ABSTRACT

OBJECTIVE: To assess the influence of feeding practices, maternal dietary habits and maternal body mass index (BMI) on growth pattern of breast-fed and formula-fed infants.

METHODS: This cross-sectional study was performed on 50 healthy infants. Twenty-five each breast-fed (BF) and formula-fed (FF) infants along with their mothers were enrolled. The infants’ weight, height, BMI, head circumference and skinfolds (biceps and triceps) were recorded. Infant’s mother weight, height, BMI, mid-arm circumference and skinfolds were also recorded. The mothers filled 24-hour dietary-recall proforma. The 24-hours dietary-recall was then analyzed by windiet® software.

RESULTS: Age of infants was 78.40±35.88 days at time of assessment. Height and weight standard deviation score (SDS) was found to be -2.759±3.10 and -0.538±2.05 with SDS of BMI was 1.59±2.30. Mean anthropometric measurements between the two groups were not significantly different except for head circumference (BF = 38.12±4.46, FF = 40.32±2.34; p-value = 0.036). BMI and age of mothers were 26.49±4.93 kg/m² and 29.54±2.86 years at assessment. Anthropometric analysis of mothers showed an increasing trend of different parameters especially waist circumference (cm) in breast-feeding mothers (lactating = 75±15.6, non-lactating = 61±18.2, p-value = 0.007). Dietary intake of lactating mothers (energy = 3032±12 Kcal; % energy intake = 125.9±53.3) was more as compared to non-lactating mothers (1878±99 Kcal; % energy intake = 78±41.2). Similarly intake of carbohydrates (lactating = 414±186, non-lactating = 274±175), fats (lactating = 109±60.4, non-lactating = 66.6±33.7), proteins (lactating = 98.2±52.5, non-lactating = 60±54.2), zinc (lactating = 14.64±7.28, non-lactating = 8.08±8.53), selenium (lactating = 30.4±22.3, non-lactating = 4.12±7.64) and dietary fiber (lactating = 41.3±19.5, non-lactating = 20.4±15.5) were significantly different.

CONCLUSION: Growth pattern of both breast-fed and formula-fed infants were not significantly different. Energy intake, percentage energy intake and intake of macronutrients & micronutrients are more in lactating mothers.

KEY WORDS: Breast Feeding (MeSH); Lactation (MeSH); Non-lactating (Non-MeSH); Bottle Feeding (MeSH); Body Mass Index (MeSH); Dietary Record (MeSH); Dietary Recall (Non-MeSH); Feeding Behavior (MeSH); Feeding practices (Non-MeSH); Dieting Behavior (MeSH); Eating (MeSH); Diet (MeSH).

INTRODUCTION

Mother and infant’s health are influenced by the dietary habits of the breastfeeding females. Malnutrition is one of the major causes of childhood mortality in early infancy. Infants up to the age of 6 months get most of their essential macronutrients and many micronutrients from the mother milk in majority of cases and even the non-nutritive oligosaccharides of breast-fed milk contribute to infant health and body composition in early years of life. For instance the levels of glucose and insulin in mother milk are the positive predictor for adiposity in infants who are born to non-diabetic mothers. It is evident from literature that body mass index (BMI) is a better indicator of body composition during early infancy. Prompt weight gain at infancy is also related to childhood obesity by the researchers. In the year 2006 World Health Organization (WHO) marketed BMI-for-age growth charts for children aged less than 2 years which are obsolete for pediatric use in routine nowadays. When growth indices (weight for age, length for age and weight for length) of both formula fed (FF) and breast-fed infant (BFI) were compared it was observed that in BFI at one, two and three months they were significantly higher whereas in formulated infants (FFI) only weight for age was significantly higher at one month interval up to 6 months and both the groups of infants exhibit different growth pattern during first 12 months of life. It has been reported that breast feeding reduces the risk of obesity in infants but there are some research based evidence that point towards the fact that babies fed with mother milk show significant weight gain in first month and maintained it for the whole period of lactation and needs further exploration.
TABLE I: ANTHROPOMETRIC CHARACTERISTICS OF INFANTS

| Variables               | Mean       | SD        |
|-------------------------|------------|-----------|
| Height (cm)             | 53.420     | 5.845     |
| Weight (kg)             | 5.374      | 1.013     |
| Age at Assessment (days)| 78.40      | 35.88     |
| SDS_height              | -2.759     | 3.106     |
| SDS_weight              | -0.538     | 2.056     |
| SDS_BMI                 | 1.598      | 2.309     |

SDS = Standard deviation score; BMI = Body Mass Index.

TABLE II: MEAN DIFFERENCES IN THE DIETARY CHARACTERISTICS OF LACTATING AND NON-LACTATING MOTHERS

| Variables          | Lactating mothers | Non-Lactating mothers | P-value |
|--------------------|-------------------|-----------------------|---------|
| Energy (Kcal)      | 3032              | 1284                  | 1878    | 992     | 0.001** |
| % Energy intake    | 125.9             | 53.3                  | 78      | 41.2    | 0.001** |
| Carbohydrate (g)   | 414               | 186                   | 274     | 175     | 0.008** |
| Carbohydrate % intake | 54.7            | 10.9                  | 54.76   | 9.78    | 0.972   |
| Fat (g)            | 109               | 60.4                  | 66.6    | 33.7    | 0.004** |
| Fat % intake       | 31.5              | 11.4                  | 33.0    | 12.6    | 0.659   |
| Protein (g)        | 98.2              | 52.5                  | 60.2    | 54.2    | 0.015*  |
| Protein % intake   | 13.82             | 4.39                  | 12.27   | 4.42    | 0.220   |
| Zinc (mg)          | 14.64             | 7.28                  | 8.08    | 8.53    | 0.005** |
| Iron (mg)          | 20.06             | 7.39                  | 25.0    | 48.4    | 0.616   |
| Vitamin A (μg)     | 1211              | 2106                  | 446     | 279     | 0.085   |
| Selenium (μg)      | 30.4              | 22.3                  | 4.12    | 7.64    | 0.000***|
| Dietary Fiber (g)  | 41.3              | 19.5                  | 20.4    | 15.5    | 0.000***|

Significant levels (*P<0.05; **P<0.01; ***P<0.001); § = Independent sample t-test

TABLE III: MEAN DIFFERENCES IN ANTHROPOMETRIC PARAMETERS BETWEEN BREAST-FED AND FORMULA-FED INFANTS

| Variables          | Breast-fed infants | Formula-fed infants | P-value |
|--------------------|--------------------|---------------------|---------|
| Head circumference (cm) | 38.12              | 4.46                | 40.32   | 2.36    | 0.036*  |
| Biceps (mm)        | 0.14               | 0.05                | 0.14    | 0.05    | 0.78    |
| Triceps (mm)       | 0.15               | 0.06                | 0.14    | 0.05    | 0.63    |
| BMI_SDS            | 1.25               | 2.41                | 1.94    | 2.19    | 0.29    |
| SDS_height         | -0.65              | 3.67                | -0.86   | 2.49    | 0.81    |
| SDS_weight         | -0.76              | 2.49                | -0.31   | 1.53    | 0.44    |

Significant levels (*P<0.05; **P<0.01; ***P<0.001); § = Independent sample t-test

anxious to regain their pre-pregnancy status rephrased. Researchers have yielded that lactation is an efficient mean of weight loss in postpartum period due to high-energy expenditure. Hatsu, et al. 13 in 2008 elaborated the effect of breastfeeding on maternal body composition. Exclusive breast feeding, has more pronounced impact in some cases on mother's weight gain during pregnancy as the percent body fat loss in mixed feeding mothers is more when compared with exclusively breast feeding, due to more caloric intake in breast feeding group as compared to mixed feeding group. Moreover, the physical activity was higher in mixed feeding group than in breast feeding group. 13 Anthropometric parameters of the breast feeding mothers when taken after one month postpartum in study of Kramer, et al. 13 revealed that the hip circumference is significantly reduced in breast feeding as compared with formula feeding mothers. Furthermore, infant's feeding practices influence anthropometric changes in postpartum women. 13 To ascertain the effect of feeding practices on infant's body composition and also to investigate how BMI of lactating and non-lactating mothers respond to these practices this study was carried out.

METHODS

This cross sectional study was carried out in district Peshawar, Khyber Pakhtunkhwa Pakistan. The study was approved by the Research Ethics board of Khyber Medical University, Peshawar, Pakistan. This study was started in October 2017 and ended in March 2018. In this whole period, identification of the participants, their enrollment and data collection was carried out. Based on median difference of 14.3 mmol/kg total short chain fatty acids between breast fed and formula fed infants at 2 months of age from the study of Sigur et al 1993 4 and considering margin of error of 5%, total of 25 infants are required in each group (total n=50). Each patient was screened (Figure 1) using a health check questionnaire to rule out conditions related to changes in physiology of the gut which can alter gut microbiota composition and metabolic activity such as medications, gut surgeries, systemic use of prebiotics and probiotics.

Anthropometric assessment of infants and mothers: Weight and length measurement of an infant was performed once. Infant crown-heel length was measured once by using headpiece and foot piece both applied perpendicular to the hard surface and non-stretch tape was used to measure the length in centimetres. Head circumference was measured at a level passing from supraorbital protuberance anteriorly and occipital protuberance posteriorly using non-stretch tape to the nearest 0.1cm. Infant’s weight was determined by using Beurer Digital Baby Scale (BY-80) in kilograms. Skin folds (biceps and triceps) were measured by using skinfold caliper (Holtain LTD, Crosswell, UK). Height of the mothers was measured with a portable stadiometer with the head in horizontal Frankfort plane. Mid upper arm circumference was measured to the nearest 0.1cm using a plastic measuring tape. Weight of the mother was measured by Beurer digital scale.
**RESULTS**

The age of infants at the time of assessment was 78.40 ± 35.88 days. Height and weight SDS was found to be -2.759 ± 3.106 and -0.538 ± 2.056 with SDS_BMI of 1.598 ± 2.309. Similarly the BMI of mothers were 26.499 ± 4.930, age of mothers were 29.540 ± 2.866 at the time of assessment (Table I).

The dietary characteristics of mothers were also analyzed among the lactating and non-lactating groups. Dietary intake of lactating mothers (energy=3032±1284 Kcal; % energy intake=125.9±53.3) was more as compared to non-lactating mothers (1878±992 Kcal; % energy intake=78±41.2) [p-value=0.001]. Similarly, intake of carbohydrates, fats, proteins, zinc, selenium and dietary fiber were significantly increased in lactating as compared to non-lactating mothers (Table II).

It was observed that the mean anthropometric measurements between the infants of the two groups were not significantly different except for head circumference, which is significantly higher in formula fed infants (40.32±2.34) as compare to breast fed infants (38.12±4.46) [Table III]. On the other hand, Lactating mothers got significant increase in waist circumference (75±15.6) when compared with non-lactating mothers (61±18.2) [p-value=0.007]. Similarly, increasing trends were also observed in lactating mothers in their biceps and triceps measurements (Table IV).

**DISCUSSION**

All the mothers had BMI near upper limit of normal range but the BMI of the lactating mothers was higher with no significant difference from the formula fed infants’ mothers. This may be attributed to the fact that majority of the mothers were non-lactating and had a higher BMI. Similarly, intake of carbohydrates, fats, proteins, zinc, selenium and dietary fiber were significantly increased in lactating as compared to non-lactating mothers (Table II).

It was observed that the mean anthropometric measurements between the infants of the two groups were not significantly different except for head circumference, which is significantly higher in formula fed infants (40.32±2.34) as compare to breast fed infants (38.12±4.46) [Table III]. On the other hand, Lactating mothers got significant increase in waist circumference (75±15.6) when compared with non-lactating mothers (61±18.2) [p-value=0.007]. Similarly, increasing trends were also observed in lactating mothers in their biceps and triceps measurements (Table IV).
formula fed infant’s mothers were on diet to lose their weight and relatively the increased BMI of the lactating mothers can be related to increase energy intake and macronutrients. These findings are consistent with the report of the national academy of science. In contrast, the BMI of lactating mothers fell to a significant level between 4 and 6 months of exclusive breast feeding. Similar results were reported by Rasmussen K. et al. The energy intake in the lactating mothers was higher than the recommended energy intake for this category whereas the mothers of formula fed infants energy intake was low. A report on breastfeeding mothers in Nigeria revealed significantly increased energy intake. The difference between their study and our results might be at least partially due to small sample size in our study although levels of energy intake were positively associated with the BMI of lactating mothers as has been reported by Lano-Maduagu, et al.

The anthropometric and dietary data were analyzed for assessing the nutritional status of mothers. Mean energy intake of the mothers increased after delivery as has been observed in American women for 4 months postpartum. The 24 hours dietary recall of the lactating mothers showed that their protein, carbohydrates and fats intake was significantly higher than the non-lactating mothers. Further analysis showed that in both lactating and non-lactating mothers, the intake of macronutrients was higher than the recommended intake but it was significantly higher in lactating groups as cited in Brazilian lactating mothers. Dietary intake of micronutrients such as, selenium and iron along with vitamin A were also considerably normal in fact more than the required intake. This can be related to the fact that iron and vitamin A can be stored by the human body, whereas, zinc intake and zinc levels in plasma were very low than the required levels. Iron intake was adequately higher in lactating mothers in our study supporting the outcome of Moser PB, et al. who studied lactating mothers in Nepal. Consumption of selenium in lactating mother was significantly low and very low in non-lactating mothers matching with a report of a study carried out in Nepal. It is cited in literature that zinc intake does not influence the plasma zinc levels of mother, as there was no association of intake with the plasma levels. Similar trends was observed in our study with positive but insignificant association of zinc intake and plasma levels. Beshgetoor D, et al. studied the same relationship in animal model by feeding the lactating and pregnant rats with marginal zinc supplemented diet and found no effect on zinc levels in breast milk and on zinc concentration. It is learnt from the literature that milk is an excellent source of nutrients for the infants and is considered to be the only source of nutrition in the first 6 months of life. It has been reported that human milk has the ability to protect infants against massive weight gain and later on obesity in adulthood. The finding of this study second the above statement, as it was found that the infants mean BMI SDS in breast fed infants was lower than the formula fed infants although the difference was not significant. It is well known fact that traditional formula milk are having higher contents of protein than breast milk. Protein-rich formulae are considered to be a factor that accelerate plasma insulin levels which in turn leads to release of insulin-like growth factor-1, as a consequence there is weight gain and later on obesity in adulthood. Other studies have also reported that the mean SDS weight of formula feeding groups was lower when compared with breast feeding group. We found the mean values of SDS weight were higher but not significant in BFI as compared to FFI. Recent researches support the fact that human milk contains more non-nutrite carbohydrates like human milk oligosaccharides (HMOs) that have the potential to affect the body composition and infants growth, inviting further research to identify the possible contributors of infants growth and body mass composition during early and late infancy.

It was observed that the growth pattern of both breast-fed as well as formula-fed infants were not significantly different, revealing a comparable impact of the two modes of feeding on infant growth. It is also inferred from the data that energy intake, percentage energy intake and intake of macronutrients as well as micronutrients are more in lactating mothers as compared to non-lactating mothers, suggesting that lactating mothers be educated regarding their caloric intake and dietary habits to avoid obesity and the co-morbidities related to it.

ACKNOWLEDGEMENT

I am grateful to Dr. Muhammad Jaffar Khan (late) my co-supervisor who designed this study and also his guidance, suggestions and constant encouragement made it possible to accomplish this research task. I am also very thankful to all the mothers who along with their infants participated in this study. In addition, I want to thank Prof. Dr. Jamil Ur Rehman who facilitated me in completing this research work.

REFERENCES

1. Moradi M, Maracy MR, Esmaillzadeh A, Surkan PJ, Azadbakht L. Associations Between Dietary Energy Density in Mothers and Growth of Breasftfeeding Infants During the First 4 Months of Life. J Am Coll Nutr 2018;37(8):731-7.
IMPACT OF FEEDING PRACTICES, MATERNAL DIETARY HABITS AND MATERNAL BODY MASS INDEX ON GROWTH PATTERN IN BREAST-FED AND FORMULA-FED INFANTS

DOI: 10.1080/07315724.2018.1465486.

2. Chauhan MG, Mehta DP, Koria B, Patel H, Singh M. Assessment of weight gain pattern of exclusively breastfed and non-exclusively breastfed infants in Bhavnagar city, Gujarat. Int J Med Sci Public Health 2016;5(01):64-8. DOI: 10.5455/ijmsph.2016.1505201518.

3. Michaelson KF, Petersen S, Greisen G, Thomsen BL. Weight, length, head circumference, and growth velocity in a longitudinal study of Danish infants. Dan Med Bull 1994;41(5):577-85.

4. Goran M, Martin A, Alderete T, Fujiwara H, Fields D. Fructose in breast milk is positively associated with infant body composition for 6 months of age. Nutrients 2017;9(2):pii. E146. DOI: 10.3390/nu9020146.

5. Fields DA, Delemath EW. Relationship of insulin, glucose, leptin, IL-6 and TNF-α in human breast milk with infant growth and body composition. Pediatr Obes 2012;7(4):304-12. DOI: 10.1111/j.2047-6310.2012.00059.x.

6. Roy SM, Fields DA, Mitchell JA, Hawkes CP, Kelly A, Wu GD, et al. Body mass index is a better indicator of body composition than weight-for-length at age 1 month. J Pediatr 2019;204:77-83.e1. DOI: 10.1016/j.peds.2018.08.007.

7. World Health Organization (WHO) Multicentre Growth Reference Study Group. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. 2006. World Health Organization, Geneva. [Accessed on: April 18, 2019]. Available from URL: https://www.who.int/childgrowth/standards/technical_report/en/

8. Agostoni C, Grandi F, Gianni M, Silano M, Torcoletti M, Giovannini M, et al. Growth patterns of breast fed and formula fed infants in the first 12 months of life: an Italian study. Arch Dis Child 1999;81(5):395-9. DOI: 10.1136/adc.81.5.395.

9. Saure C, Armeno M, Barcala C, Giudici V, Mazzia CS. Excessive weight gain in exclusively breast-fed infants. J Pediatr Endocrinol Metab 2017;30(7):719-24. DOI: 10.1515/jpem-2017-0028.

10. Kulis H, Heinrich J, Borte N, Schaaf B, Von Berg A, Von Kries R, et al. The effect of breastfeeding on weight gain in infants: results of a birth cohort study. Eur J Med Res 2005;10(1):36-42.

11. Dewey KG, Heining MJ, Nonnemse LA. Maternal weight-loss patterns during prolonged lactation. Am J Clin Nutr 1993;58(2):162-6. DOI: 10.1093/ajcn/58.2.162.

12. Hatsu IE, McDougald DM, Anderson AK. Effect of infant feeding on maternal body composition. Int Breastfeed J 2008;3(1):18. DOI: 10.1186/1746-4358-3-18.

13. Kramer FM, Stunkard AJ, Marshall KA, McKinney S, Liebschutz J. Breast-feeding reduces maternal lower-body fat. J Am Diet Assoc 1993;93(4):429-33. DOI: 10.1016/0002-8223(93)92289-a.

14. Sigur U, Ormisson A, Tamm A. Faecal short-chain fatty acids in breast-fed and bottle-fed infants. Acta Paediatr 1993;82(6-7):536-8. DOI: 10.1111/j.1651-2227.1993.tb12747.x.

15. Institute of Medicine. 1991. Nutrition during lactation. Washington, DC: The National Academies Press. DOI: 10.17226/1577.

16. Dewey KG, Cohen RJ, Brown KH, Rivera LL. Effects of exclusive breastfeeding for four versus six months on maternal nutritional status and infant motor development: results of two randomized trials in Honduras. J Nutr 2001;131(2):262-7. DOI: 10.1093/jn/131.2.262.

17. Rasmussen K, K. McGuire M. Effects of Breastfeeding on Maternal Health and Well-Being. Food Nutr Bull 1996;17(4):364-9. DOI: 10.1177/156482659601700416.

18. Sanusi R, Falana O. The nutritional status of mothers practicing breast feeding in Ibadan, Nigeria. Afr J Biomed Res 2009;12(2):107-12.

19. Lano-maduagu AT, Abiola OM, Akorede OJ, Tunrayo EB. Assessment of socio-economic, dietary intake, hygienicpractice and anthropometric indices in determining the nutritional status of mothers in Akure south local government, Ondo state. Int J Recent Res Appl Stud 2013:15:158-67.

20. Butter NF, Garza C, Stuff JE, Smith E, Nichols B. Effect of maternal diet and body composition on lactational performance. Am J Clin Nutr 1984;39(2):296-306. DOI: 10.1093/ajcn/39.2.296.

21. do Carmo MdGT, Colares LGT, Sandre-Pereira G, Soares EdA. Nutritional status of Brazilian lactating women. Nutr Food Sci 2001;31(4):194-200. DOI: 10.1186/00346650110392280.

22. Moser PB, Reynolds RD, Acharya S, Howard MP, Andon M, Lewis S, Copper, iron, zinc, and selenium dietary intake and status of Nepalese lactating women and their breast-fed infants. Am J Clin Nutr 1988;47(4):729-34. DOI: 10.1093/ajcn/47.4.729.

23. Choi YK, Kim J-M, Lee J-E, Cho MS, Kang BS, Choi H, et al. Association of maternal diet with zinc, copper, and iron concentrations in transitional human milk produced by Korean mothers. Clin Nutr Res 2016;5(1):15-25. DOI: 10.7762/cnr.2016.5.1.15.

24. Beshgetoor D, Lönnerdal B. Effect of marginal maternal zinc deficiency in rats on mammary gland zinc metabolism. J Nutr Biochem 1997;8(10):573-8. DOI: 10.1016/S0955-2863(97)00091-0.

25. Jooste P, Rossouw L, Steenkamp H, Brettell L, Swart D, Rossouw J, Swanepoel A, Charlton LA. Maternal weight-loss patterns during pregnancy and lactation: results of two randomized trials in Honduras. J Nutr 2001;131(2):262-7. DOI: 10.1093/jn/131.2.262.

26. Nielson SE, Rogers RR, Ziegler EE,.
Impact of feeding practices, maternal dietary habits and maternal body mass index on growth pattern in breast-fed and formula-fed infants

28. Dewey KG, Heinig MJ, Nommsen LA, Peerson JM, Lonnerdal B. Growth of breast-fed and formula-fed infants from 0 to 18 months: the DARLING Study. Pediatr 1992;89(6 Pt 1):1035-41.

29. Ziegler EE. Growth of breast-fed and formula-fed infants. Nestle Nutr Workshop Ser Pediatr Program 2006;58:51-9; discussion 59-63. DOI: 10.1159/000095010.

30. Salmenpera L, Perheentupa J, Siimes MA. Exclusively breast-fed healthy infants grow slower than reference infants. Pediatr Res 1985;19(3):307-12. DOI: 10.1203/00006450-198503000-00011.

AUTHORS’ CONTRIBUTIONS
Following authors have made substantial contributions to the manuscript as under:

MD: Conception and study design, acquisition, analysis and interpretation of data, drafting the manuscript, final approval of the version to be published

RN: Study design, critical review, final approval of the version to be published

SF & MA: Acquisition, analysis and interpretation of data, drafting the manuscript, final approval of the version to be published

MS: Analysis of data, drafting the manuscript, critical review, final approval of the version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST
Authors declared no conflict of interest

GRANT SUPPORT AND FINANCIAL DISCLOSURE
NIL

This is an Open Access article distributed under the terms of the Creative Commons Attribution-Non Commercial 2.0 Generic License.

KMUJ web address: www.kmuj.kmu.edu.pk
Email address: kmuj@kmu.edu.pk