



Assessing Compatibility of Growth Indices of Exclusive Breast-feeding Infants to World Health Organization Growth Standards: A Regional Study in Urban Centers of Iran

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Abstract

Background: Breastfeeding as a normal way provides all the nutrients for infant's growth and development. World health organization (WHO) growth standards are definitely recommended for breastfed infants monitoring. We attempted to compare the growth of males and females exclusively breastfed infants founded on WHO standards and to assess whether the infant growth is consistent with the growth standard of WHO.

Methods: Data was roundup from two surveys, a clinic owned by a physician and four public health organization instructed from 2011-2016 containing 500 healthy infants exclusively breastfed, aged birth up to 6 months, in northeastern Iran, Mashhad.

Results: Growth criteria for male infants were significantly higher than females $P < 0.0001$. Founded on WHO standards, the growth was different between female and male infant's weight at 1-2 months $P = 0.034$. Moreover, height at birth and 5-6 months of age $P = 0.003$ and < 0.001 . Furthermore, newborns' head circumference $P = 0.003$, and 4-5 months of age, $P = 0.019$. There were no significant differences at the other months of age between growth indexes of males and females. Growth indexes in 70% of infants in these months of age were observed within normal range and similar to WHO standards, especially in male infants.

Conclusion: Growth indexes were similar to WHO standards. However, in Iran, these breastfed growth standards are not respected. Implementing WHO standards may have important implications for child health programs, which leads to monitoring of correct growth of breastfed infants and preserving exclusive breastfeeding with developing nutritional intervention program.

Keywords: Breastfeeding; Growth; World health organization; Standard; Infant

Introduction

Breast milk is an unequal way for providing nutrient food with high range of benefits for health, growth and immunity, in addition, development and lifelong benefits for both mothers and infants. Exclusive breastfeeding

(EBF) in the first six months of life contributes to protect the infants against infections, atopic problems as well as asthma(1, 2). Breastfeeding within the first hour of birth protects newborns from infections, reduces the risk of disease, such

as childhood acute leukemia, lymphoma, celiac disease, cardiorespiratory disease, sudden infant deaths syndrome. Breastfeeding for infants is also associated with higher intelligence quotient (IQ) (1, 3-7).

The positive impacts of breastfeeding on the health of mothers is associated with reductions the risk of breast, uterine, endometrial and ovarian cancers, type 2 diabetes, metabolic syndrome and rheumatoid arthritis (1,8-11). These benefits make us responsible to guide the nursing mothers to preserve breastfeeding and even encourage adoptive mothers to induce lactation (12, 13). Many physicians are worried about breastfed infants who are healthy babies but with low weight gains because they are not aware of the normal growth gain patterns of the breastfed infants and the difference between breastfeeding and formula feeding infants growth.

Healthy breastfed infants grow more rapidly during the first 2-3 months of age and less rapidly from 3 to 12 months than their formula-fed counterparts. Growth chart before 2006 still used, realized from infants data who were not EBF and they are not considered proper for breastfed infant's growth. Decreasing the growth rate on this chart is the cause of wrong result suggestion that the baby is not growing adequately and recommendation to supplement with formula, and sometimes stopping breastfeeding, which results in malnutrition in developing countries (14)

Selection a suitable growth curve based on the breastfed infant leads to proper interpretation of breastfed infant's growth and breast milk preserve. The pooled international samples were considered from different regions of six countries: Brazil, Ghana, India, Norway, Oman and the USA (California). The standard is the samples taken from the infants of six countries and the other infants are compared with the standard. In these charts, 100% of the reference population was fed breast milk for 12 months. In contrast, approximately 50% of the infants in the Centers for Disease Control (CDC) data had ever been fed by breast milk (15-17).

The purposes of this study were to evaluate and compare growth indexes between exclusively breastfed male and female infants based on WHO standards and determine if infants' growth follows WHO standards in the first six months of birth.

Materials and Methods

Patients and Study Design

This cohort study, included 500 healthy exclusively breastfed infants younger than 6 months old, born in 2011–2016, admitted to a private clinic and four public health centers and were followed in a north-eastern of Iran, Mashhad. Two stages of sampling were used. At the first stage, the infants who were considered as sample size in easy sampling from a private clinic were calculated by using the following specific formula: $n = \frac{Z_{1-\alpha/2}^2 * S^2}{d^2}$ and $Z_{1-\alpha/2} = 1.96$, $S = 510$ and

$d = 100$, and sample number were expected 99.92 (18). We considered 109 infants as sample size. In the second stage, four public health centers were selected by simple random sampling, which totally included 411 infants in easy sampling. The public health centers were different from these points: socially, economically and culturally.

Seven patients from the private clinic and thirteen patients from four public health centers rejected the study and a subset of 500 infants from reference population was screened for enrollment if they were healthy, exclusively breastfed infants, single birth with healthy mothers who had consumed similar and suitable nutrition during pregnancy and lactation which considered at least three meals a week, consumption of vitamins and iron supplements. The exclusion criteria for mothers and infants included: maternal smoking during pregnancy or lactation, specific disease in mother, lack of exclusive breastfeeding, persistence of any health or environmental constraints on growth, congenital or chronic diseases in infants, preterm, twin and multiple birth, the infant with intra uterine growth retardation (IUGR) and infant older than six months. Data collection form was prepared for the study.

The medical history and general health status of each participant was evaluated by a physician. Anthropometrics included weight, height (HT) and head circumference (HC) were measured by two medical students. The age was calculated from birth to visit dates. Data gathering tools included standard mechanical personal scale for infants (Seca-Germany), standard typical non-textile plastic tape (cm), Breastfed growth standard curves (WHO 2006) and questioner. Research instrument had acceptable validity and reliability. Standard mechanical personal scale for infants is a valid research instrument, that accuracy of which is as precise as 1 mg. Weighing started after sinker regulation. The device was repetitive checked for accuracy. A lot of care was taken to ensure the accuracy of the research and reliability tools. Researchers agreed on data collection and data analysis. The weight was measured with lightweight underwear at a similar medical scale. HT and HC were measured in supine position to the nearest mm, in duplicate (in case of a difference exceeding four mm between measurements, a third measurement was taken). Age and sex of infants, nutritional status of mothers during pregnancy and lactation and other variables were considered as well. The data was extracted from the files of infants and the relevant information was recorded in the questionnaires. Based on the WHO growth charts, 70% of the infants fell between 15 and 85%, considered as optimal growth. Present study evaluated EBF infant's growth indices and compared them with male and female infants' growth based on WHO standards. Moreover, in comparing infants under study based on WHO standards and their sex, it can be assessed what percent of breastfed infants were under the 3rd percentile or between 3 to 15th, 15 to 85th, 85 to 97th, and over 97th percentile. Infants were evaluated at birth, and at ages 1-2, 2-3, 4-5 and 5-6 months old.

Statistical Analysis

Data was analyzed by SPSS software (ver. 16, Chicago, IL, USA). The growth indices were analyzed and compared between male and female infants by using independent t-test. Growth indices were compared based on WHO standards between male and female infants by chi-square test. Statistical significance was considered at *P*-value less than 0.05.

Ethical approval

This study was conducted according to the guidelines of Helsinki, the Guidelines for the Ethical Conduct of Medical Research Involving Children, revised by the Royal College of Pediatrics and Child Health: Ethics Advisory Committee. We considered the Committee on Publication Ethics (COPE) guidelines as well. It is explained to all colleagues and parents about the study method. We received informed consent and moral acknowledgment from all parents. Ethical issues are entirely considered by the authors.

Results

The populations of study were 500 infants, 246 female and 254 males. The average age of mothers and fathers was 27.58 and 31.6 yr respectively. Most of the mothers (84.2%) had alike and suitable nutrition during pregnancy and breast-feeding by comparing growth indices in the first six months of life, between male or female infants by independent *t*-test, differences in variables between weight and two sexes were statistically significant, HT and HC were higher in male infants in comparison with those of females $P < 0.0001$. Average weight, HT and HC related to sex has been shown in Table 1. In comparing growth indices between male and female infants based on WHO growth standards by Chi-Square, there was significant difference between weight in male and female infants at 1-2 months of age, $P = 0.034$. There were no significant differences at birth, 2-3, 4-5 and 5-6 months old, $P = 0.17, 0.62, 0.36$ and 0.13 respectively (Table 2).

Table 1: Comparing growth indices between male and female exclusive breastfed infants from birth to 6 months of age

<i>Age</i>	<i>Variable</i>	<i>Sex</i>	<i>Mean</i>	<i>SD</i>	<i>P value</i>
At birth	Weight (gr)	Male	3338.5	443.2	0.003
		Female	3215.4	467.1	
	Height (cm)	Male	50.5	2.1	0.004
		Female	49.9	2.5	
1-2 months	Head circumference (cm)	Male	35.3	1.6	0.002
		Female	34.8	1.9	
	Weight (gr)	Male	4913.3	774.6	<0.001
		Female	4652.7	721.5	
	Height (cm)	Male	55.6	2.7	0.002
		Female	54.8	2.5	
2-3 months	Head circumference (cm)	Male	38.1	1.5	<0.001
		Female	37.4	2.1	
	Weight (gr)	Male	5867.2	747.7	<0.001
		Female	5519.3	737.7	
	Height (cm)	Male	59	2.7	0.003
		Female	58.2	3.2	
4-5 months	Head circumference (cm)	Male	39.8	1.4	<0.001
		Female	38.8	1.5	
	Weight (gr)	Male	7203.4	785.7	<0.001
		Female	6741.1	859.9	
	Height (cm)	Male	64	2.5	<0.001
		Female	62.8	2.8	
5-6 months	Head circumference (cm)	Male	42	1.3	<0.001
		Female	40.9	1.3	
	Weight (gr)	Male	8035.6	863.1	<0.001
		Female	7582.3	977.4	
	Height (cm)	Male	67.4	2.6	<0.001
		Female	66.3	2.8	
Head circumference (cm)	Male	43.5	1.3	<0.001	
	Female	42.5	1.4		

There were significant differences between HT in male and female infants at birth and 5-6 months of age, $P=0.003$ and <0.001 respectively. However, there were no significant differences at 1-2, 2-3 and 4-5 months old, $P=0.09$, 0.05 , and 0.13 , respectively (Table 2).

There were meaningful differences between HC in male and female infants at birth and 4-5 months of age, $P=0.003$ and 0.019 respectively, without significant differences at the other months of age, 1-2, 2-3 and 5-6 months old, $P=0.32$, 0.57 , and 0.55 respectively (Table 2). The study also reported that growth indices in most of the months of age in nearly 70% of infants fell within the WHO normal range (between 15 to 85th), similar to the WHO standards, in six-

month-old male and female infants or younger, especially in male infants.

Discussion

The growth of children is the most important indicator of child health and society's well-being. Growth references are the best guideline for growth monitoring and are important part of childcare to improve child health and nutrition. The evaluation of child growth pathways and the interventional charts on improving child health are dependent on the different types of growth charts. It is important to know the methods of growth interpretation which are dependent on growth parameters (19-21). Selection of a suitable

growth chart designed based on the healthy breastfed infant leads to proper assessment of breastfed infant's growth. Various studies had been conducted in different regions of the world to evaluate the performance of WHO breastfed standards in breastfed infants' growth. In present study, approximately 70% of infants fell within

the WHO normal range (between 15 to 85th), alike the WHO standards. Present study recommended that the growth indices of EBF infants based on the WHO growth standards appear suitable for optimum growth during the first six months of life. Like other alike studies (14, 17).

Table 2: Comparison infants' growth indices between male and female breastfed infants based on WHO growth standards

Age	Variable	Sex	<3percentage N (%)	3-15 per- centage N (%)	16-85 per- centage N (%)	86-97 per- centage N (%)	>97 per- centage N (%)	P value
At birth	Weight(gr)	Male	6 (2.4)	27 (10.6)	201(79.1)	17 (6.7)	3 (1.2)	0.179
		Female	9 (3.7)	30(12.2)	177(72.0)	29(11.8)	1 (0.4)	
	Height(cm)	Male	3 (1.2)	10 (3.9)	211(83.1)	19(7.5)	11(4.3)	0.003
		Female	9 (3.7)	12(4.9)	169(68.7)	38(15.4)	18(7.3)	
	Head circumfer- ence(cm)	Male	2 (0.8)	5 (2)	154(60.6)	57(22.4)	36(14.2)	0.003
		Female	7 (2.8)	15 (6.1)	142(57.7)	52(21.1)	30(12.2)	
1-2 months	Weight	Male	13(5.1)	28(11.4)	171(67.3)	27(10.6)	15(5.9)	0.034
		Female	8 (3.3)	18 (7.3)	155(63)	49(19.9)	16 (6.5)	
	Height	Male	14(5.5)	42(16.5)	159(62.6)	23(9.1)	16 (6.3)	0.09
		Female	8 (3.3)	30(12.2)	149(60.6)	37(15)	22 (8.9)	
	Head circumfer- ence	Male	10(3.5)	31(12.2)	173(68.1)	29(11.2)	11(4.3)	0.325
		Female	17(6.9)	38(15.4)	148(60.2)	33 13.4)	10 (4.1)	
Weight	Male	14 (5.5)	25(9.8)	187(73.6)	21(8.3)	7(2.7)	0.626	
	Female	9 (3.7)	22 (8.9)	179(72.8)	29(11.8)	7 (2.8)		
2-3 months	Height	Male	27 (10.6)	40(15.8)	162(63.8)	14(5.5)	11(4.3)	0.058
		Female	19 (7.7)	43(17.5)	142(57.7)	31(12.6)	11(4.5)	
	Head circumfer- ence	Male	16 (6.3)	31(12.2)	165(65.0)	28(11.0)	14(5.5)	0.575
		Female	11(4.5)	35(14.2)	169(68.7)	22 (8.9)	9 (3.7)	
	Weight	Male	12 (4.7)	32(12.6)	185(72.8)	20(7.9)	5(2.0)	0.365
		Female	8 (3.3)	24 (9.8)	186(75.6)	17 (6.9)	11 (4.5)	
4-5 months	Height	Male	25(9.8)	46(18.1)	161(63.4)	17(6.7)	5(2.0)	0.134
		Female	12 (4.9)	38(15.4)	165(67.1)	22(8.9)	9 (3.7)	
	Head circumfer- ence	Male	12(4.7)	19(7.5)	203(79.9)	13(5.1)	7(2.8)	0.019
		Female	13(5.3)	26 10.6)	168(68.3)	31(12.6)	8 (3.3)	
	Weight	Male	3 (1.2)	18(7.1)	175(68.9)	51(20.1)	7(2.8)	0.131
		Female	3(1.2)	16 (6.5)	161(65.4)	46(18.7)	20(8.2)	
5-6 months	Height	Male	9(3.5)	20(7.9)	173(68.1)	23(9.1)	29(11.4)	<0.001
		Female	5(2.0)	14 (5.7)	140(56.9)	57(23.2)	30(12.2)	
	Head circumfer- ence	Male	5 (2.0)	16 (6.3)	174(68.5)	41(16.1)	18(7.1)	0.551
		Female	3(1.2)	10 (4.1)	167(67.9)	41(16.7)	25(10.2)	

We showed a slower rate of weight and length gain by age increasing in males and females. A prospective study in Nigeria carried out to determine the growth pattern of EBF infants in the first 6 months of life and compare them to the National Centre for Health Statistics (NCHS) and WHO reference. The growth in weight, length

and circumference of EBF infants were sufficient for the first six months of life (22). In a longitudinal study of infants who received primary care at a public institution (EBF Stimulation Program, PROAME) in Belem, Brazil, the growth of 102 EBF infants aged from birth to six months were assessed and compared to the NCHS curve. The

mean weight was higher than the 50th percentage of the NCHS growth standard at six months that confirms the benefits of breastfeeding (23). In a comparable study included 500 healthy exclusively breastfed infants in Iran, their growth indices were compared to NCHS growth standards to evaluate efficacy of EBF. The average growth criteria was significantly over the alike percentile in NCHS growth standard at males and females. (18). In a longitudinal study, 73 Canadian infants from birth to 18 months of age were compared to infant's weight, length, and BMI scores with the WHO standards. Breastfed infant's growth was consistent with the WHO standard but formula-feds had a higher weight curve than that of the age (24). In present study, growth indices were alike to the WHO standards.

In Flanders, growth of breastfed infants was identical to the WHO standards for length, but not for weight, BMI and HC, and the use of the local growth reference is advised for both breastfed and formula-fed children (25). In comparing WHO and NCHS Growth Standards, the WHO standards provide a better instrument for monitoring the rapid and changing rate of growth in early infancy (26). Comparisons of the WHO standards and national references, in Japanese breastfed infants for both length and body weight indicated that breastfed infants were significantly shorter and lighter.

Unlike, HC were meaningful larger at 1 and 6 months and 6 months of age in boys and girls, respectively. No significant differences were seen between national references and WHO growth standards (27).

In a uniform research growth of Czech breastfed children differs from the current national references but the nonconformity was smaller compared to the WHO charts. The WHO standard in the Czech Republic is not advocated (28). The growth pattern of the breastfed children more closely followed the WHO standards than it did the NCHS reference (29).

The Indonesian children's growth rate does not appear correctly with WHO standards and may overestimate them as the children with insufficient weight and length (30).

The differences between the means of HC for children belonging to racial or national groups were so large that it would have been possible that using the WHO charts wrongly placed many children in the microcephaly or macrocephaly groups (31).

Another similar study shows that WHO standards describe normal growth, regardless of ethnicity, economic, social situation and nutrition type (32). In comparing the growth of Belgian and Norwegian children with the WHO standards, there were meaningful aberrations in dimension of children outside normal limits of the WHO standards including those who were exclusively breastfed. These findings recommends the use of national references in Belgium and Norway, for breastfed children (33).

In another study, assessment was performed using growth charts that were compatible with CDC and Prevention (CDC/2000), National Center for the Health Statistics (NCHS /1977), and WHO/2006. Of the 3 charts listed, WHO charts seems to be more useful for screening children's nutrition. WHO charts provided an opportunity to check the number of malnourished children or those who are at risk of malnourishing (34). Pakistan needs to update WHO growth standards to assess nutritional deficiencies and at the same time, with the training of health workers, new growth charts should be introduced (35). Shorter measurement intervals in the WHO standards results in a better instrument for monitoring the rapid and changing rate of growth (15). To evaluate underweight and stunted children in Gabon by using and comparing WHO, CDC and NCHS growth standards, the dimension of underweight and stunted children were highest with the WHO growth standards compared to CDC and NCHS standards (36).

Growth is influenced by various factors including diet, genetics, and environment. Therefore, growth indices in every area may have disparate international growth standards. In Feb 2012, the American Academy of Pediatrics (AAP) recommended WHO growth standards for infant growth monitoring to avoid inappropriate infants as underweight or failing to thrive. The CDC

recommends the WHO growth charts for 0-24 month children and exclusively breastfed infants. The CDC growth charts should be used for growth evaluation of age 2-19 yr old because the charts extend up to age 20 yr, whereas the WHO standards are recommended for children aged birth to 59 months (14, 17).

In Iran and many other countries, CDC growth charts are used for breastfed infants' growth monitoring. About half of the infants in the CDC performing chart had ever been breastfed but 100% of the infants in the WHO data set had been breastfed. Selection of a suitable growth curve designed based on the healthy breastfed infants leads to proper explanation of breastfed infants' growth. In present study, growth indices were similar to the WHO standards. As there is no regional or national growth standard released for breastfed infants in Iran, using the WHO growth charts would result in correct evaluation of breastfed infants' growth and would have an important concept for evaluation of lactation execution. This growth standard is a reminder and recommendation of breastfeeding necessity, which leads to correct monitoring and preserving exclusive breastfeeding, developing nutritional intervention policy for child health programs, as well as acting on AAP and CDC avocation. Our research also should be supported by similar studies in Iran.

Our limitation in this study was lack of cooperation for some parents and health workers. In some public health centers, although there were accompanied by an introductory letter from the central health center.

Conclusion

As there is no national growth standard released for breastfed infants in Iran, using growth charts of breastfed infants (WHO standards) would result in correct evaluation of breastfeeding pattern.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission,

redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors announce oneself that, "this study received no specific grant and no conflicts of interest".

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