



Quantitative Assessment of Breastfeeding Practices and Maternal Body Composition in Moroccan Lactating Women during Six Months after Birth Using Stable Isotopic Dilution Technique

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Abstract - The evaluation of breast milk intake is of particular importance for setting future breast-feeding recommendations and to investigate success strategies for breastfeeding promotion. Exclusive breastfeeding during the first 6 months of an infant's life is an important factor for optimal growth and health of the child. Moreover, the assessment of postpartum changes in maternal body composition provides important information. In Morocco, this is the first time that breastfeeding practices and human milk intake have been quantified, and that changes in maternal body composition postpartum have been assessed. This study included 32 mother-baby pairs. The exclusive breastfeeding rate, intake of human milk and water from other sources, and the body composition of the mothers were measured at 1st, 3rd and 6th month postpartum by using the deuterium oxide dose-to-mother technique. Results showed that the exclusive breastfeeding rate was 33.3% at the first month, 26.7% at the third and 12.5% at the sixth. Mean intake of breast milk was 615.6 g/d, 741.9 g/d and 843.6 g/d at 1, 3 and 6 months respectively. As expected, there was a significant change in the mothers' body composition between the first and sixth months. As a proportion of body weight, fat free mass increased by 13.4% and fat mass decreased by 33.4%. In conclusion, the rate of exclusive breastfeeding in Morocco remains low, despite advice on the benefits of breastfeeding, clearly showing a resistance to change the behavior of these mothers.

Keywords - Breast Milk, Exclusive Breastfeeding, Maternal Body Composition, Deuterium

1. Introduction

In the last decade much attention has been paid to the effect of breastfeeding not only on healthy childhood outcomes but also for long term health outcomes, including its role in prevention of adult diseases (WHO, 2002). It is well known that breastfeeding may protect mothers against haemorrhage, overweight and obesity, and certain types of cancer (Lipworth, Bailey, and Trichopoulos, 2000). Maternal milk is an important source of antibodies early in life and provides adequate amounts of minerals, vitamins, and other nutrients during the first 6 months of life. Thus, the World Health Organization (WHO) recommends exclusive breastfeeding during 6 months post-partum, followed by progressive introduction of appropriate complementary foods with continued breastfeeding for up to 2 years (WHO, 2003).

In Morocco, there has been an alarming decline in the practice of exclusive breastfeeding (EB) over the past fifteen

years. Based on questionnaire analysis, the proportion of exclusive breastfeeding until 6 months decreased from 41% in 1997 (Minist ère da la sant édu Maroc, 1977) to 32% in 2004 (Minist ère de la sant é 2004) and is currently around 15% (ENIMSJ, 2006-2007, 2008). According to residence area, this practice seems more common among rural children (18%) than those in urban areas (12%) and among children whose mothers are of primary education level or illiterate (16.5%) than among those whose mothers have a secondary or higher education level (7.6%). The practice of exclusive breastfeeding is more common in children from the poorest households (21.2%) against 9.8% among children from the richest households (ENIMSJ, 2006-2007, 2008).

There is a worldwide lack of reliable information on the quantity of human milk consumed by breastfed infants. This lack of information is due to the difficulty of measuring maternal milk intake by conventional technique, which involves weighing the baby before and after each breastfeed. This technique lacks specificity and can disturb the normal feeding

pattern (Savenije & Brand, 2006). The deuterium oxide dose-to-mother technique can be used to provide quantitative information on the intake of human milk by breastfed infants as well as the intake of water from sources other than human milk, and thus can be used to assess the exclusivity of breastfeeding. Moreover, this technique does not obstruct natural breastfeeding practices and overcomes the limitation of questionnaires. The technique also gives an assessment of the mother's total body water, from which her body composition can be calculated using a two compartment model, which assumes the body is composed of fat and fat free mass (Coward, Cole, Sawyer, Prentice and Orrewing, 1982; Haisma et al., 2003). Assessment of postpartum changes in maternal body composition provides important information on her nutritional status (Larciprete et al., 2003; Mardones-santander, Salazar, Rosso, & Villaroel, 1998). Furthermore, this is the first time that breastfeeding practices and human milk intake has been quantified in Morocco, and that changes in maternal body composition postpartum have been assessed.

In the deuterium oxide dose-to-mother technique, the mother consumes an accurately weighed dose of deuterium oxide, which rapidly equilibrates with her body water, including her milk. Saliva samples are collected from both the mother and her baby during the following two weeks. Deuterium in the baby's body comes only from maternal milk, and therefore an estimate can be obtained of the quantity of human milk consumed by the infant over this period. This technique is precise, non-invasive and does not interfere with the normal breastfeeding practices (Haisma et al., 2003).

The objective of this study was to quantitatively assess the rate of exclusive breastfeeding among Moroccan lactating mothers at 1, 3 and 6 months postpartum and to determine changes in maternal body composition during this period.

2. Materials and Methods

2.1. Design and Target Population

This investigation is a longitudinal study conducted on 32 mother/baby pairs. Women were recruited before delivery, during the third prenatal visit (38th week of gestation) by a pediatrician at the maternity hospital of Rabat, Morocco. The women (aged 18 to 49) had singleton pregnancies and were healthy with no pregnancy complications. Ethical approval was obtained from the Moroccan Ministry of Health. Women were informed of the objectives and protocol of the study and gave their written consent prior to participation. The women also benefited from advice on breastfeeding practices. All measurements were made in the mothers' home. Visits were made at the 1st, 3rd and the 6th month postpartum.

2.2. Anthropometric Measurements

The length of the child was measured to the nearest ± 0.1 cm using a calibrated mobile baby measuring mat (Seca 210). The child was weighed to the nearest ± 0.01 kg using a paediatric scale (Seca 745). The head circumference (HC) of the

infant was measured to ± 0.1 cm using a measuring tape (Seca 201). The body weight of the mothers was measured to the nearest ± 0.1 kg using a floor scale (Seca 761). The mothers' height was measured to the nearest ± 0.1 cm using a wall mounted measuring tape (Seca 206). These measurements were taken at 1, 3 and 6 months postpartum. Body Mass Index (BMI, kg/m^2) of the mothers was calculated at each time point. The infants' Z-scores (weight-for-age, length-for-age, weight-for length, BMI-for-age and head circumference-for-age) were calculated using the software Anthro 200, version 2 (WHO, 2007).

2.3. Deuterium Dose Administration and Collection of Saliva Samples

Quantification of human milk ingested by the infants was determined by the deuterium oxide dose-to-mother technique using a standardized procedure (International Atomic Energy Agency, 2010). Deuterium oxide is water labelled with deuterium, a stable isotope of hydrogen, and presents no radiation hazard to either the mother or her infant. After an oral administration of an accurately weighed dose of deuterium oxide (30 g, 99.8% ^2H , sterility tested) to the mother, saliva samples (at least 2 ml) were collected from both the mother and the baby. Saliva samples were collected at home at time $t = 0$, prior to the administration of the dose, and at 1, 2, 3, 4, 13 and 14 days after administration of the deuterium oxide dose. The date and time of sample collection were recorded on the study information sheet. Samples were placed in a cool box (4°C), transported to the laboratory and stored at -20°C until analysis.

2.4. Measurement of Deuterium Enrichment and Quantification of Human Milk Intake

The enrichment of deuterium in saliva samples was measured by Fourier transform infrared spectrometry (FTIR, Shimadzu Model 8400S). The absorbance was determined from $2300\text{-}2900\text{ cm}^{-1}$. An algorithm (Isotope.exe), developed by the Medical Research Council Collaborative Centre for Human Nutrition (MRC-HNR), Cambridge, UK, was used to calculate the deuterium enrichment by comparing the sample to that of a known concentration of deuterium (1000 mg/kg) (IAEA, 2010; Jennings, Bluck, Wright, & Elia, 1999). Human milk intake and the infants' intake of water from sources other than human milk were calculated using a spreadsheet template, which can be down loaded from the International Atomic Energy Agency's Human Health Campus (<http://nucleus.iaea.org/HHW/Nutrition/MilkIntake/RefsHumanmilkintake/index.html#add>). There is an error associated with the estimate of the baby's intake of water from sources other than human milk because of the assumptions used in the model. This error (25 ± 62 g/d) results in a small apparent intake of water from sources other than human milk in babies who are reported to be completely exclusively breastfed (EB) (Moore, Prentice, & Coward, 2007).

2.5. Determination of Mother's Body Composition

The mothers' total body water (TBW, kg) was calculated using the back-extrapolation technique (IAEA, 2010). Fat free mass (FFM, kg) was determined from TBW using a non-aqueous exchange factor of 1.041. Fat mass (kg) was calculated as the difference between the mother's body weight (kg) and FFM (kg).

2.6. Statistical Analysis

Data were analyzed using Epi-info version 6 and MedCalc 11.5.1. Software. Independent two sample t-tests were used to assess the significance of the difference between means. Significance ($p < 0.05$) was determined at the ninety five per cent confidence level.

3. Results

3.1. Anthropometric Characteristics and Mothers' Body Composition According to Infants' Age

Mothers' mean BMI was 26.2 ± 4.5 kg/m² at the first month and 25.1 ± 3.4 kg/m² at 6 months. There was no significant change in BMI during the six months of the study (Table 1). However, there was a significant change in body composition between the first and sixth months. There was 13.4% increase in fat free mass, ($p=0.003$) and 33.4% decrease in fat mass ($p=0.0001$) (Table 1), this decrease was significant ($p=0.04$) from the 3rd month postpartum (Table 1).

Infants' anthropometric data showed that they did not suffer from any form of malnutrition (Z-scores between -1.28 and 0.78) and showed normal growth during the six months of the study (Table 2).

3.2. Intake of Human Milk and Fluids other than Human Milk

The infants' intake of human milk increased significantly ($p=0.007$) between one and six months, as would be expected (Table 3); 615.6 ± 198.9 g/day during the 1st month, 741.9 ± 281.7 g/day at the third month and 843.6 ± 415.6 g/day at 6 months. The mean amount of liquid other than human milk consumed by infants during the six months of the study also increased significantly ($p=0.001$); 134.8 ± 149.9 g/day in the 1st month to 299.5 ± 101.1 g/day in 6 months (Table 3).

3.3. Breast Milk Intake by Feeding Mode

The prevalence of babies who were EB was 33.3% in the first month, 26.7% in third month and only 12.5% in the sixth (Figure 1). The amount of milk consumed by EB babies during the first and the third month postpartum was 690.3 ± 163.1 g/d and 891.8 ± 206.8 g/d. This amount was ($p=0.0001$) higher than that consumed by babies who were not exclusively breastfed (NEB) (respectively 466.2 ± 189.1 g/d and 442.0 ± 117.5 g/d). At sixth months of age the difference is not statistically significant (Table 4). In addition, the intake of liquids other than human milk varied from 207.3 ± 142.4 g/d

to 434.2 ± 341.8 g/d between the 1st and 6th months postpartum in infants NEB (Table 4).

4. Discussion

The importance of breastfeeding on infant's development and growth and maternal health, is well documented (WHO, 2002; Lipworth, 2000; OMS, 1970; Barkat, Lyaghfour, Alaoui, & Bouazzaoui, 2004). However the protective effect of breastfeeding depends on its duration and its exclusive practice to 6 months (Senarath, Dibley, & Agho, 2010). In Morocco, there has been a decline in the practice of exclusive breastfeeding over the past 15 years. Based on data from self-reported questionnaires, exclusive breastfeeding in Morocco decreased from 41% in 1997 to 32% in 2004 and currently is around 15% [4, 6] unlike other countries where exclusive breastfeeding is practiced by a large proportion of women, such as Cambodia (60.1%), Germany (45%), Indonesia (39%), Syria (38%) and Switzerland (32%) (Senarath *et al.*, 2010; WHO, 2000). In the Moroccan context various and very complicated factors (economic, social or cultural) contribute to the decline of breastfeeding in Morocco. A high percentage of mothers (20%) reported that insufficient milk was the major and direct cause of breastfeeding cessation, but the indirect causes were diverse. Changes in family structure (the mother working more often outside of the home and she contributing considerably in the income of the family), aesthetic concerns (the Moroccan women becoming more interested to their physical appearance), the absence of psychological support for the family and particularly to mothers and lack of training for mothers on good breastfeeding practice were important indirect causes of stopping breastfeeding. Other reasons for breastfeeding cessation included the occurrence of a new pregnancy (8%) and the health of mother (6%) (Rjimati, Chekli and Zerrari, 1999; Lyaghfour, Chekli, Rjimati, and Zerrari, 2005).

In this study we followed the breastfeeding practice of 32 mothers and their infants for six months postpartum. This is the first time that breastfeeding practices and human milk intake has been quantified in Morocco and North Africa. The deuterium oxide dose-to-mother technique made it possible to quantify human milk intake and the intake of water from sources other than human milk and hence to determine whether the mothers practiced exclusive breastfeeding (EB) or not (Larciprete *et al.*, 2003). Thus, our results showed that in the first month 33.3% of mothers practiced EB while, despite our efforts in raising mothers' awareness about the importance of EB, only 12.5% of women practiced EB at the end of the study (6 months). This is below the expectations of the national program for breastfeeding promotion, which has set a rate of 50% of EB at the age of 6 months by the year 2012 (WHO, 2004). In Morocco, as other developing countries, the non-practice of EB until 6 is mainly due to the ignorance of the mothers of the impact on health, performance and productivity of EB. Moreover, negative beliefs, for example, fear

that human milk alone is insufficient to meet the nutritional needs of babies, and the necessity to work outside the home, play significant role in premature cessation of EB (Lyaghfour et al., 2003).

Elsewhere, according to WHO and UNICEF, the total volume of maternal milk production and infant milk intake is highly variable, and although a mean milk intake by infants between 1 and 6 months is quoted to 650 and 850 g/day, values ranging from very little volume to more than 1 liter a day, depending on the frequency and effectiveness of infant suckling (WHO, 2003). In our study, the quantity of human milk intake ranged from 615.6 ± 198.9 g/day in the first month to 843.6 ± 415.6 g/day at the 6th month after birth, which is within the normal range of human milk intake according to WHO and UNICEF.

The deuterium oxide dose-to-the-mother technique has been used in some other populations with different ethnicity and culture. The EB data obtained from Moroccan children at 3 months of age (891.8 ± 206.8 g/d) is similar than observed in Bangladesh (889.8 ± 175.6 g/d) (Moore et al., 2007), Mexico (885 ± 146 g/d) (Villalpando et al., 1992), Papua New Guinea (863 ± 157 g/d) (Orr-Ewing, Heywood, & Coward, 1986) and the Gambia (820 ± 38 g/d) (Coward et al., 1982). At 6 month, the quantity of human milk consumed by EB infants is highly variable. The amount consumed by Moroccan EB infants (984.8 ± 252.5 g/d) is similar to that reported from Mali (909 ± 157 g/d) (Galpin et al., 2007), but is higher than observed in Pakistan (757 ± 249 g/d) (Nazlee, Bilal, Latif, & Bluck, 2011) or in Mexico (869 ± 150 g/d) (Villalpando et al., 1992). This could be partly due to the children being smaller, particularly in Pakistan.

Direct markers of nutritional status of lactating mothers, such as body composition may provide direction for public health and nutrition policy, to our knowledge, information on changes in body composition of lactating women are limited and poorly documented particularly in Arab and African countries. In this study, the FFM of lactating women increased by 13.4% during six months of lactation. However, the body fat compartment decreased very significantly by about 33%. This is in perfect agreement with the literature which have observed an increase in FFM and a decrease in body fat compartment during the six months of lactation after child birth (Sohlstrom & Forsum, 1995; Sadurskis, Kabir, Wager, & Forsum, 1988), excepting for Goldberg *et al.* who reported a non-significant increase in FM between 1 and 3 months postpartum (Goldberg et al., 1991). Furthermore, the change rate in mothers' body compartments differs between studies and depends on several factors; namely weight gain before birth, level of physical activity, stage of lactation, the mother's nutritional status, cultural practices and food availability (Butte & Hopkinson, 1998; Robinson, 1986).

Although evaluation of communication strategies was not part of the study design, the rate of exclusive breastfeeding in the study cohort remained low despite the mothers receiving advice on the benefits of breastfeeding throughout the study. This clearly indicates a need for more innovative, culturally

appropriate, communication strategies on the benefits of exclusive breastfeeding (at all levels from health policy makers to lactating mothers and their families), to overcome resistance to change and make it easier for mothers to continue breastfeeding, whatever their circumstances. Further discussion of this matter is beyond the scope of this manuscript.

In conclusion, this study, the first to be conducted in the North of Africa, provides new information on the amount of human milk consumed by breastfed infants less than 6 months old. The rate of exclusive breastfeeding in the study cohort remains low despite the mothers receiving advice on the benefits of breastfeeding throughout the study, showing clearly a resistance to change the behaviour of these mothers and the need for alternative communication strategies to encourage exclusive breastfeeding until 6 months for optimum child growth and health.

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Appendix

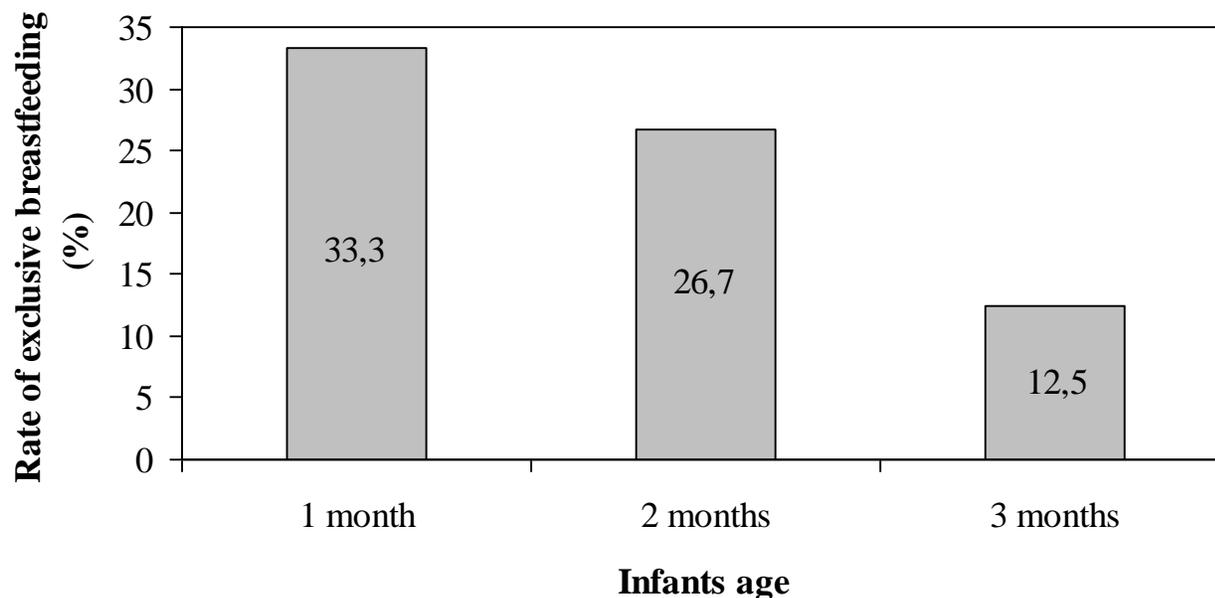


Figure 1. Rate of exclusive breastfeeding in infants under 6 months

Table I. Maternal anthropometric and body composition characteristics at one, three, and six months postpartum (n=32).

	1 month	3 months	6 months	% Change Between 1 and 6 months
Age (y)		28.1 ± 6.6		
Height (cm)		158.0 ± 0.05		
Weight (kg)	67.0 ± 11.5	63.3 ± 11.0	63.0 ± 8.1	- 6.0
BMI (kg/m ²)	26.2 ± 4.5	25.2 ± 4.3	25.1 ± 3.4	- 4.2
FFM (kg)	38.2 ± 6.0	39.1 ± 6.0	43.3 ± 7.2 ^{ab}	+ 13.4
FM (kg)	28.7 ± 8.0	24.0 ± 10.0 ^a	19.1 ± 9.4 ^{ab}	- 33.4
FM (%)	42.5 ± 7.1	37.5 ± 6.6 ^a	29.6 ± 6.1 ^{ab}	- 30.4

a: significantly different from 1 month (p <0.05); b: Significantly different from 3 months (p <0.05).

Table II. Infant's anthropometric characteristics by age (n=32)

	1 month	3 months	6 months
Sex ratio (Male / Female)	13/19		
Length (cm)	51.9 ± 2.8	59.3 ± 2.2	68.7 ± 5.4
Weight (kg)	3.89 ± 0.52	5.84 ± 0.85	8.08 ± 0.86
Head circumference, HC (cm)	35.8 ± 1.8	39.0 ± 2.4	43.5 ± 1.9
Z-score Weight/Height	0.43 ± 1.27	0.34 ± 1.20	0.27 ± 1.23
Z-score Weight/Age	-0.91 ± 1.44	-0.28 ± 1.38	0.53 ± 1.41
Z-score Height/Age	-1.28 ± 1.67	-0.57 ± 1.62	0.78 ± 1.64
Z-score BMI/Age	-0.34 ± 1.49	0.14 ± 1.51	0.21 ± 1.45
Z-score HC/Age	-1.03 ± 1.23	-0.65 ± 1.31	0.59 ± 1.27

Table III. Mean amount (g/day) of human milk and water from sources other than human milk consumed by children during the first, the third and the sixth months postpartum.

	Mean (SD) human milk consumed by infants (g/day)	Mean (SD) water from sources other than human milk consumed by infants (g/day)
1 m (n=32)	615.6 ± 198.9 ^a	134.8 ± 149.9 ^a
3 m (n=32)	741.9 ± 281.7 ^b	212.0 ± 239.5 ^{ab}
6 m (n=31)	843.6 ± 415.6 ^b	299.5 ± 101.5 ^b

a: significantly different between human milk consumed (p <0.05); b: Significantly different between sources other than human milk consumed (p <0.05).

Table IV. Mean (SD) daily intake of human milk and water from other sources by feeding mode.

Age of infant	Exclusively breastfed		Non-exclusively breastfed		P
	Human milk intake (g/day)	Other liquid (g/day)	Human milk intake (g/day)	Other liquid (g/day)	
1 month	690.3 ± 163.1	5.8 ± 1.0	466.2 ± 189.1	207.3 ± 142.4	<0.0001
3 months	891.8 ± 206.8	2.5 ± 0.5	442.0 ± 117.5	281.8 ± 238.6	<0.0001
6 months	984.8 ± 252.5	9.3 ± 6.4	877.0 ± 398.5	434.2 ± 341.8	0.2082