.002
Gestational age	-	0.96 (0.94-0.98)	<0.001

The results of the marginal model for the weight growth trend (Table 5) suggested that the chance of a desirable length growth trend could be reduced by 21% for a month increase in child's age (OR=0.79, 95% CI: 0.78-0.80, p<0.001) and also, this chance could be increased by 11% for children who live in urban area (OR=1.11, 95% CI: 1.06-1.16, $p<0.001$). Moreover, the chance of a desirable weight growth trend could be increased by 24%, 19% and 16% for children whose mothers are illiterate, have primary and high school diploma compared with children whose mothers have academic degree, respectively ($p<0.001$).

Also, children's special healthcare ($p=0.004$), exclusively breast fed ($p=0.002$) and gestational age ($p<0.001$) had significant effects on length growth trend and the main effects of the child's birth order, mothers' occupation were not significant on the length growth trend of children less than two years old.

Discussion

The results of the present study showed that the prevalence of stagnation in the length growth curve was 8% and the highest stagnation prevalence rates occurred at the age range of 18-24 months from birth (20 out of 100 children) which was 31 and 10 out of 1000 children among boys and girls, respectively. Also, the prevalence of decline in the weight growth curve was 12% and the highest prevalence was reported at the age range of 9-12 months (32 out of 1000 children) which was 32 and 31 out of 1000 children among boys and girls, respectively. In addition, the results obtained from the longitudinal modeling indicated that the child's age, child's residence area and gestational age had a significant effect on the child's length and weight growth trends, while the child's gender, child's special healthcare and exclusively breast fed had only a significant effect on the length growth trend. Also, the mothers' education had only a significant effect on the weight growth trend and the child's birth order had no effect on any of the length and weight growth trends. Of course, it should be noted that, in the present study, instead of directly using the length and weight, the length and weight growth trends or slopes were utilized and this different selection of the dependent variables are caused the results of the present study to be rather different from similar studies. Also, Due to the large sample size in this research, p-values are not practically interpretable. So, researchers can make inferences based on the effect sizes.

In a national study carried out by Sheikholeslam et al in Iran, it was revealed that about 12.8% of the rural children under age 5 suffered from mild-to-moderate growth failure and 4.8% are stunted and 13.7% are underweight (13). In the present study, likewise, the city where children lived was regarded to be an effective factor on children's weight and length growth.

With regard to the effect of age and gender on child growth, the results of the present study are suggestive of a significant relationship between age and gender, on the one hand, and child growth trend, on the other hand. In this regard, the results of the study conducted by Heidari on urban children of different urban areas revealed that, in line with the results of the present study, the average weight of male infants was significantly more than the average weight of their female counterpart (14). Furthermore, some other studies have been carried out in other countries, which are indicative of the significant effect of age and gender on the growth of children under the age of 5 (15-17). Besides, in a research carried out by Fathipour on children below three years of age, the average weight of male children was more than their male counterpart; however, the observed difference was not statistically significant (4). Moreover, Steinbaker et al investigated the effect of diseases and nutrition factors on the growth of children aging 5 to 18 months. The results of their study revealed that the effect of age and gender variables is not significant; rather, children's nutrition plays a determinative role in the reduction of growth failure (18).

In the present study, parents' educational level is construed as a determinative factor on the length growth of children, such that as mothers' educational level increases, the level of weight loss in children under the age of 2 decreases. The result of the present study in this connection is in line with the results of Vahidi et al and Naderi and Ali's research (19-21). Although, in a study conducted by Vahabi et al, it was shown that mothers' educational level does not play a statistically significant role in the development of growth failure, it was revealed that, in general, it decreased the development of growth failure (3).

Stopping breastfeeding causes children to be deprived of proper, immunological, and nutritious food, of which in the literature is mentioned as an important factor of growth failure. The results of the present study suggest that exclusive breastfeeding is significant merely in the length growth of children under the age of 2 and did not have a significant effect on the weight of the children under investigation. However, it is worth mentioning that one of the indirect results of the present research showed significant effect of exclusive breastfeeding on the weight of the children below 6 months of age, compared with children who were not breastfed. Vahabi et al, Fold et al, and Kopra showed that stopping exclusive breastfeeding is one of the risky factors in child's weight loss, thus, if they do not receive supplementary food at the due time, it will have detrimental effect on their weight (3, 22-24). Birth order of children, which has been construed of as being one of the effective factors in the growth of children below 5 years of age, was proved not to have a significant effect on the trend of child's weight and length growth.

Given that it is better to use local growth reference centile for growth monitoring, conducting a similar study using the local growth indexes is recommended.

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