

Breast milk composition varies among mothers with maternal anthropometric indices (somatotyping upper extremities)

Madhushree Bhowmik¹, Krishnendu Paul¹, Jasmine Sultana¹, Jagannath Ghosh²

¹Research Scholar, Swami Vivekananda University, Telenipara, Barasat – Barrackpore Road, Barakanthalia, Kolkata (West Bengal) – 700121

²Assistant Professor, Swami Vivekananda University, Telenipara, Barasat – Barrackpore Road, Barakanthalia, Kolkata (West Bengal) – 700121

Corresponding E-mail: jagannathg@svu.ac.in

Abstract

Breast milk offers various nutritional and non-nutritional components which possess association with nourishment and protection from diseases to the infants. Breast milk is the golden standard which is the source of macronutrients such as carbohydrates, proteins, lipids with other micronutrients and bioactive components are ideal for infant's growth and development. Nutrient composition differs with genetic, nutrition, environment and other maternal factors. Maternal Body mass index (BMI) is commonly employed metric for evaluating nutritional status that correlates with body composition rather than somatotypic parameters relating breast milk composition in different population. Overweight mothers with higher BMI and raised upper extremities anthropometry possess more fat and protein with low amount of carbohydrates and higher leptin, insulin and CRP concentrations in their milk compared to those of normal weight. Mother with broader and athletic stature shows better correlation with the breast milk retention as researches showed. This particular review is based upon identification of major anthropometric indices focusing on upper extremities to elaborate about necessary correlation with breast milk composition. The anthropometric measurements

include measurement of arm, weight, height, waist and hip circumferences, along with triceps and subscapular skinfold measurements of the mother postnatally is not so impactful on milk volume and nutrient composition but prenatal shows correlation with it.

Keywords : Breast milk composition, Obesity, Body Mass Index (BMI), Anthropometric measurements, Upper extremities

Introduction

Breast milk exists as the best milk with respect to infant which is designated as golden standard and multifunctional biofluid (1,2,5) with full of nutritional and non-nutritional components (1,7), hence exclusive breast feeding is endorsed by World Health Organization (WHO) and UNICEF (42) for the first six months of life (4,9) to prevent infections and chronic diseases, build up immunity and fulfill the overall nutritional status among infants (1,2,4). A combination of nutritional, environmental, socioeconomic, psychological and genetic factors establish an extensive list of benefits linked to lactation and health impacts for the nursed infant and to the nursing mother (3,5,7). Extending breast feeding up to one year or more very much effective for the growth, development and overall wellbeing regarding the infant (2,8). Mother's milk comprises macronutrients like carbohydrates, proteins, lipids, micronutrients and additional bioactive agents (e.g., hormones, antibodies, bioactive molecules, stem cells) pertaining to optimum growth of infant (1,7) and its composition is very dynamic (7). Several studies reported a varying percentage of nutrient contents in human milk which were associated with maternal physique in varying lactation period (7,11).

Mother's Body mass index (BMI) is popular parameter for determining nutritional state that correlate with body mass evaluation and human milk composition (4), although breast milk constituents vary with the lactational age (25). Overweight mother's milk contains more fat and protein and lesser amount of carbohydrates and leptin, C-reactive proteins (CRP) concentrations and insulin existed higher in comparison

with normal weight mothers (3). The anthropometric measurements were done by measuring weight, height, arm, waist and hip circumferences, triceps and subscapular skinfolds of the mother (6,46). The World Health Organization (WHO) categorizes overweight as having a body mass index (BMI) greater than or equal to 25 kg/m^2 and defines obesity as having a BMI equal to 30 kg/m^2 or higher (9). However, BMI is an inadequate measure of adiposity, as it fails to effectively differentiate between fat tissue and lean body mass (23). Several studies have shown maternal adiposity may correlate with alterations in the macronutrient constituents of breast milk (9,11,12,13,16). Studies have shown that nursing mothers with low body weight have identified reduced concentrations of maternal plasma and breast milk micronutrients, such as carotenoids relative to appropriately nourished mothers (13). Divergence in milk volume production between right and left breast have been documented, indicating that the right breast may produce markedly more milk than the left (18). A consequence of this study is that mothers who notice a marked asymmetry in breast size or a strong preference for one breast can be assured that the milk quality from the smaller or non-dominant breast remains unaffected. The macronutrients concentration was consistent regardless of size differences or breastfeeding side preference. Past studies have documented a larger volume of human milk produced by the dominant (preferential) side, more likely to be the right breast than the left (34,35). Human milk produced by a dominant breast appears to be no more liquidish and or less nourishing than milk produced by the other breast. In this study authors stated that macronutrients content of mid expression human milk is unaffected by maternal handedness, breast size or breast side dominance (18). A prior study demonstrated that there is no link between other macronutrients and breast size, suggesting that having large breasts is not essential for sufficient milk production (19).

Literature Review

The main motive of this review is to build an interrelationship between the maternal/postpartum anthropometric indices and breast milk macronutrient composition which reflects the

nutritional fulfilment with overall growth and development of infant. Numerous researchers represented different data on the basis of their works.

Most of the existing studies used separate analytical instruments regarding the analysis of lactose, protein and fat content of breast milk that existed time taking (7). All the study was conducted in lactating mother by measuring Height, Weight, BMI, Waist Circumference, WHR, Skin fold thickness. By using an electronic scale, maternal body weight assessed and calibrated marked wall helped to measure height of the mothers (23). The body mass index (BMI) was determined by dividing the body weight by the square of the height (kg/m^2) (7,23). World Health Organization (WHO) interprets data by following this classification: below $18.5 \text{ kg}/\text{m}^2$, underweight; $18.5\text{--}24.9 \text{ kg}/\text{m}^2$, normal weight; $25.0\text{--}29.9 \text{ kg}/\text{m}^2$, pre-obese; $\geq 30 \text{ kg}/\text{m}^2$, obese (7). Percentage fat mass (%FM) was assessed using an ImpediMed SFB7 tetra-polar bioelectrical impedance analyser (23).

In first year of lactation period, no variation was reported in composition of protein, energy, lactose and fat content between milk from right and left breasts and preferred and nonpreferred breasts (34,35).

Carbohydrate

Lactose is the primary carbohydrate found in human milk (38,44). Several studies indicated that maternal BMI was not linked to lactose levels at 4-5 months postpartum and overall lactation period does not influence on lactose concentration (12,21). Lactose concentration within human milk was analysed by enzymatic spectrophotometric method (7,23) and colorimetric technique (44). Rising maternal adiposity might be linked to reduced lactose synthesis in milk, with the increase in milk fat possibly indicating this reduction in sugar content (25). Studying in a High-Altitude Adapted Population of Tibetans, it was concluded that milk sugar was markedly and negatively associated with maternal number of previous pregnancies and triceps skinfold thickness (43). Another study has indicated that maternal overall milk sugar content can be measured using a phenol-sulfuric acid procedure and diet

has no association regarding milk composition, while BMI showed a significant inverse association with sugar (2). Rising maternal adiposity might be linked to reduced lactose synthesis in milk, with the increase in milk fat possibly indicating this reduction in sugar content (7,20,23). Several researches have demonstrated that mother's milk contains oligosaccharide and colostrum has high concentration of oligosaccharide than mature milk (2). Another study reported BMI is strongly associated with concentration of galactose (23) and glucose concentration was elevated in colostrum of obese mother than normal weight mother (33). Certain sugar alcohols and monosaccharides were more predominant in overweight and obese mother's milk, including 1,5-anhydroglucitol, arabinol, arabinose, glucose-6-phosphate, erythritol, and ribitol. It was found that maternal obesity was correlated to human milk oligosaccharide content at 1st month of lactation postpartum (36).

Protein

Casein and whey proteins are two broad classifications of milk protein which is vital for infant's nutritional, immunological, and hormonal support (44). Several studies investigating a relationship between maternal BMI and adiposity with protein content of milk and pointed maternal adiposity, measured by BMI is correlated with higher protein content of milk (2,7,12,20,21,22,24,49). Also seen a proportionally higher levels of caseins (2) but a study proved that lower BMI in lactating mother is associated with elevated concentrations of breast milk protein (23), contrarily several studies reported no correlation between protein concentrations and maternal BMI (4,16,27). Although protein concentration was declined with duration of lactation or lactation stage (12,20). Mothers with more adipose tissue have more amino acid concentrations in blood (28) which reflects in breast milk composition variations. Infants nursed by obese mothers are more prone to future obesity and this report needs further investigation (15).

Breast milk protein was analysed by using Bradford assay as stated in the methods of Mitoulas et al. (23). It was observed that BMI is not an exact tool to measure adiposity (7) and

researches showed higher maternal body fat composition was assuredly linked to elevated protein levels in milk (23,25). Using advanced techniques to assess mother's physique, it was stated that total protein percentage in breast milk was closely associated with maternal body composition like maternal weight, BMI, % fat mass and muscles and also reported an inverse relationship with percent total body water in the third month of postpartum (7). It has also been noted that several serum amino acid concentrations, especially branched chain amino acids (BCAAs), are elevated in mothers with higher adipose tissue, facilitating to pass more amino acids to the breast and also in breast milk. This may clarify a positive association between maternal fatness and milk protein content (15,21). Mother's preconception weight and height displayed a positive relationship with glutamic acid but not BMI whereas glutamine was positively associated with length of 4 months aged infant. Mothers who have higher weight and stature showed free glutamic acid in the breast milk (14).

Lipid

Majority of studies reported that mother's higher BMI and adipose mass are favorably and significantly correlated with higher fat content in breast milk (4,7,11,12,17,20,21,25,37). In a study, maternal percent fat mass was measured using bioimpedance spectroscopy (23). Another study used well described methods such as creatatocrit method and the micro-Roese-Gottlieb method to analyse milk fat (44,45). Also it was reported that maternal obesity is strongly associated with higher fat percentage in colostrum (33) and transition milk than normal or overweight mothers (12,20). Triacylglycerides (96%) are the main form of breast milk lipid and remaining are the phospholipids and cholesterol (26). Higher intake of dietary fat predisposes high maternal Body Mass Index with dyslipidemia and triglyceridemia which results in increase breast milk fat concentrations (33). In case of fatty acid composition, a strong association was observed with mother's BMI. Breast milk from mothers who are obese possessed elevated concentration of omega-6 than omega-3 fatty acids and lesser content of alpha linolenic acid (ALA), docosaheptaenoic acid (DHA), eicosapentaenoic

acid (EPA) and docosapentaenoic acid (DPA) in contrast to mothers with lower body weight (13). Using a beam balance and stadiometer, maternal weight and height were assessed, revealing a positive correlation between milk fat concentration and maternal body fat. Conversely, reduced levels of fat and energy in milk are more prevalent among malnourished women in Bangladesh, Gambia, Honduras, and Mexico (17). One study reported women with higher arm circumference and triceps skinfold thickness possess more fat percentage in mature milk (40).

Body circumferences at the arm, chest, waist, hip, thigh, and calf were measured twice using a non-stretchable measuring tape. Skinfold thicknesses were assessed using Lange calipers (Cambridge Scientific Industries, Cambridge, MD) at the biceps, triceps, subscapular, and suprailiac sites (17). Higher upper body measurements in mothers are associated with proportionally elevated levels of lipid (2) and saturated fatty acids (37) in breast milk, although dietary lipids influence the fatty acid profile of breast milk composition (2,37). In certain but not all previous studies, maternal body fat has been demonstrated to be a strong indicator of milk fat and energy content (11,25,26). BMI showed a positive correlation with protein and fat concentrations, and a negative correlation with lactose (20). It is concluded that human lactation performance is highly resilient and that BMI does not serve as a useful indicator of function based on the current study level (22,23). Besides higher maternal BMI, pregnancy weight gain and sampling methods significantly influence fat concentration of breast milk (24). Overweight and obese mother's milk have higher long chain fatty acids (LCFAs) content that may be due to maternal adiposity but there is no overall difference in the omega 3 and omega 6 long chain PUFA ratio (31). The fat concentration in hind milk was notably greater compared to fore milk, while no significant variations observed in either lactose or protein (34). It has also been established that the fat composition of mother's milk fluctuates based on mother's diet, hind or fore milk (12), timing of feeding (morning/night or day time/early evening) (35), and storage environment (12). In a population of Tibetan, it was examined that milk fat was positively associated with infant age and maternal

triceps skinfold thickness. They reported, measuring maternal triceps skinfold thickness is the more effective method than measuring maternal BMI to correlate milk fat, sugar, and energy with maternal postpartum upper extremities. Low triceps skinfold thickness of postpartum mothers denotes high milk fat (43). Similar correlations between macronutrient composition and triceps skinfold thickness were reported in other populations by some researchers (21,26,40).

Other factors

Leptin, insulin (32, 48), and CRP levels were higher in overweight (OW) mother's milk than in normal-weight (NW) mothers (10,47,52). One study has reported the insulin concentrations in human milk (HM) are higher than those in maternal plasma and are associated with maternal BMI and insulin sensitivity (10). Infants of OW mothers were exposed to leptin and insulin concentrations 1.5 to 2.5 times higher than those of infants born to NW mothers (3). At two weeks, it was observed that mothers with increased BMI have higher insulin levels in milk (32). In one study, Obese mothers had higher serum CRP concentrations, but not in their colostrum (33). Several studies have reported the adiponectin concentrations in breast milk has positive association with maternal BMI (50,51).

Discussion

In this study, we found that the composition of human milk is highly intricate (44) and among all the macronutrients, protein (2,7,12,20,21,22,24) and lipid contents (4,7,11,12,17,20,21,25,37) are highly correlated with maternal BMI and adiposity, depending on the lactation stage.

According to maternal somatotyping upper extremities there is no variations found in lactose content (12). Human milk represents the richest source of lactose compared to other animal milk (38). The concentration of lactose in milk shows a negative correlation with maternal body composition and lactation period has no effect on lactose concentration (12) but maternal BMI is strongly associated with high galactose content (23). Also one study report concluded that colostrum contains more concentrations of oligosaccharide than mature milk (2).

Casein and whey proteins are main two types of milk proteins (44) which have a strong relationship with maternal body fat or mass and adiposity (2,7,12,20,21,22,24) but contrary another study stated that lower BMI in lactating mother is associated with elevated level of breast milk protein (23). Contrarily, few studies reported no correlation between protein concentrations and maternal BMI (4,16,27). Mothers with higher adiposity shown a high level of amino acids in blood also in breast milk (28). Using advanced techniques of maternal body composition assessment, a study demonstrated that total protein percentage in human milk was highly associated with maternal body composition like maternal weight, BMI, % fat mass and muscles in the month three of lactation (7). Mother with more body fat composition exerts more BCAAs in blood which reflects in breast milk composition with higher BCAAs (15,21). A study reported that mother's prepregnancy weight and height have a positive association with glutamic acid but not in body mass index and maternal higher weight and stature possess free glutamic acid in breast milk (14).

The majority of studies which measured body circumferences at the arm, chest, waist, hip, thigh, and calf indicated that higher BMI and fat mass of lactating mothers are positively correlated with higher fat content in breast milk (4,7,11,12,17,20,21,25,37). Diet has a strong influence on maternal body fat composition with dyslipidemia and triglyceridemia predisposes breast milk fat composition (33). Compared to underweight mothers, obese mothers exhibit a higher omega-6 to omega-3 fatty acid ratio and reduced levels of ALA, DHA, EPA and DPA (13). Maternal higher arm circumference and triceps skinfold thickness are connected with more fat concentrations in mature milk (40). Overweight and obese mother's milk have higher content of long chain fatty acids (LCFAs) (31). Although fat composition in mother's milk varies depending on maternal diet, hind or fore milk, morning/night or day time/early evening feeding, and storage conditions (12,35). Maternal triceps skinfold thickness is the more effective assessment than BMI to correlate milk fat, sugar, and energy with maternal postpartum upper extremities in Tibetan mothers (43) and in other populations (21,26,40). Researcher showed low triceps skinfold thickness was associated with high milk fat (43).

The impact of maternal higher body weight and other anthropometric indices regarding human milk macronutrients is overall complex (44). One study's strengths include employing advanced techniques to evaluate maternal body composition and implementing a milk collection protocol that minimized errors in analyzing macronutrient compositions (7). Although infant's needs, the time of day, foremilk or hindmilk of a particular feeding are the different factors of fluctuation in breast milk volume and nutrient content (12). Further research documenting longitudinal changes in milk composition and maternal status is needed (20). Studies have also suggested impacts of several other factors to change the macronutrient composition of human milk (3,5,7).

A previous study has shown that there is no correlation between macronutrients and breast size, suggesting that having large breasts is not essential for sufficient milk production (19). Additionally, during the first year of lactation period, no variation was reported in composition of protein, energy, lactose and fat content between milk from right and left breasts & preferred and nonpreferred (34,35). Socioeconomic factors could potentially influence variations in the macronutrient content of breast milk (2).

Many studies have reported that insulin concentrations, leptin, CRP levels and adiponectin in human milk (HM) are higher in obese mothers than normal weight mothers (3,10,32,33,47,48,50,51,52).

Conclusion

Investigating breast milk macronutrient composition in relation to maternal anthropometric indices, particularly somatotyping of upper extremities, reveals notable variability. In conclusion, this review underscores a significant relationship between composition of breast milk macronutrient like carbohydrates, proteins and fats and maternal body composition. Nearly, all studies employed BMI as a variable to categorize women into overweight, obese, normal and underweight classifications. While BMI is a widely used measure, it may not always precisely indicate maternal fat mass or body composition. Evidence suggests

that correlations between certain components of human milk and measures of maternal obesity may be more pronounced for fat mass than for BMI. According to the above discussion, we conclude that there is a positive and strong association between breast milk macronutrient composition and maternal body mass or adiposity and somatotypes. High-quality studies by using better analytical instruments and anthropometric indices or variables are required to enhance understanding of the connections between maternal adiposity and the composition of human milk. Adequate and balanced diet is an essential key of mother's health during preconception, pregnancy and lactation stage in influencing the balanced nutritional profile of breast milk composition. Further research on the volume and divergences in macronutrient composition of breast milk is vital due to invaluable nature of this biofluid as a consequence of its energy, lactose, essential amino acids and essential fatty acids value which are crucial for infant's growth and overall development for life long.

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