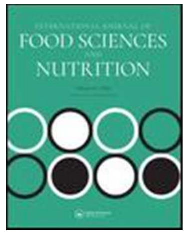

POOR EARLY GROWTH AND HIGH SALT INTAKE IN INDIAN INFANTS

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Keywords:	Salt, India, Growth, hypertension, Infants, Nutrition

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ABSTRACT

The influence of feeding patterns on the growth of infants and how salt is included in the diet are unknown in the area of West Bengal, India. A cross-sectional study was carried on 517 infants (median age 6.5 months). Negative Z-scores were observed for all anthropometric parameters. 72.7% of infants aged 0-6 months received exclusive breastfeeding. In the 6-12 month-old group (n=235), 91.5% had salt added to foods. In a regression model adjusted for age, a low salt diet resulted a significant factor in increasing weight-for-length and BMI-for-age z-scores, with increments equal to 0.637 SD (p=0.037) and 0.650 SD (p=0.036), respectively.

In West Bengal infants showing poor growth, breastfeeding was associated with better anthropometric indexes, but early in life salt is added to their diet. Early life low weight coupled with high salt intake may be a risk factor for arterial hypertension in Indian children.

INTRODUCTION

According to the World Health Organization, non-communicable chronic diseases, including hypertension and kidney disease, are the most relevant public health problems worldwide, also in developing countries (WHO/FAO, 2002). Recent studies from our group showed a high prevalence of hypertension within an Indian population living in West Bengal, both in adults (Gallieni et al. 2013) and children (Genovesi et al. 2011). The causes of these findings remain uncertain, considering that the association with increased body weight, even if significant, is rather modest. Further studies were therefore undertaken through a collaboration of two Italian Universities, the Indian non-governmental organization (NGO) Institute for Indian Mother and Child (IIMC), operating in West Bengal, and the Italian NGO Project for People (Gallieni et al. 2014). IIMC health workers follow and support pregnant women in district 24 of South Parganas, a rural/suburban area south of the city of Kolkata, which allowed us to recruit mothers for the present study.

The impact of early nutrition in regulating the expression of chronic degenerative disease later in life has been receiving increasing attention in the last decades (Agostoni et al. 2013). The incidence and outcomes of several metabolic diseases, such as hypertension and cardiovascular disorders, have been associated with birth weight, growth and feeding patterns in early childhood (Wu et al. 2009). In addition, low birth weight may be a marker of impaired nephrogenesis, which may be causally related to hypertension and chronic kidney disease (White et al. 2009). Epidemiological and clinical evidence indicates that salt intake is a key regulator of blood pressure in children (Cooper et al. 1980, Geleijnse et al. 1997). Strengthening the possible role of salt intake in infancy, several clinical studies (Whitten et al. 1980, Hofman et al. 1983, Pomeranz et al. 2002) and meta-analyses of controlled trials (He et al. 2006) established a clear beneficial effect of the reduction in salt intake on blood pressure in children.

The purpose of this cross-sectional study was to analyze the influence of feeding patterns, from lactation to weaning, on the growth of infants up to their first year of life. In addition, the timing of salt intake in their diets was also investigated. Such information could be useful in better understanding the possible link between salt intake in infants and the possible effects of this habit on the higher prevalence of hypertension in pediatric age observed in this geographic area (Gallieni et al. 2013, Genovesi et al. 2011).

METHODS

IIMC health care workers and international volunteers collected data on the health status of infants and mothers. We studied 517 babies from 11 centers of aforementioned area, from January to

March 2013. Their median age was 6.5 months (interquartile range = 3.1-9.2, range =1-12), and 48.6% were females babies. A team composed of doctors, nurses, health workers and international medical students participated in the screening procedures. Visits and measurements were carried out in IIMC owned medical ambulatory structures or schools, adapted as day-clinics (Figure 1). The children nutritional status was assessed by a dietary questionnaire, administered to mothers by experienced nutritionist at the time of children visit, and consisting of two parts. The first part related to children demographic data (name, surname, gender and date of birth). The second part related to two periods of child feeding: lactation and complementary feeding. Information about lactation concerned breastfeeding and its duration and the possible intake of other types of milk (cow's milk or formula). Information about introduction of complementary foods concerned type and time of introduction. Specific questions about adding further salt to food and “adult food” intake were also provided. Anthropometric characteristics of the sample were assessed by measuring length and weight with an infantometer and mobile digital scale (SECA, Vogel & Halke GmbH, Hamburg, Germany).

No formal evaluation and approval of the study protocol was obtained by an ethics committee, for the following reasons: the study was conducted in a very poor suburban/rural area in Kolkata suburbs as part of the regular volunteer activities of IIMC in support of poor mothers and children without access to medical care; IIMC is a NGO institution without an internal ethics committee; the study was observational and no drugs or diagnostic tests were administered to the studied subjects. Nevertheless, mothers gave their consent for the study participation and the study was conducted following the principles and guidelines in the World Medical Association (2000) Declaration of Helsinki on medical research involving human subjects (http://www.wma.net/en/30publications/10policies/b3/). No human subject included in this study can be identified via the paper; data were fully anonymized.

The study population was partitioned into 3 age groups: 0 (1day)-3 completed months, 3 (3 months + 1 day)- 6 completed months, 6 (6 months +1 day)-12 completed months. The impact on growth of exclusive breastfeeding versus not exclusive breastfeeding was evaluated in the first two age groups. Babies aged 6-12 completed months were analyzed to evaluate the impact of solid food introduction.

Raw anthropometric measures were processed by calculating the gender-specific z-score of length-for-age, weight-for-length, body mass index (BMI)-for-age, and weight-for-age, according to the World Health Organization charts (de Onis and Yip, 1996). Calculating z-score converts anthropometric measurements in the number of standard deviations the observed value is far from the expected median value in the reference population. Z-score values were subsequently categorized into <-3 standard deviations, within -3 and -2 standard deviations, within -2 and -1 standard deviations for the definition of poor growth (WHO, 2009) as follows:

- severe, moderate and mild stunting when based on length-for-age,
- severe, moderate and mild wasting when based on weight-for-length or BMI-for age.
- severe, moderate and mild under-weight when based on weight-for-age.

Statistical analysis

Anthropometric measures and z-score distributions were described graphically by box-plot graphs and by the summary measures mean, standard deviation, median and the 0.25 and 0.75 quantiles. Distributions were compared across age groups by F test and Bonferroni correction for post-hoc pairwise comparisons. Percentages of z-score <-3, within -3 and -2, within -2 and -1 standard deviations were represented graphically by bar-plot graphs. Percentages of z-score <-1, as overall percentages of poor growth, were compared across age groups by Chi-square test. The dependence between the z-score distributions and exclusive vs non exclusive breastfeeding, salt consumption vs non consumption, adult food consumption vs non consumption were investigated in regression models adjusted for age.

RESULTS

Table 1 describes anthropometrics characteristics according to age group, which are represented by box-plots in Figure 2. Length-for-age z-score showed, in all age groups, negative mean values with a mild, non-significant worsening trend over time. When considering standardized measures of weight with respect to the achieved length, namely weight-for-length z-score and the BMI-for-age z-score, negative mean values were observed in all age groups. For both, weight-for-length z-score and BMI-for-age z-score, there was a sensible difference across age groups with a tendency to improve growth from 0-3 months to 3-6 months. A subsequent flexion at 6-12 months was observed only for weight-for-length z-score. Negative averages were observed in all age groups for weight-for-age z-score.

Table 2 describes the percentages of severe, moderate and mild poor growth showing that about 50% of children aged 0-3 months showed poor growth for all parameters. For stunting (length-for-age z-score) and wasting (weight-for-length z-score) no significant differences were observed across age groups, whereas the percentage of moderate and severe BMI-for-age z-score alterations significantly decreased with increasing age. A similar trend was observed for under weight (weight-for-age z-score) from 0-3 months to 3-6 months. When considering only severe and moderate poor growth, the overall percentages were about 20% for all parameters with the exception of wasting (weight-for-length z-score), which was more modest.

The analysis of dietary habits showed that 72.7% of the 238 babies aged 0-6 months received exclusive breastfeeding, a further 25.2% received mixed feeding, and thus only 2.1% artificial feeding. When contrasting mixed breastfeeding versus exclusive breastfeeding a modest non-significant tendency to increase was observed for all parameters (i.e. observed averages for weight-for-length z-score were -0.69 and -0.62, p=0.676), even when adjusting for age.

Considering the 6-12 months group (n=235 babies), we observed that 91.5% (n=215 babies) had salt added to foods and the majority of them (n=209/215, 97.2%) started at six completed months. In a regression model adjusted for age, not having added salt resulted a significant factor in increasing weight-for-length z-score and BMI-for-age z-score, with increments equal to 0.637 SD (p=0.0373) and 0.650 SD (p=0.0360) respectively (Table 3). No significant relationships were observed for length-for-age z-score and weight-for-age z-score.

Among infants fed adult foods, most ingested “kitchuri”, consisting of rice, lentils, vegetables, chicken or fish with added salt, cornmeal, sugar and fried oil. The percentage of infants fed adult foods starting at 6 months of life was 79.2%. A regression model adjusted for age showed that infants not assuming adult food had higher weight-for-length and BMI-for-age z-scores, with increment equal to 0.560 SD (p= 0.0071) and 0.589 SD (p= 0.0051) (Table 4).

Further differences were not detectable in infants fed other types of solids, such as flour, biscuits, vegetables, fruits, meat and fish.

DISCUSSION

In this population, there was a high prevalence of malnutrition, in particular in the first three months of life, as suggested by anthropometric parameters. Unfortunately, the analysis could not be adjusted for infants’ birth weight since the delivery occurred at home where weighing the newborn is still an unusual practice. However, considering the rates of malnutrition observed in the youngest group, a high prevalence of low birth weight for gestational age may be hypothesized. A low intrauterine growth would lead to increased insulin resistance, according to Barker hypothesis, (Barker et al 2010). In addition, insulin increase is associated with higher blood pressure values also in children (Genovesi et al. 2012). We found a high percentage of breastfeeding mothers and the breastfeeding practice was associated with an improvement of all anthropometric indexes of infants, underscoring the importance of encouraging breastfeeding even in low income countries. The complementary feeding period shows some peculiar characteristics. A high percentage of infants have salt added to foods quite early. Salt intake starting in the pediatric age is associated to a high prevalence of arterial hypertension (Whitten et al. 1980, Hofman et al. 1983, Pomeranz et al. 2002, He et al. 2006, Strazzullo et al. 2012) and we speculate that this evidence could at least partly explain the high prevalence of hypertension observed in our previous investigations in the West Bengal region (Gallieni et al. 2013, Genovesi et al. 2011). Infants who received added salt showed also lower body weight measures standardized for height than those who did not. This association was observed even in those 6 to 12 month-old infants fed the kitchuri food. While the biologic plausibility of high salt intake and lower body weight is unclear, it has already been observed both experimentally (Coelho et al. 2006) and clinically in children (Stein et al. 2006), suggesting some hormone-mediated mechanisms. This unusual salt consumption coupled with early low weight conditions may contribute to the early development of arterial hypertension (Calkins et al. 2011). However, because the results of this study do not include a long term evaluation of blood pressure, the effects of increased salt intake during infancy on the prevalence of hypertension in Indian children remain hypothetical.

In conclusion, the nutritional pattern of West Bengal babies can be considered adequate only in the 0-6 months period, when exclusive breastfeeding is common. Breastfeeding practice prevents the development of infections and dysentery causing underweight or mortality, and is therefore particularly important. However, the complementary feeding period in this population ensues in a critical time, because the early intake of added salt and adult food may have a negative effect on growth and later health, if coupled with the major risk of unfavorable programming associated with intrauterine growth retardation (Keijzer et al. 2005). The results of this study may be used for informing mothers of the importance of continuing breastfeeding as well as retarding the introduction of salt in their babies' diet.

Geolocation information.

This study was undertaken in West Bengal, India

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Declaration of interests statement

The authors report no conflicts of interest.

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Table 1. Descriptive statistics of anthropometric characteristics (raw and z-score) according to age group

Continuous variable	0-3 months (n=124;24.0%)					3-6 months (n=131;25.3%)					6-12 months (n=262;50.7%)					
	mean	SD	median	q25	q75	mean	SD	median	q25	q75	mean	SD	median	q25	q75	p-value
Length (cm)	54.5	3.5	54.5	52.0	57.0	61.1	3.4	61.0	59.5	63.0	68.2	4.1	68.0	65.0	71.0	<0.0001
Weight (kg)	4.2	0.8	4.2	3.6	4.7	6.0	1.0	5.9	5.4	6.6	7.5	1.1	7.4	6.7	8.1	<0.0001
BMI (kg/m^2)	13,8	1.6	13.9	12.5	15.1	16.0	1.6	16.0	14.9	16.8	16.0	1.8	15.8	14.9	16.9	<0.0001
Length for age (z-score)	-1.01	1.43	-1.02	-1.89	-0.16	-1.09	1.38	-1.14	-1.86	-0.29	-1.32	1.43	-1.21	-2.09	-0.52	0.0864
Weight for length (z-score) * ^	-0.88	1.24	-0.97	-1.54	-0.11	-0.43	1.13	-0.31	-1.21	0.27	-0.71	1.28	-0.79	-1.44	0.05	0.0115
BMI for age (z-score)*	-1.32	1.13	-1.18	-1.89	-0.66	-0.72	1.16	-0.55	-1.39	-0.04	-0.73	1.29	-0.81	-1.47	0.01	<0.001
Weight for age (z-score)*	-1.17	1.27	-1.09	-1.88	-0.48	-0.81	1.23	-0.77	-1.28	-0.02	-0.90	1.14	-0.88	-1.67	-0.11	0.0474

0-3 months = from 1 day to 3 completed months, 3-6 months = from 3 months + 1 day to 6 completed months, 6-12 months = from 6 months + 1 day to 12 completed months, BMI = body mass index; SD=standard deviation; q25 = 0.25 quantile; q75 = 0.75 quantile; * = significant post-hoc comparison 0-3 months vs 3-6 months; ^ = significant post-hoc comparison 3-6 months vs 6-12 months.

Table 2. Growth status according to age group

Categorical variable	0-3 months (n=124;24.0%)						3-6 months (n=131;25.3%)						6-12 months (n=262;50.7%)						p value
	severe		moderate		mild		severe		moderate		mild		severe		moderate		mild		
	n	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	
Stunting (Length for age)	**6**	4.8	**20**	16.1	**38**	30.7	**8**	6.1	**20**	15.3	**39**	29.8	**30**	11.5	**40**	15.3	**75**	28.6	0.662
Wasting (Weight for length)	**2**	1.6	**4**	3.2	**40**	32.3	**1**	0.8	**6**	4.6	**31**	23.7	**6**	2.3	**14**	5.3	**72**	27.5	0.345
Wasting (BMI for age)*	**14**	11.3	**13**	10.5	**46**	37.1	**3**	2.3	**12**	9.2	**36**	27.5	**10**	3.8	**26**	9.9	**73**	27.9	0.002
Under weight (Weight for age)*	**11**	8.9	**16**	12.9	**43**	34.7	**6**	4.6	**13**	9.9	**28**	21.4	**10**	3.8	**35**	13.4	**73**	27.9	0.004

0-3 months = from 1 day to 3 completed months, 3-6 months = from 3 months + 1 day to 6 completed months, 6-12 months = from 6 months + 1 day to 12 completed months, severe = below -3 SD, moderate = between -3 and -2 SD, mild = between -2 and -1 SD, BMI = body mass index; SD=standard deviation; * = significant post-hoc comparison 0-3 months vs 3-6 months.

Table 3. Effect of salt consumption on growth indexes (model adjusted for age, n=235, 6-12 months)

Variable	**Intercept**				**Salt**				**Age (months)**			
	b	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*
Length for age (z-score)	-0.717	-1.718	0.284	0.162	0.271	-0.381	0.922	0.416	-0.087	-0.181	0.007	0.072
Weight for length (z-score)	-0.217	-1.133	0.699	0.643	-0.637	-1.232	-0.041	0.037	0.007	-0.079	0.093	0.872
BMI for age (z-score)	-0.710	-1.637	0.218	0.135	-0.650	-1.253	-0.046	0.036	0.060	-0.027	0.148	0.175
Weight for age (z-score)	-0.467	-1.263	0.329	0.251	-0.427	-0.945	0.091	0.107	-0.002	-0.077	0.073	0.958

310 Table 4. Effect of adult food consumption on growth indexes (model adjusted for age, n=235, 6-12 months).

Variable	**Intercept**				**Adult food**				**Age (months)**			
	b	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*
Length for age (z-score)	-0.757	-1.680	0.165	0.109	0.404	-0.038	0.846	0.075	-0.090	-0.183	0.003	0.059
Weight for length (z-score)	-0.342	-1.186	0.501	0.427	-0.560	-0.964	-0.156	0.007	0.006	-0.079	0.091	0.898
BMI for age (z-score)	-0.827	-1.681	0.026	0.058	-0.589	-0.998	-0.180	0.005	0.059	-0.027	0.145	0.177
Weight for age (z-score)	-0.649	-1.389	0.091	0.087	-0.202	-0.557	0.152	0.264	-0.007	-0.082	0.067	0.851

Figure legend

Figure 1. **A room of an elementary school from a remote village turned into a day-clinic for data collection.** On the front-left the infantometer used for measurements of babies. On the right a group of mothers.

Figure 2. Graphical representation of anthropometric characteristics (z-scores) according to age group. Boxplot explanation: upper horizontal line of box = 75th percentile; lower horizontal line of box = 25th percentile; horizontal bar within box = median, square within box = mean; vertical lines out of the box = minimum and maxim.

Table 1. Descriptive statistics of anthropometric characteristics (raw and z-score) according to age group

Continuous variable	**0-3 months (n=124;24.0%)**					**3-6 months (n=131;25.3%)**					**6-12 months (n=262;50.7%)**					
	mean	SD	**median**	q25	**q75**	**mean**	SD	**median**	q25	**q75**	**mean**	SD	**median**	q25	**q75**	p-value
Length (cm)	**54.5**	3.5	**54.5**	52.0	**57.0**	**61.1**	3.4	**61.0**	59.5	**63.0**	**68.2**	4.1	**68.0**	65.0	**71.0**	<0.0001
Weight (kg)	**4.2**	0.8	**4.2**	3.6	**4.7**	**6.0**	1.0	**5.9**	5.4	**6.6**	**7.5**	1.1	**7.4**	6.7	**8.1**	<0.0001
BMI (kg/m^2)	**13,8**	1.6	**13.9**	12.5	**15.1**	**16.0**	1.6	**16.0**	14.9	**16.8**	**16.0**	1.8	**15.8**	14.9	**16.9**	<0.0001
Length for age (z-score)	**-1.01**	1.43	**-1.02**	-1.89	-0.16	**-1.09**	1.38	**-1.14**	-1.86	**-0.29**	**-1.32**	1.43	**-1.21**	-2.09	**-0.52**	0.0864
Weight for length (z-score) * ^	**-0.88**	1.24	**-0.97**	-1.54	-0.11	**-0.43**	1.13	**-0.31**	-1.21	**0.27**	**-0.71**	1.28	**-0.79**	-1.44	**0.05**	0.0115
BMI for age (z-score)*	**-1.32**	1.13	**-1.18**	-1.89	-0.66	**-0.72**	1.16	**-0.55**	-1.39	**-0.04**	**-0.73**	1.29	**-0.81**	-1.47	**0.01**	<0.001
Weight for age (z-score)*	**-1.17**	1.27	**-1.09**	-1.88	-0.48	**-0.81**	1.23	**-0.77**	-1.28	**-0.02**	**-0.90**	1.14	**-0.88**	-1.67	**-0.11**	0.0474

0-3 months = from 1 day to 3 completed months, 3-6 months = from 3 months + 1 day to 6 completed months, 6-12 months = from 6 months + 1 day to 12 completed months, BMI = body mass index; SD=standard deviation; q25 = 0.25 quantile; q75 = 0.75 quantile; * = significant post-hoc comparison 0-3 months vs 3-6 months; ^ = significant post-hoc comparison 3-6 months vs 6-12 months.

Table 2. Growth status according to age group.

Categorical variable	*0-3 months (n=124;24.0%)*						*3-6 months (n=131;25.3%)*						*6-12 months (n=262;50.7%)*						*p value*
	severe		moderate		mild		severe		moderate		mild		severe		moderate		mild		
	n	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	
Stunting (Length for age)	**6**	4.8	**20**	16.1	**38**	30.7	**8**	6.1	**20**	15.3	**39**	29.8	**30**	11.5	**40**	15.3	**75**	28.6	0.662
Wasting (Weight for length)	**2**	1.6	**4**	3.2	**40**	32.3	**1**	0.8	**6**	4.6	**31**	23.7	**6**	2.3	**14**	5.3	**72**	27.5	0.345
Wasting (BMI for age)*	**14**	11.3	**13**	10.5	**46**	37.1	**3**	2.3	**12**	9.2	**36**	27.5	**10**	3.8	**26**	9.9	**73**	27.9	0.002
Under weight (Weight for age)*	**11**	8.9	**16**	12.9	**43**	34.7	**6**	4.6	**13**	9.9	**28**	21.4	**10**	3.8	**35**	13.4	**73**	27.9	0.004

0-3 months = from 1 day to 3 completed months, 3-6 months = from 3 months + 1 day to 6 completed months, 6-12 months = from 6 months + 1 day to 12 completed months, severe = below -3 SD, moderate = between -3 and -2 SD, mild = between -2 and -1 SD, BMI = body mass index; SD=standard deviation; * = significant post-hoc comparison 0-3 months vs 3-6 months.

Table 3. Effect of salt consumption on growth indexes(model adjusted for age, n=235, 6-12 months)

Variable	**Intercept**				**Salt**				**Age (months)**			
	b	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*
Length for age (z-score)	-0.717	-1.718	0.284	0.162	0.271	-0.381	0.922	0.416	-0.087	-0.181	0.007	0.072
Weight for length (z-score)	-0.217	-1.133	0.699	0.643	-0.637	-1.232	-0.041	0.037	0.007	-0.079	0.093	0.872
BMI for age (z-score)	-0.710	-1.637	0.218	0.135	-0.650	-1.253	-0.046	0.036	0.060	-0.027	0.148	0.175
Weight for age (z-score)	-0.467	-1.263	0.329	0.251	-0.427	-0.945	0.091	0.107	-0.002	-0.077	0.073	0.958

Table 4. Effect of adult food consumption on growth indexes. (model adjusted for age, n=235, 6-12 months).

Variable	**Intercept**				**Adult food**				**Age (months)**			
	b	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*	*b*	*(95% CI)*		*p-value*
Length for age (z-score)	-0.757	-1.680	0.165	0.109	0.404	-0.038	0.846	0.075	-0.090	-0.183	0.003	0.059
Weight for length (z-score)	-0.342	-1.186	0.501	0.427	-0.560	-0.964	-0.156	0.007	0.006	-0.079	0.091	0.898
BMI for age (z-score)	-0.827	-1.681	0.026	0.058	-0.589	-0.998	-0.180	0.005	0.059	-0.027	0.145	0.177
Weight for age (z-score)	-0.649	-1.389	0.091	0.087	-0.202	-0.557	0.152	0.264	-0.007	-0.082	0.067	0.851

Figure 1. A room of an elementary school from a remote village turned into a day-clinic for data collection. On the front-left the infantometer used for measurements of babies. On the right a group of mothers.
Figure 1
245x164mm (300 x 300 DPI)

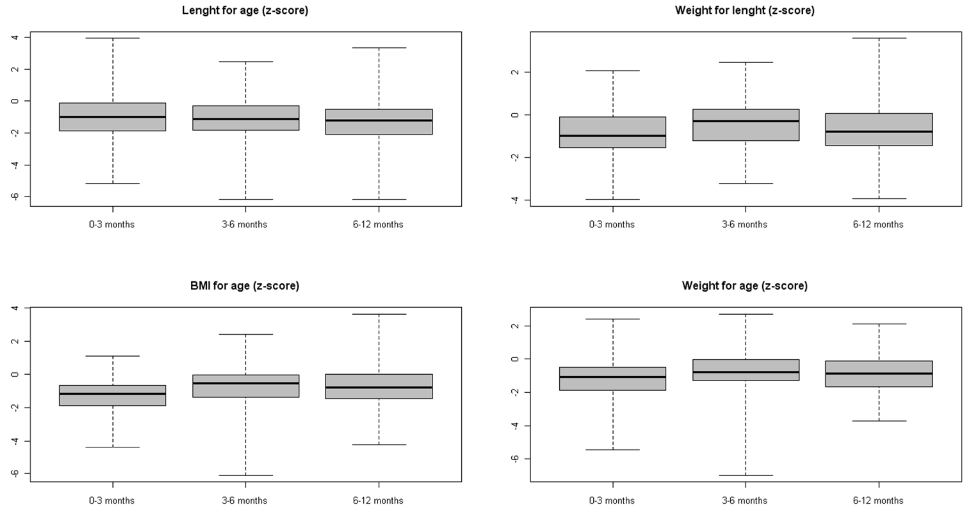

Figure 2. Graphical representation of anthropometric characteristics (z-scores) according to age group. Boxplot explanation: upper horizontal line of box = 75th percentile; lower horizontal line of box = 25th percentile; horizontal bar within box = median, square within box = mean; vertical lines out of the box = minimum and maxim.
Figure 2
508x281mm (72 x 72 DPI)