Maternal Dietary Pattern with an Emphasis on Child Growth Pattern and Exclusive Breastfeeding Duration

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ABSTRACT

Background: maternal nutrition and breast milk nutrient concentration are associated with infant's growth. Enhanced knowledge encourages mothers to breast feed for the sake of optimizing growth and development.
Methods: the current study was performed longitudinally in some rural areas, south of Iran, from birth to six months. Out of 319 candidates with serial anthropometric measurements of an infant, including weight, height, and head circumference at four times (birth, two, four, and six months), 195 were included in the multivariate regression model (total measurements, n=776) to construct the pattern of growth. Then, information regarding demographic background, lactation status and infant supplementation intake status, feeding practices, maternal anthropometric measurements, and food frequency questionnaire were collected from mothers and their children during six months in two rural health centers.
Results: The most important association between dietary factors and infant anthropometrics (weight, height, and head circumference) involved Factor2 vegetables, including leafy vegetables, tomato, onion and garlic, (weight β=0.35 95%CI 0.27 - 0.44, length β=3.82 95%CI 3.42 - 4.22, head circumference β=2.55 95%CI 2.32 - 2.79) and Factor1 fruit, including orange, kiwi, cherries, watermelon, date, and grapes) (weight β=0.117 95%CI 0.04-0.189, length β=0.59 95%CI 0.257-0.929, head circumference β=0.307 95% CI 0.108-0.507), respectively. Generalized Estimation Equation model revealed that Factor2 dairy (including low fat milk, yogurt and dough) significantly contributed to weight growth velocity (β=-0.009 95% CI -0.016 - 0.001).
Conclusion: a dietary habit of fruit and vegetables, which are rich in bioactive components by breast feed mother showed better growth for infants. As growth is multifactorial, maternal nutrition and breastfeeding duration is a simple modifiable factor which can affect the subsequent growth and development of the child during the first six months.

Key words: exclusive breastfeeding, growth, anthropometric measures, maternal nutrition, and multivariate multiple regression.

INTRODUCTION

Early postnatal growth is a physiological process for optimum survival with long-term effects.

Exclusive breastfeeding in the first six months of life is assumed as the most appropriate type of feeding for infants [1]. Additionally, human milk is identified as the important protective source of nutrients and bioactive compounds such as immune cells, growth factors, and hormones for promoting the infant growth and body composition [2]. Epidemiological studies have revealed that early food environments in the uterus or during lactation, beyond the benefits of breastfeeding and duration [3], are likely to have an impact on later infant food preferences through repeated exposure in early life [4]. Infancy is a period of rapid growth; meanwhile human milk is a complex fluid which has the potential to positively impact infant's and his or her mother's health. The macronutrient [5] and micronutrient [6] content of human milk is associated with maternal habitual dietary intake. Studies suggest that maternal dietary habits are related to breast milk composition. The impact of maternal dietary habits can be seen for a variety of dietary components [7-10]. So, a diet is a modifiable key to internalize adequate dietary changes to correct deficiencies and to improve the nutritional quality of breast milk. Previous studies have revealed that adherence to a healthy, full dietary pattern is associated with a long-life effect [11]. Thus, highlighting the need to determine dietary patterns as a broad approach to capture cumulative effects [12] and assuming that food pattern without intervention continually, we monitor the next period of 1000 days which is considered as a critical time. Also, it is known that poor breast milk quality and maternal nutrient depletion are substantially associated with growth. Finally, it is of interest to see whether maternal dietary pattern during lactation makes differences in infant growth pattern with effects of type of feeding.

METHOD

Sample design

The present study was undertaken in some rural areas, south of Iran on mother-children who came from different small villages to the two main health centers for their baby growth monitoring from June to October 2015. Initially, participating mothers (319 candidates) were informed and included in the study and gave verbal consent. Data from 195 pair of mother-children were finally accounted based on the serial measurements of weight, height, and head circumference (n=776) from birth to six months, as well as a maternal type of feeding practice and regularity of supplement use. On the other hand, those with multiple children, any clinical diagnosis of chronic disease (mother/child), growth delay, and low birth weight were excluded.

At the first visit, research assistants randomly selected the maternal - child documents and by a phone call, made an appointment to invite them into the study, and obtained written informed consent from all participants. Next, they made the next appointment to measure maternal anthropometric and dietary data. The serial weight, height, and head circumference measurements were collected from an offspring's health document in rural health centers while maternal anthropometric measurements were completed in the health center. Completion of dietary questionnaire for some of the subjects who had difficulty to come the health center was done by direct home visit. The questionnaire regarding socio-economic status, maternal anthropometric, maternal lactation practice and child anthropometric traits (0-6 months), along with type of child feeding and maternal dietary assessment were obtained by related documents and food frequency questionnaire, respectively.

Analysis

Exploratory factor analysis with principal component extraction and the varimax rotation method was used to reduce the large volume of information (food items) to extract the factors constituting distinct dietary patterns. Factor score was estimated as a sum of the daily frequency of consumption of each food group multiplied by the loading score for the food group. Food groups with a factor loading above 0.40 were accounted as contributors to each factor and were used to determine the dietary pattern. In this regard, the PCA method was used for different food items means; 9 different cereal-grain and pulses reduced to 3 factors, with Table 1 presenting the factors and loading scores in detail. Finally, 17 factors were identified and established the association between food factors and infant biometrical parameters.

Anthropometric measurements of infant growth, including weight, height, and head circumference were performed by multivariate multiple regression where a significant prediction was made by a different maternal food pattern.

To assess the association between longitudinal infant biometric parameters and maternal food intake variables, we ran the multivariate multiple regression (MMR) models and estimated β coefficient with their 95% CIs.

The MMR model is an extension of the univariate version of multiple regression models. This model, the covariance structure of the responses, means biometric growth of infant measures, is included in the model and the coefficients of the covariate in the model are estimated by considering the correlation structures of the responses. However, in univariate regression model, the covariance structure of the response variables is not considered in the model.

In model I, we evaluated the role of some dietary factors including factor1 and factor2. Oil, factor1 and factor2 fruit, factor1 and factor2 vegetables, factor1 and factor2 sugar on infant weight, height, and head circumference (0-6 months). Then, we assessed the potential role of dietary factors in model II including factor1, factor2, and factor3 Cereal, factor1 and factor2 meat, and factor1 and factor2 dairies on infant parameters (zero-six month).

Lastly, generalized equation estimation (GEE) model was fitted to construct the association between dietary exposure and growth velocity. In this model, the dependent variable was collected over time as longitudinal data; thus, it violated the independence assumption which was necessary for linear regression. Therefore, GEE model was fitted as an appropriate model for longitudinal data. In this model, we considered the structure of correlation among longitudinal data through the versatile correlation matrix such as autoregression used in our model.

The fitted model was assessed using the Akaikes information criterion (AIC) to obtain the best model under autoregressive correlation matrix from among longitudinal data. To present the effect of education and income status on the type of infant feeding and maternal dietary pattern, ANOVA, Welch, and the independent T student test were utilized.

RESULTS

The mean maternal age was 27 years old. The gestational age at delivery was between 37 and 42 weeks. The majority of them had a normal delivery. The number of subjects at each stage (birth=120,2nd month=109,4th month=120 and 6th month=120).

The mean weight at birth, as well as two, four, and, six months postnatal was 3.2, 5.3, 6.7, and 7.7 kg, respectively. The majority of mothers did the breast feeding during first six months. The average maternal body mass index (BMI) and Waist/Hip ratio was 25.11 and 0.92, respectively. More than 40% of the mothers had a higher educational level. The proportion of infant feeding status had a similar pattern at a different level of maternal educational status. Likewise, there was no significant difference between income levels and infant feeding status, as the major proportion of entire data had breast milk practice. So, education-income status did not make any difference to initiate and continue with breast feeding. Importantly, those mothers with higher income levels were more likely to consume fruit (P= 0.002), vegetables (P=0.001), and sweets (P=0.037). Mothers with a higher education level significantly consumed more vegetables

TABLE 1. Factor loadings of various food groups during lactation

DIET PATTERN & FOOD GROUP	FACTOR LOADING	DIET PATTERN & FOOD GROUP	FACTOR LOADING	DIET PATTERN &FOOD GROUP	FACTOR LOADING
***Factor1 cereal**		Fat yogurt	0.559	Onion-garlic	0.739
Bread	0.458	Kashk	0.553	**Factor 1 fruit**	
Pasta	0.661	cream	0.546	Citrus –kiwi	0.739
Vermicelli	0.670	**Factor2 dairy**		cherries	0.832
Pulses	0.657	Low fat milk	0.411	Watermelon	0.545
Factor2 cereal		Yogurt	0.694	Date-palm	0.478
Wheat flour	0.788	Dough	0.744	grapes	0.859
Wheat flaks	0.77	**F3 dairy**		**Factor 2 fruit**	
Factor 3 cereal		High Fat cheese	0.855	Fruit juices	0.750
Rice	0.709	Cheese	-0.658	canned	0.725
Potato	0.598	**Factor 1 oil**		**Factor 3 fruit**	
Bread bean	-0.351	Unsaturated oil	0.878	Dry fruits	0.913
F1 meat		Saturated oil	-0.875	**Factor 1 sweet**	
Red meat	0.529	**Factor 2 oil**		Cake	0.712
White meat	0.709	Butter	0.997	Halwa- Gaz	0.766
Egg	0.805	**F1 vegetables**		Nuts	0.680
Factor 2 meat		Beans	0.765	**Factor 2 sweet**	
Susage	0.925	Cabbage	0.845	Sugar	0.584
Factor 1 dairy		**Factor 2 vegetables**		chips	0.841
High fat milk	0.598	Leafy vege	0.765		
Choclate milk	0.765	Tomato	0.515		

(P=0.011), sweets, (P=0.026), and dairies (P=0.06).

We extracted a number food patterns by principal component analysis to offer deeper description of data in contrast to single food or nutrients. In terms of having a more precise association, each food group was distributed in two to three food patterns (Table 1). Means, cereals had three food patterns, or fruits had three food patterns as well. Overall, within each food pattern, we found a relationship between different food patterns and anthropometric measurements of an infant.

The finding of multivariate regression model was used to elucidate the relationship between diet of the mother during lactation and growth of anthropometric parameters of the child (0-6 month) (Table 2).

The results of model I showed that the consumption of factor1and factor3 fruit, consisting of all fruits, except juices, led to a positive and significant association toward enhancement of weight, height, and head circumference of the child (0-6 month) F1 (β=0.11, β=0.59, β=0.30), F3(β=0.28 β=2.36 β= 1.45), respectively. This report shows that among dry fruits, the date was mostly consumed thanks to being more affordable for mothers in the rural areas and being occupationally more produced and packaged it in the south. Therefore, provision of some nutrients is warranted. It is simply recommended considering the Recommended Dietary Allowance during lactation.

On the other hand, factor2 fruit including canned fruits and juices was negatively associated with weight (β=-0.05), height (β=-0.035), and head circumference (β=-0.05); hence, lower intake shows proper growth of the parameters significantly. A similar result was found for the relationship between factor2 sweet intake, in which there was an insignificant inverse association with weight, height, and head circumference (data not shown).

The other related factor rich in nutrient to promote the growth is factor2 vegetables which were strongly associated with weight (β=0.35), height (β= 3.8), and head circumference (β= 2.55).

In model II, factor3 cereals were weakly associated with weight (β= 0.209), height (β=3.48), and head circumference (β=2.39). Lastly, factor1 meat in model II, consisting of egg, red and white meat, positively contributed to the elevation of weight (β= 0.176), height (β= 0.936), and head circumference (β=0.576). Among the models, factor2 vegetables more predicted a higher weight, height, and head circumference in contrast to factor2 and factor1 fruits. Comparing factors, factor1 cereals, including pulses, pasta, bread, and vermicelli more contributed to weight gain. On the other hand, factor3 cereals (rice, potato, bread, and bean) were related to the enhancement of height along with factor1 meat and factor1 cereals. The diet of mother high in fruits and vegetables was associated with increased chance of better improvement in the rate of weight gain during the first six months of birth. Further, the improper trend of infant weight gain was consistently predicted by higher intake of sweets, canned fruits, and fruit juices.

The following graphs were depicted to easily compare the effect of different types of feeding during the first six months and growth patterns of infant biometric measures: weight, height, and head circumference. Obviously, breast milk feeding consistently showed a greater ascending trend in breast-fed infants.

DISCUSSION

The findings revealed that the rate of exclusive breastfeeding among rural mother in the current study from birth, as well as 2, 4 and 6 months postnatal was 84.6, 84.6, 77.6, and 74.5% respectively. On the other hand, among Iranian infants, the rate was 53%, with higher values in rural areas (67.76%), as compared to urban areas (47.79%) [13]. Among mothers, 30.3 % were in first gravid and the rest were in second and more gravid.

We observed a significant direct association between maternal fruit, vegetables, cereal and meat consumption during six-month exclusive breastfeeding and growth of anthropometric measurements of a child. Further, the women with high fruits, vegetables, cereals and grain adherence delivered better child weight and height. In contrast to formula-fed, consumption of habitual vegetables was mostly observed among mothers of breast-fed infants. With increase in maternal BMI and age, there was a reducing non-significant trend for exclusive breastfeeding. While epidemiological studies have examined the association between maternal diet and pregnancy outcome, postnatal growth [14,15], this is the first study to evaluate the maternal diet during lactation and growth of the child during the first –six months of life.

Growth trend and type of feeding

We discovered that the cumulative growth during 0-6 months was higher in human milk–fed groups than in other groups (Figure 1). In this regard, sequential growth measures including weight, height, and head circumference could present a picture of the current growth trend, with the obtained growth differing given the type of milk in early infancy. One of the contributors to a high growth rate among breast-fed infants may be higher IGF-I level and their binding protein to promote faster growth [16].

Further, there was a subsequent moderate reduction of IGF-I components over approximately the first 1-3 months, was after which it remained stable up to nine months postnatal [17].

On the other hand, the results of a meta-analysis suggested that formula-fed infants had higher fat-free mass due to level of circulating leptin throughout the first year of life as compared to breast-fed infants. So, formula-fed in contrast to breast-fed children had lower fat mass at 3-4 and 6 months, while by 12 months, this effect was reversed [18].

TABLE 2. Regression coefficients of the dietary exposures and infant biometric measures

Equation (Model I)	Obs	Parms	Rmse	'R-Sq'	F	P
Weight	519	9	1.987839	0.8905	460.7794	0.00
Height	519	9	9.275111	0.9755	2257.054	0.00
Head circumference	519	9	5.515613	0.9804	2829.418	0.00
Weight	**Coef**	**Std Err.**	**t**	**P**	**95%CI**	
F2 Veg	0.3587861	0.0435381	8.24	0.000	0.27325	0.4443232
F1 fruit	0.1176606	0.0366431	3.21	0.001	0.0456705	0.1896507
F2 fruit	-.0564634	0.0514127	-1.10	0.273	-0.1574701	0.0445423
F3 fruit	0.2845249	0.1398614	2.03	0.042	0.0097496	0.5593002
Height	**Coef**	**Std Err.**	**t**	**P**	**95%CI**	
F2oil	0.8572879	0.3008174	2.85	0.005	0.2662941	1.448282
F2 Veg	3.823532	0.2031457	18.82	0.000	3.424427	4.222638
F1fruit	0.5937369	0.1709742	3.47	0.001	0.2578364	0.9296374
F3fruit	2.36787	0.6525828	3.63	0.000	1.085788	3.649951
F1sweet	0.6569555	0.2252171	2.92	0.004	0.2144881	1.099423
Head circumference	**Coef**	**Std Err.**	**t**	**P**	**95%CI**	
F2oil	0.6046804	0.1788865	3.38	0.007	0.2532352	0.9561256
F2 Veg	2.557745	0.1208043	21.17	0.000	2.32041	2.79508
F1fruit	0.3079738	0.1016729	3.03	0.003	0.1082245	0.5077231
F3fruit	1.458196	0.3880702	3.76	0.000	0.6957829	2.220609
F1sweet	0.4891423	0.13392994	3.65	0.000	0.226021	0.7522636
Equation (Model II)	**Obs**	**Parms**	**RMSE**	**R-Sq**	**F**	**P**
Weight	625	7	1.967802	0.8918	727.861	0.00
Height	625	7	8.556634	0.9791	4126.447	0.00
Head circumference	625	7	4.952748	0.9840	5437.252	0.00
Weight	**Coef**	**Std Err**	**t**	**P>t**	**95%CI**	
F1 Cereal	0.2730168	0.06427	4.25	0.00	0.1468027	0.3992309
F3 Cereal	0.2097756	0.0883149	2.38	0.018	0.036342	0.3832093
F1meat	0.1766175	0.0758159	2.33	0.020	0.0277296	0.3255055
F2meat	0.151909	0.0850057	1.79	0.074	-0.0150262	0.3188441
Height	**Coef**	**Std Err**	**t**	**P>t**	**95% CI**	
F1Cereal	2.680388	0.2794666	9.59	0.00	2.131569	3.229207
F2Cereal	0.5795231	0.3237817	1.79	0.074	-0.0563227	1.215369
F3Cereal	3.485469	0.3840214	9.08	0.000	2.731324	4.239614
F1meat	0.936453	0.3296716	2.84	0.005	0.2890406	1.583865
Head circumference	**Coef**	**Std Err**	**t**	**P>t**	**95% CI**	
F1 Cereal	1.823951	0.1617607	11.28	0.000	1.506284	2.141619
F2Cereal	0.4564602	0.1874112	2.44	0.015	0.0884202	0.8245003
F3Cereal	2.397896	0.2222791	10.79	0.000	1.961382	2.83441
F1meat	0.5768894	0.1908204	3.02	0.003	0.2021544	0.9516243

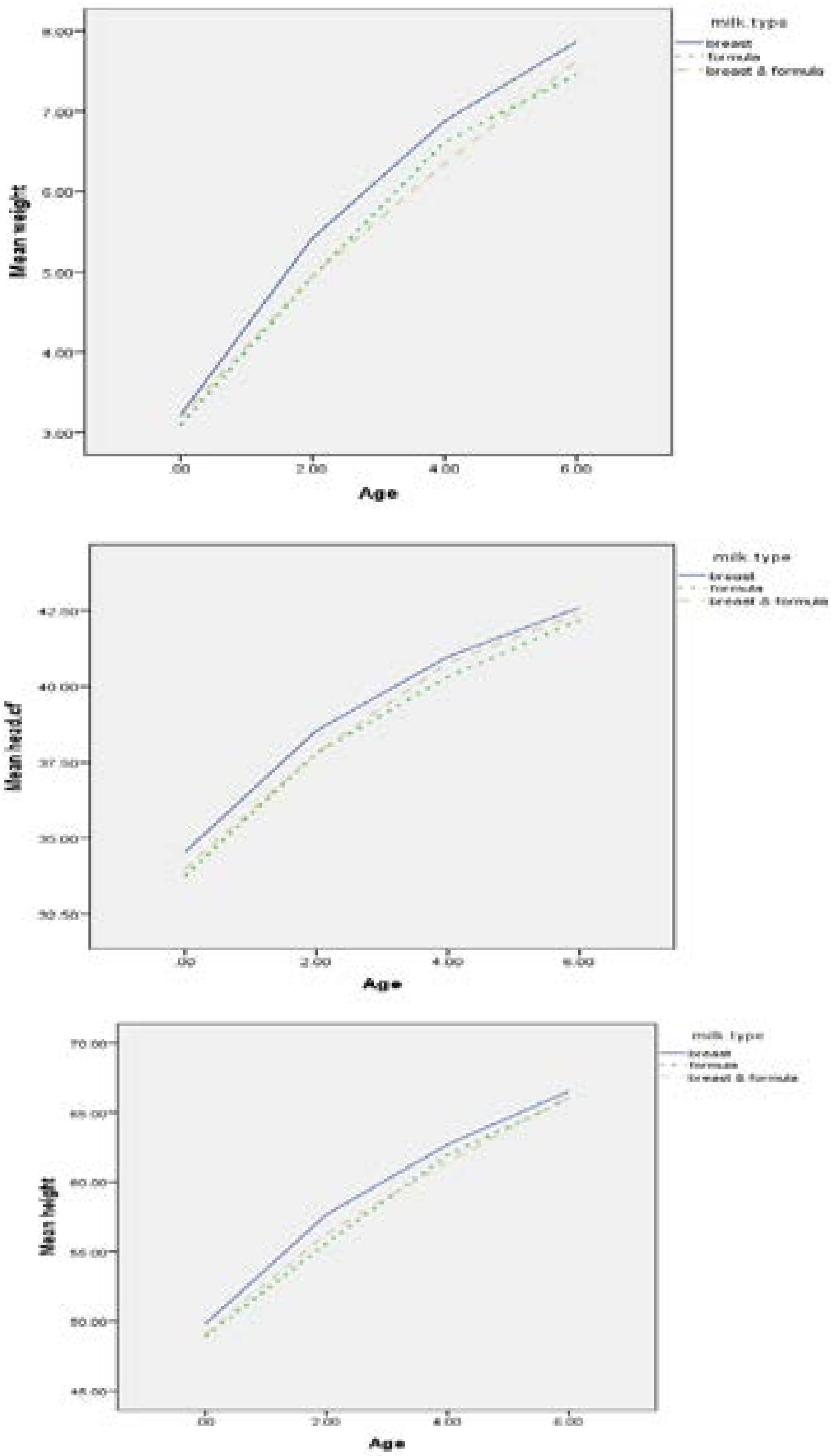
Impact of Fruit-vegetables and cereal on the trend of child growth

The results of the present study indicated that a corresponding increase in maternal fruit and vegetables (F&Vs) consumption was particularly high where a positive association was observed for fresh fruits, leafy vegetables, and dry fruits, while, low and negative for canned and juices during first six months of breastfeeding. Similarly, promoting increased duration of breastfeeding might be one way to reduce infant consumption of juices. Therefore, breastfeeding is associated with better feeding habits during infancy to exert more control or self-regulation over the quantity of milk consumed [19].

Importantly, fruit and vegetables are nutrient-dense foods, accounting for a variety of other bioactive substances which may play a substantial role in successful growth [20].

It is generally accepted that maternal prudent diet, characterized by a high intake of fruit and vegetables along with whole meal cereal and low intake of –high-fat snacks is associated with greater offspring bone size and

FIGURE 1. Trend of growth for postnatal weight (kg), height (cm), and head circumference (cm) from 0 to 6 months of age based on type of feeding



bone mineral density [21]. In this regard, a Danish birth cohort [22] found F&Vs are associated with an increase in birth weight. Additionally, intake of leafy vegetables among rural undernourished women in India [23] at early 3rd trimester and in Egypt [24] at 2nd trimester was associated with an increase in birth weight.

Also, the metabolic effect of maternal dietary habits during pregnancy and lactation may be related to dietary characteristics and growth of the child in later life [3]. Previously, a study showed that a diet rich in fruit and vegetable during childhood may give protection against certain diseases and result in improved cognitive abilities through improving antioxidant status [25].

Therefore, duration of exclusive breastfeeding is a sensitive period for the attainment of a variety of flavors that reflect their mother's diet making them familiar. Furthermore, early food environments should serve to enhance acceptance and preference of a variety of wholesome foods that meet nutritional needs for optimal growth and development. This highlights the importance of the maternal diet profiles on taste stimuli through exposure to amniotic fluid and volatile chemical transmitted from the maternal diet [26]. So provision of a potential strategy is required to keep healthful diet track into later life.

Previously, an observational cohort of pregnant women in Denmark found that the higher frequency of consumption of fruit in the second trimester was associated with a 10.4 g higher birth weight [22]. In line with this finding, a retrospective study of 5632 women in Hungary suggested that less frequent intake of fruits exhibited a positive association with birth weight [27]. However, other studies [28-31] failed to reach the direct association between fruit intake and birth weight. Further, animal studies suggest that low protein diet during gestation and lactation has a detrimental effect on postnatal growth [32]. Likewise, cereal and pulses in addition to different types of meat contributed to growth of a child. So, we can assume maternal diet during lactation as a composite measure whose effect on pregnancy outcome has been more studied than during lactation which is transmitted through exclusive breast feeding. Interestingly, in this report biometric measures of growth had a more ascending slope and faster growth among exclusive breast-fed infant (Figure 1).

Maternal dairy intake and growth of a child

In the present study, higher intake of maternal dairy products during exclusive breastfeeding showed better growth for the infant, which is consistent with the results of another study [33-35], and in pregnancy it was associated with increasing birth and fetus weight, respectively.

The observed increase in dairy intake is mostly attributed to the velocity of the child's weight which was significantly more pronounced in boys than in girls (β= -0.009 95% CI – 0.016 - 0.001 P=0.025).

Growth velocity of weight (GVW) naturally had a decreasing pattern over 0-6 month. So, the negative coefficient explained the relative velocity of reduction of GVW. In this regard, dairy product consumption showed a better association with the velocities of growth, which was affected by advancing age of an infant during the first year. In summary, higher dairy intake caused less reduction of growth velocity.

On the other hand, human growth characterized by many aspects that have been widely determined based on transition of hormonal secretion, could have anabolic effects and explain the greater difference between weight growth velocity in males and females [36]. Remarkably, milk can act as an endocrine signaling, which appears to promote postnatal growth. Substantially, epidemiological evidence suggests that milk consumption led to more elevation of IGF-1 plasma levels in comparison to non-dairy consumers [37].

CONCLUSION

In this report, maternal intake status was assessed through a dietary food frequency questionnaire, where the type of infant feeding on growth measurements during first six months of life in rural area, was a picture and state of later growth. This is the first work conducted in a rural area, south of Iran. The traditional food habits in rural areas are more expected and advisable. In this regard, the findings revealed more intake of leafy vegetables, onion-garlic, orange-kiwi, cherries, grapes, watermelon and dry fruit (date) was interrelated and explained better promotion of growth. Having regular growth promotion monitoring along with maternal diet during lactation showed a more ascending trend in breast-fed infants. Additionally, the finding exhibited that the infant velocity of growth was more affected by maternal dairy products intake. Since maternal-infant serum and milk nutrient quality were not nutritionally assessed, so, the generalizability of the results to the target population was limited.

As there is a correlation between maternal intake and growth of infants affected by human milk, maternal deficiency of some micronutrients (vitamin D, B12, B6, A, thiamin, riboflavin, choline) is associated with maternal diet status, while some (folate, calcium, iron, zinc) are relatively unaffected by maternal intake. So, the current diet pattern indicated a positive cross link between maternal intakes during exclusive breastfeeding and subsequent infant growth. However, further longitudinal research is necessary from the early pre-pregnancy and lactation period to assess dietary habit, serum concentration of bioactive nutrients and serial measurements of the infant to directly evaluate the factors affecting the infant pattern of growth and velocity during this critical period.

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