



ORIGINAL RESEARCH ARTICLE

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## GROWTH CHARTS AMONG A SELECTED SAMPLE OF LEBANESE INFANTS FROM BIRTH UNTIL 2 YEARS OF AGE: ASSOCIATION WITH BREASTFEEDING AND CHILD RANK IN THE FAMILY

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### ARTICLE INFO

#### Article History:

Received 19<sup>th</sup> August 2017  
Received in revised form  
22<sup>nd</sup> September, 2017  
Accepted 23<sup>rd</sup> October, 2017  
Published online 29<sup>th</sup> November, 2017

#### Key Words:

Growth, Development,  
Growth Charts,  
Infant,  
Lebanon, WHO.

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Citation: Titsiana Maria Samir Mahayri. 2017. "Growth charts among a selected sample of lebanese infants from birth until 2 years of age: association with breastfeeding and child rank in the family", *International Journal of Development Research*, 7, (11), 16750-16755.

## INTRODUCTION

Children's growth is an important marker of their well-being and their nutritional status, thus the monitoring of their development is crucial. Normal growth is defined as the progression of changes in weight, height and head circumference, it can reflect the overall health status of the child (Boom *et al.*, 2010). Poor growth is associated with short-term and long-term effects, including increased rates of infection in children (Ayatollahi *et al.*, 2015). Several factors can have a positive or negative effect on infant growth. Optimal growth can only be achieved when all the genetic, nutritional and environmental factors work in harmony (Delemarre-van de Waal, 1993). The main source of growth assessment includes growth charts, which cannot be applied to all countries due to cultural, economic, and genetic differences between them. Moreover, various studies have shown that the growth model is a function of time and space, that's why the charts have to be updated periodically as the corresponding data are modified over time (Heydari *et al.*, 2009).

In Lebanon, growth charts are used for the evaluation of infants' growth. However, doctors are often facing problems with identifying the appropriate growth curve for each child, as some of them are above or below the usual limits (outside the white zone, the area in which the child's growth is considered normal). This can lead to misinterpretation of the child's growth profile. Appropriate local measurement should be provided to monitor the growth of children in each region (Heydari *et al.*, 2009), because ethnic differences in body composition and size are evident between populations (Lee *et al.*, 2014; Natale & Rajagopalan, 2014). Growth even differs among populations and ethnic groups that live in close vicinity within the same geographic area (Hermanussen *et al.*, 2016). For example, mean heights and weights of African and European children were greater than those of Indian and Chinese children (Ashcroft *et al.*, 1976). Consequently, the recent trend is for many countries to produce their own local growth reference for use in their clinics, because pediatricians prefer the accuracy of their own locally produced references.

It is also useful for studies concerning the change in stature over generations (Karlberg *et al.*, 2007). Since many countries have created their own local growth charts (Ekhard *et al.*, 2010), it is important to develop national standards for the growth of children in each population (Al-Amoud *et al.*, 2004). The aim of this study is to develop specific growth charts for Lebanese children and to determine the influence of gender, breastfeeding duration and child's rank in the family on children's development and the corresponding growth charts.

## MATERIALS AND METHODS

### Population and Setting

This retrospective longitudinal study was conducted in Lebanon among 400 healthy Lebanese infants (197 boys and 207 girls), from birth until 2 years of age. Demographic information including gender, age, child rank, breastfeeding duration, weight and height were collected from the medical records of four pediatricians at their private clinics in Keserwan and Matn districts. Infant growth depends on several other factors, but only those aforementioned factors were present in the medical records. Weight and height at birth were documented in the records. Measurements were recorded at different target ages (birth, monthly from 1 to 8 months, 10 months, 12 months, 14 months, 16 months, 18 months, 20 months, 22 months, and 24 months). The four clinics adopt standardized protocols for anthropometric measurements, using a recumbent measuring board for the height and digital scale for the weight.

### Inclusion Criteria

Children must be from middle-class families, thus, the parent's annual income is between \$9,000 and \$15,000. They must be the product of an essentially normal birth, because there is an increased risk of the child contracting diseases during cesarean section delivery (Neu *et al.*, 2011), and the children must be healthy. Normal birth and the child's good health were confirmed from the medical records and after the review of the charts.

### Exclusion Criteria

Several exclusion criteria were noted. First of all, infants with very low birth weight (<1500 grams) were excluded from the study because their growth was obviously different from that of infants with higher birth weight (Majlesi *et al.*, 2001). Then, children from families with low socioeconomic status were excluded because their growth might have been negatively affected. Moreover, children from families with high socioeconomic status were also excluded because they are at risk of obesity (Zayed *et al.*, 2016). Additionally, twins and triplets were excluded because they have different growth trajectory (Chaudhari *et al.*, 1997). Finally, infants with perinatal morbidity or health conditions known to affect growth have been excluded.

### Statistical Analysis

All information was checked before entering the data on Microsoft Excel. A specific code for each piece of data was used.

The analysis of the data was carried out using the Statistical Package for Social Sciences software; SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc. Data were expressed as a percentage for all discrete variables and on average and standard deviation for continuous variables. The Independent Samples t Test was used for groups containing fewer than two variables; however, the ANOVA test was used for groups containing more than two variables to identify factors that may have some influence on the growth of children. The values were considered significant for  $p \leq 0.05$ . The graphs were realized on Microsoft Excel, using the maximum value, the minimum value and the average taken from SPSS.

## RESULTS

Overall, 400 Lebanese infants, 193 boys (48.3%) and 207 girls (51.8%), were recruited from the files of four pediatricians, after excluding 93 infants according to the exclusion criteria. The characteristics of the study population are summarized in Table 1. Approximately half of the women exclusively breastfed their children for three months (55.3% versus 12.8% who exclusively breastfed their children for 3 to 6 months and 7% who exclusively breastfed their children for a duration of more than 6 months). In addition, more than half of the children are firstborns, (68.5% versus 22.5% who represent the second child and 9% represent the third child). As shown in Table 1, the breastfeeding duration was considered in three categories: 3 months, from 3 to 6 months, more than 6 months, and child's rank categories in first child, second child, and third child. Gender has a highly significant effect on child growth ( $P = 0.000$ ), and since boys have higher weights and heights than girls, these differences in growth are totally expected (Table 2).

**Table 1. Demographic Characteristics of the Study Population (n=400)**

	Frequencies	Percentage (%)
Gender		
Boys	193	48.3
Girls	207	51.8
Breastfeeding Duration:		
3 months	221	55.2
From 3 to 6 months	51	12.8
More than 6 months	28	7
Missing	100	25
Rank		
First child	274	68.5
Second child	90	22.5
Third child	36	9

In addition, children's birth order had a significant effect on growth ( $P = 0.000$ ), since the weight and height differ between the first, second and the third child. Indeed, children born first have lower weights and heights than their brothers. Breastfeeding duration also affects infant growth in the following months ( $P = 0.000$ ). For example, children breastfed for more than six months have weights and heights greater than those that are breastfed for only three months (Table 3, 4 and 5). The growth charts for weight and height must be specific according to the gender of the children, so four curves have been established (Figures 1, 2, 3 and 4). These curves were established using the minimum, maximum and mean. The percentile method that eliminates the 5% of the extreme values was not used, since the exclusion criteria had already eliminated the extreme values.

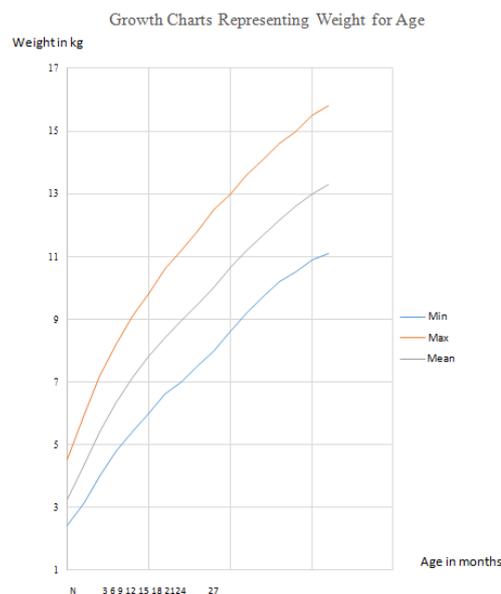
**Table 2: Mean of Weight and Height for Each Month According to Gender**

	Boys N = 193	Girls N = 207	P value Significant for: $p \leq 0.05$
Birth			0.000
Weight (kg)	3.2464	2.9837	
Height (cm)	50.0026	49.3565	
1 <sup>st</sup> month			0.000
Weight (kg)	4.2907	3.9889	
Height (cm)	53.5181	52.2995	
2 <sup>nd</sup> month			0.000
Weight (kg)	5.4129	5.0315	
Height (cm)	56.7552	55.3285	
3 <sup>rd</sup> month			0.000
Weight (kg)	6.3455	5.8527	
Height (cm)	59.9793	58.3454	
4 <sup>th</sup> month			0.000
Weight (kg)	7.1290	6.5440	
Height (cm)	62.6425	60.8720	
5 <sup>th</sup> month			0.000
Weight (kg)	7.8161	7.1973	
Height (cm)	65.2927	63.3841	
6 <sup>th</sup> month			0.000
Weight (kg)	8.4054	7.7444	
Height (cm)	67.4404	65.9155	
7 <sup>th</sup> month			0.000
Weight (kg)	8.9469	8.2361	
Height (cm)	69.4637	68.0435	
8 <sup>th</sup> month			0.000
Weight (kg)	9.4733	8.7696	
Height (cm)	71.5337	70.1159	
10 <sup>th</sup> month			0.000
Weight (kg)	10.0376	9.9087	
Height (cm)	73.8782	72.4010	
12 <sup>th</sup> month			0.000
Weight (kg)	10.6472	9.9087	
Height (cm)	76.3653	74.9029	
14 <sup>th</sup> month			0.000
Weight (kg)	11.1927	10.4312	
Height (cm)	78.6425	77.3043	
16 <sup>th</sup> month			0.000
Weight (kg)	11.6793	10.9217	
Height (cm)	80.8078	79.4227	
18 <sup>th</sup> month			0.000
Weight (kg)	12.1461	11.3700	
Height (cm)	82.9845	81.5109	
20 <sup>th</sup> month			0.000
Weight (kg)	12.5969	11.7917	
Height (cm)	84.8679	83.4662	
22 <sup>th</sup> month			0.000
Weight (kg)	12.9995	12.1874	
Height (cm)	86.6140	85.1304	
24 <sup>th</sup> month			0.000
Weight (kg)	13.4073	12.5377	
Height (cm)	88.5078	86.7314	

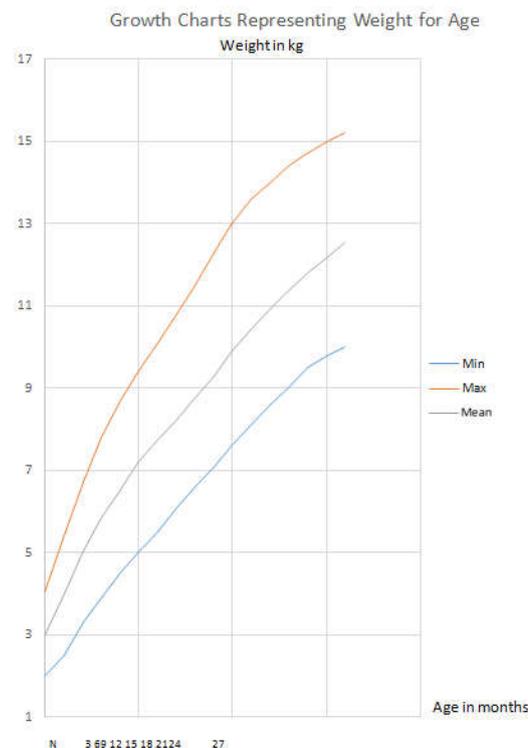
According to the graphs, we note that in the first months, infant growth is rapid, then with time, the speed of growth of weight and height decreases. It is also noted that the weight and height of the boys are greater than the weight and height of the girls, which was totally expected.

**DISCUSSION**

In this study, gender affected children’s growth. We note that boys have a higher weight and height than girls. This is in agreement with several studies, first, Hosseini *et al.*, 2014; Ayatollahi *et al.*, 2015; Ong *et al.*, 2002 and finally Lee *et al.*, 2015. The production of testosterone might be the cause of increasing growth rate of males (Smith *et al.*, 1976). In our study, the child rank in the family had a significant effect on growth. This finding is in line with some previous studies done by Hosseini *et al.*, 2014, showing that children born first may be smaller than their younger siblings. However, in the study done by Ong *et al.*, 2002, infants born first are smaller and thinner at birth, but show a catch-up, so that they compensate their early deficit, which leads to a risk of obesity.



**Figure 1. Weight-for-age, birth to 24 months Boys**



**Figure 2. Weight-for-age birth to 24 months Girls**

Finally, several studies show no significant effect of child’s rank on growth (Raum *et al.*, 2011, Ayatollahi *et al.*, 2015). Breastfeeding duration is a very important factor that positively influences infant’s growth. Breastfeeding is associated with better cognitive development in children, because of the composition of breast milk, the behavior of mothers with their child, the socio-cultural level, or because the contribution of all these factors at the same time. This effect is further enhanced by exclusive and prolonged breastfeeding. In addition, it is noted that exclusive and prolonged breastfeeding of 4 to 6 months is recommended for the prevention of a large number of diseases in children, more or less in the long term: otitis, gastrointestinal infections, intestinal diseases, atopic diseases, and cardiovascular diseases (Chantry *et al.*, 2015).

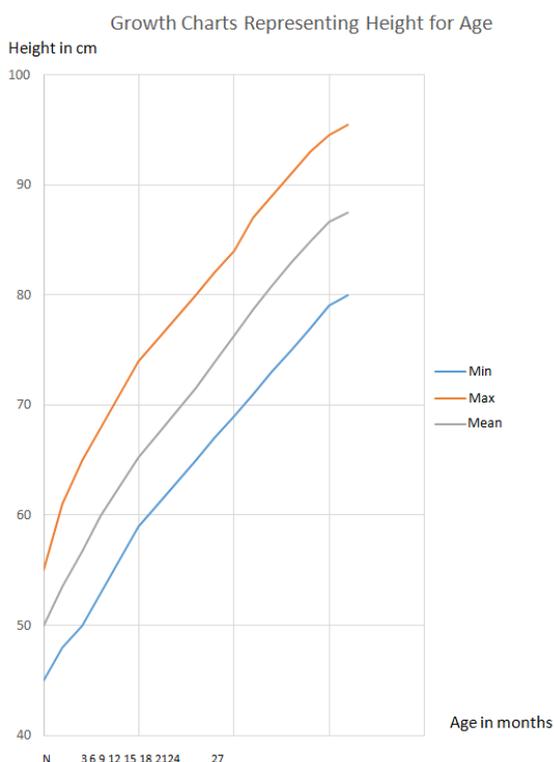


Figure 3. Height-for-age birth to 24 months Boys

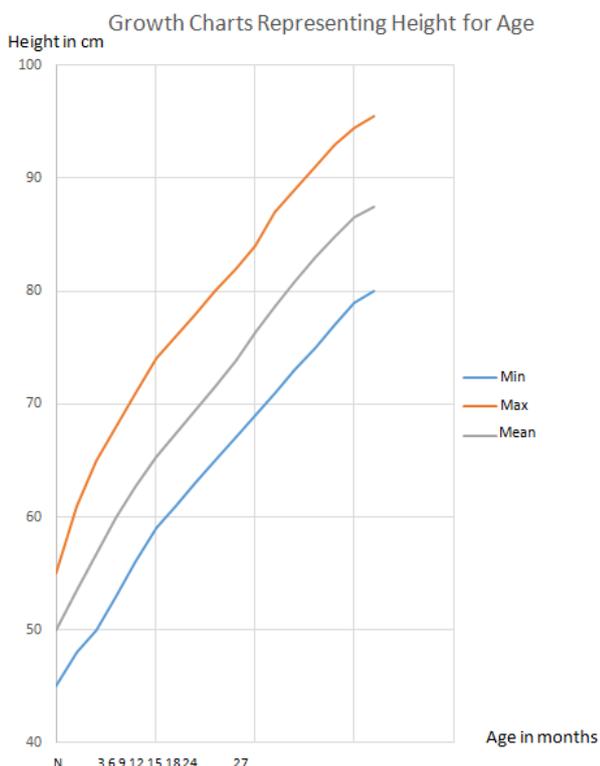


Figure 4. Height-for-age birth to 24 months Girls

In this study, breastfeeding duration affects children, for example infants who were breastfed for a longer duration had a higher weight and height. This finding is in line with several studies, first of all, Hosseini *et al.*, 2014; confirms that infants who are exclusively breastfed have a higher weight than others, up to 24 months. Thereafter, the other children have a higher mean weight.

This shows the dual role of breastfeeding: on the one hand it improves the growth of the infants during the first months of their life, and on the other hand it prevents obesity. Moreover, Chantry *et al.*, 2015 claims that exclusively breastfed infants have a higher weight than others. A reverse association between breastfeeding duration and the risk of obesity was revealed in a meta-analyses (Harder *et al.*, 2005). However, a non-significant relationship between breastfeeding duration and overweight was shown in the study of Vafa *et al.*, 2012. For this reason, the WHO recommends exclusive breastfeeding during the first six months before the introduction of complementary feeding. Then, comparing the growth charts of Lebanese children with those of American children, WHO 2006, we note that at birth the weights of Lebanese boys are between 2.5 kg and 4.5 kg which is roughly similar to that of American boys, weighing between 2.4 kg and 4.5 kg. After one year, the weights of Lebanese boys range from 7.4 kg to 11.9 kg, which is also similar to that of American boys, weighing between 7.6 kg and 12 kg. However, at two years old, the weights of Lebanese boys vary between 11.1 kg and 15.1 kg, which differs from those of American boys, weighing between 9.6 kg and 15.3 kg. Therefore, the two-year interval is larger in American boys, thus the weights of Lebanese boys remain within the normal and acceptable margin. As for girls, we note that at birth, the weights of Lebanese girls are between 2.3 kg and 4.2 kg, which is roughly similar to those of American girls, weighing between 2.4 kg and 4.4 kg. After one year, the weights of Lebanese girls vary between 6.8 kg and 11.4 kg, which is also similar to those of American girls, weighing between 7 kg and 11.4 kg. However, at two years old, the weights of Lebanese girls are between 10 kg and 15.1 kg, which differs slightly from those of American girls weighing between 9 kg and 14.8 kg.

As for height, it is noted that at birth the heights of the Lebanese boys are between 45 cm and 55 cm, which is approximately similar to those of the American boys, whose heights are between 46 cm and 54 cm. After one year, the heights of Lebanese boys vary between 66 cm and 80 cm, which differs somewhat from those of American boys whose heights vary between 71 cm and 81 cm. However, at two years old, the heights of Lebanese boys vary between 80 cm and 95 cm, which is similar to those of American boys, whose heights vary between 81 cm and 94 cm. In the case of girls, it should be noted that at birth the heights of Lebanese girls range from 44 cm to 53 cm, which is roughly similar to that of American girls whose heights range from 45 cm to 53 cm. After one year, the heights of the Lebanese girls vary between 63 cm and 77 cm, which is also similar to those of American girls, whose heights vary between 68 cm and 78 cm. Moreover, at two years old, the heights of the Lebanese girls are between 78 cm and 94 cm, which is similar to those of American girls, whose heights are between 80 cm and 93 cm.

Finally, it can be concluded that the growth of Lebanese children is similar to that of American children, so the WHO charts can be used to assess children's development in Lebanon and to detect anomalies and growth problems. Thus, the interpretation of the growth profile of the child will not be erroneous. The limitations of this study include the following: The sample is limited, with only 400 infants. Several important pieces of information were not available in the pediatrician's files. The sample may not be representative of the entire population.

**Table 3. Influence of Child Rank and Breastfeeding Duration on Child's Growth**

Weight (kg)	Mean	Lower bound	Upper bound	Std deviation	P value: Child's rank	P value: breastfeeding duration
BIRTH	3.1105	3.0596	3.1614	0.51757	0.004	0.193
1 <sup>ST</sup> MONTH	4.1346	4.0772	4.1919	0.58301	0.000	0.021
2 <sup>ND</sup> MONTH	5.2155	5.1494	5.2817	0.67309	0.000	0.000
3 <sup>RD</sup> MONTH	6.0905	6.0173	6.1636	0.74422	0.000	0.000
4 <sup>TH</sup> MONTH	6.8263	6.7472	6.9053	0.80381	0.000	0.000
5 <sup>TH</sup> MONTH	7.4959	7.4148	7.5769	0.82472	0.000	0.000
6 <sup>TH</sup> MONTH	8.0634	7.9772	8.1496	0.87683	0.000	0.000
7 <sup>TH</sup> MONTH	8.5791	8.4874	8.6708	.93287	0.000	0.000
8 <sup>TH</sup> MONTH	9.1091	9.0163	9.2020	.94450	0.000	0.000
10 <sup>TH</sup> MONTH	9.6559	9.5585	9.7532	.99012	0.000	0.000
12 <sup>TH</sup> MONTH	10.2650	10.1668	10.3632	.99951	0.000	0.000
14 <sup>TH</sup> MONTH	10.7986	10.6999	10.8973	1.00429	0.000	0.000
16 <sup>TH</sup> MONTH	11.2873	11.1871	11.3874	1.01922	0.000	0.000
18 <sup>TH</sup> MONTH	11.7445	11.6433	11.8457	1.02955	0.000	0.000
20 <sup>TH</sup> MONTH	12.1802	12.0745	12.2859	1.07494	0.000	0.000
22 <sup>TH</sup> MONTH	12.5793	12.4708	12.6877	1.10369	0.000	0.000
24 <sup>TH</sup> MONTH	12.9573	12.8489	13.0656	1.10220	0.000	0.000
Height (cm)	Mean	Lower bound	Upper bound	Std deviation	P value: Child's rank	P value: breastfeeding duration
BIRTH	49.6683	49.4582	49.8783	2.13655	0.000	0.001
1 <sup>ST</sup> MONTH	52.8875	52.6435	53.1315	2.48249	0.000	0.000
2 <sup>ND</sup> MONTH	56.0169	55.7386	56.2951	2.83073	0.000	0.000
3 <sup>RD</sup> MONTH	59.1338	58.8352	59.4323	3.03678	0.000	0.000
4 <sup>TH</sup> MONTH	61.7263	61.4220	62.0305	3.09510	0.000	0.000
5 <sup>TH</sup> MONTH	64.3050	63.9905	64.6195	3.19942	0.000	0.000
6 <sup>TH</sup> MONTH	66.6513	66.3438	66.9587	3.12785	0.000	0.000
7 <sup>TH</sup> MONTH	68.7288	68.4320	69.0255	3.01908	0.000	0.000
8 <sup>TH</sup> MONTH	70.8000	70.4962	71.1038	3.09053	0.000	0.000
10 <sup>TH</sup> MONTH	73.1138	72.7990	73.4285	3.20169	0.000	0.000
12 <sup>TH</sup> MONTH	75.6085	75.2864	75.9306	3.27632	0.000	0.000
14 <sup>TH</sup> MONTH	77.9500	77.6220	78.2780	3.33697	0.000	0.000
16 <sup>TH</sup> MONTH	80.0910	79.7653	80.4167	3.31366	0.000	0.000
18 <sup>TH</sup> MONTH	82.2219	81.8977	82.5461	3.29829	0.000	0.000
20 <sup>TH</sup> MONTH	84.1425	83.8215	84.4635	3.26613	0.000	0.000
22 <sup>TH</sup> MONTH	85.8463	85.5290	86.1635	3.22770	0.000	0.000
24 <sup>TH</sup> MONTH	87.5885	87.2757	87.9013	3.18232	0.000	0.000

**Table 4. Means for Weight and Height According to Child's Rank and Breastfeeding Duration for the First Month**

Variable	F	ERROR DF	P value
INTERCEPT	3945.577	253.000	0.000
GENDER	1.943	253.000	0.002
BOY			
GIRL			
RANK	3.189	254.000	0.000
1 <sup>ST</sup> CHILD			
2 <sup>ND</sup> CHILD			
3 <sup>RD</sup> CHILD			
BREASTFEEDING DURATION	1.258	254.000	0.005
3 MONTHS			
FROM 3 TO 6 MONTHS			
MORE THAN 6 MONTHS			
RANK*BREASTFEEDING DURATION	1.562	254.000	0.030
RANK*GENDER	2.404	254.000	0.000
BREASTFEEDING DURATION*GENDER	1.155	254.000	0.134

**Table 5. Influence of the Different Factors on Child's Growth**

Rank	Weight Mean (kg)	Height Mean (cm)
1 <sup>ST</sup> CHILD	4.0627	52.3802
2 <sup>ND</sup> CHILD	4.1883	53.7200
3 <sup>RD</sup> CHILD	4.5472	54.8182
Breastfeeding duration	WEIGHT MEAN (KG)	HEIGHT MEAN (CM)
3 MONTHS	4.0900	52.622
FROM 3 TO 6 MONTHS	4.2380	53.8922
MORE THAN 6 MONTHS	4.3896	54.1786

## Conclusion

Growth charts established specifically for the Lebanese population show a certain similarity with the WHO charts. However, the establishment of new charts specific for each nation is recommended. The factors influencing growth were child sex, birth order, and breastfeeding duration. Finally, further studies covering all the regions of Lebanon must be carried out to assess the growth of children and to ensure the accuracy of these results.

## Acknowledgement

This research was supported by the department of nutrition in the Lebanese University, faculty of Sciences II, Fanar. The author is grateful to the pediatricians who generously permitted the use of their data. Author's appreciation also goes to the staff of the dietetic department at Saint Georges Hospital for their contributions in checking the work and providing feedback. Finally the author would like to thank Dr. Antonios Dina for his assistance on this project and Ashley El-Jor for helping out in the proofreading of the manuscript.

## Ethical approval and consent to participate

Ethical approval was obtained from the pediatricians. The information was received in a depersonalized form. The data was collected and handled anonymously.

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