Maternal and infant essential fatty acid status in Havana, Cuba¹–³

Julia M Krasevec, Peter J Jones, Alejandrina Cabrera-Hernandez, D Luisa Mayer, and William E Connor

ABSTRACT

Background: Adequate intake of essential fatty acids (EFAs) is required for optimal development of the central nervous system and visual acuity in infants. Little information exists regarding the EFA status of vulnerable populations living in Southern regions.

Objective: We examined the adequacy of EFA status in Cuban breast-feeding mothers and their infants.

Design: Blood and breast-milk samples were obtained from a cross-sectional sample of mothers and term infants in Havana at 2 mo postpartum. We determined the fatty acid profiles of total lipids in breast milk, plasma, and erythrocytes and assessed infant visual acuity by using Teller acuity cards.

Results: Of the 56 mothers and infants examined, none showed biochemical signs of poor EFA status. Compared with values reported in the literature, mothers had an adequate EFA profile in their breast milk, plasma, and erythrocytes. The docosahexaenoic acid (DHA) concentration in breast milk was 0.43 ± 0.26% of total fatty acids. It appeared that these breast-fed infants had an adequate dietary supply of DHA, as reflected by the mean plasma and erythrocyte DHA concentrations (2.82 ± 0.84% and 7.41 ± 1.16% of total fatty acids, respectively). Infant visual acuity testing showed a mean of 2.00 ± 0.68 cycles/degree, which is within the normal range of mean binocular acuities for 2-mo-old term infants. The data did not show any relation between EFA concentrations and visual acuity.

Conclusion: The results suggest that n–3 fatty acid deficiency and potential related deficits in early visual neural development are rare, if they exist at all, in breast-feeding women and their infants in Havana. Am J Clin Nutr 2002;76:834–44.

KEY WORDS Essential fatty acids, human milk, breast milk, breast-feeding, infant nutrition, maternal nutrition, visual acuity, visual development, brain development, central nervous system, Cuba, docosahexaenoic acid, n–3 fatty acids

INTRODUCTION

Early infancy is a period of rapid brain growth; this requires an adequate intake of essential fatty acids (EFAs), especially those of the n–3 series, for optimal neurologic development (1, 2). It is therefore important to provide infants with breast milk or formula containing adequate amounts of EFAs. The need for adequate n–3 EFA consumption during early development has also been shown in animal models (3, 4), in which there were detrimental effects of diets that were very low in n–3 fatty acids. Of all the EFAs, the most important for the development of the central nervous system (CNS) are docosahexaenoic acid (DHA) and arachidonic acid (AA). However, AA is found in relatively large amounts in the membranes of all tissues, whereas DHA is relatively scarce in nonneuronal membranes (5). Because visual function may be affected when optimal intakes are not achieved, tests of visual acuity can be performed to assess the adequacy of development (1, 2).

In Cuba, a combination of factors caused people to have difficulties in obtaining an optimal diet through the early to mid 1990s. Consequently, the possibility of poor EFA intakes in Cuba was suspected. A serious health problem that surfaced during this period was an epidemic of optic and peripheral neuropathies; occurring between 1991 and 1996, this affected nearly 50 000 inhabitants. The clinical manifestations included blurred vision, photophobia, loss of visual acuity, loss of color vision, burning pain in the extremities, decreased or absent ankle reflexes, and increased urinary frequency (6, 7). Morphologic characterization of the peripheral nervous system lesions showed that they were compatible with nutritional, toxic, or metabolic etiologies and were not of viral, genetic, or inflammatory origin (6).

The exact etiology of the epidemic has not yet been determined. However, neuropathies of nutritional origin usually involve generalized signs of undernutrition, such as loss of subcutaneous fat (8). The per capita weight loss among Cuban adults between 1992 and 1993 was 4.5–9 kg, with greater losses reported in individuals who developed the neuropathy (9). Because the type of malnutrition involved loss of body fat, it appears that aberrant fatty acid metabolism may have played a role in the onset of the epidemic, along with other potential factors such as B-vitamin deficiencies. It is generally difficult to produce n–3 fatty acid deficiency because n–3 fatty acids present in the CNS are aggressively conserved (10). However, previous articles reported human n–3 fatty acids...
acid deficiency that caused symptoms similar to those of the Cuban epidemic (11, 12).

The objective of the current study was to examine the adequacy of EFA status in a group of Cubans who would have a particularly high risk of developing the negative effects of poor n−3 fatty acid intake, namely breast-feeding mothers and their infants. It was hypothesized that EFA status and infant visual acuity, which reflected differences in dietary EFA intakes in some studies (13–15), would be subnormal in Cuban women and infants.

SUBJECTS AND METHODS

Subject characteristics and anthropometry

Seventy-three pregnant women were recruited to participate in the present investigation. Potential subjects were recruited in the pre-delivery room of the maternity ward of America Arias Maternity Hospital, which serves residents of Old and Central Havana. The inclusion criteria, evaluated from the medical history, included 1) experiencing a normal pregnancy with no medical risks that may affect fatty acid metabolism, including heart disease, kidney disease, gestational or other diabetes, hypertension, gallbladder disease, or thyroid disease; 2) being a resident of Central or Old Havana; and 3) being between the ages of 17 and 36 y. All subjects provided informed consent. The study procedures were in accordance with ethical standards for human experimentation of the Cuban Ministry of Health, which are consistent with the Helsinki Declaration of Human Rights.

At enrollment, a questionnaire concerning socioeconomic, demographic, and behavioral factors was completed. Anthropometric data, including maternal weight gain during pregnancy and infant birth weight as recorded by family practitioners and hospital staff, were obtained from the medical histories. One to 2 d after delivery, mothers and infants underwent additional anthropometric measurements, which were taken by 2 anthropometrists involved in the project with the use of international standards (16). Infants were weighed without clothes to the nearest gram on a pediatric pan scale. Infant length was measured to the nearest mm with an infantometer. Mothers were weighed while wearing a minimal amount of clothing on a platform beam scale. Maternal height was measured with a stadiometer. Anthropometric measurements were also taken at 2 mo postpartum, with the same methods and by the same anthropometrists who had taken them at birth.

Infant feeding practices and maternal diet

Other information, including infant feeding practices, was also collected at 2 mo postpartum. These data showed that the infants were either exclusively breast-fed (n = 31; 55%), fed with a combination of breast milk and bottle-feeding (n = 22; 39%), or not fed any breast milk (n = 3; 5%). The most common supplemental milk fed to these infants was a cow milk formulation made with skim milk powder and vegetable oil. This was probably because the cow milk formulation was most readily available to all families as it was provided through the ration system. EvaNotorated milk and yogurt were also used, but only by a small number of subjects. The fatty acid profile of the cow milk formulation was analyzed (data not shown), and it was consistent with infant formulas available in North America. Supplemental milks had been fed for an average of 2–4 wk before the 2-mo study visit. More specific data on feeding practices are not available, although part of the questionnaire, because this information was not recorded for one-third of the infants who were weaned.

At the time of the study, all Cubans received 227 g of a high-fat fish, Trachurus mediterraneus, every week through the ration system. Thus, all the subjects received this amount of fish before and during their pregnancies. While breast-feeding, they received a greater quantity of the same fish (454 g/wk). Therefore, a dietary source of long-chain EFAs was readily available to the subjects before, during, and after their pregnancies.

Blood and breast-milk sampling

At 2 mo postpartum, breast-milk samples were collected with a method designed to assure a representative fat content in each sample, as described by Jensen (17), with the exception that an afternoon sample was not obtained because of logistical constraints. The method for obtaining milk samples was as follows. The mother was asked to nurse her infant on the breast of her hand of dominance until the infant was satisfied. She was then assisted in applying the electric breast pump (The Lactina; Medela, Baar, Switzerland) to the dominant breast to ensure complete emptying of the breast. Milk extracted at this stage was not used for the analysis. After 1.5 h, the dominant breast was washed with distilled water. The breast pump was applied to the breast for ≈8 min to obtain a sample. Breast-milk samples were placed on ice with butylated hydroxytoluene, which functioned as an antioxidant, and were immediately frozen at −70°C.

At 2 mo postpartum, venous blood samples were obtained from the mothers and infants. All blood samples were collected into evacuated tubes containing EDTA and were placed immediately into an ice bath. Samples were centrifuged at 2333 × g for 15 min at 4°C. Plasma was removed and placed into tubes containing butylated hydroxytoluene in methanol. Plasma was then flushed with nitrogen gas and frozen at −70°C. Erythrocytes were washed with 0.15 mol NaCl/L and 1 mmol EDTA/L and were stored in a similar manner. Samples were transported from Cuba to Canada on ice packs frozen at −70°C and were placed on dry ice upon arrival in Canada (≈6 h after storage with ice packs). Samples were then transferred to a −70°C freezer until analyzed.

Lipid extraction and analyses

For each fatty acid of interest, we determined the relative percentage of total fatty acids (% by wt of total fatty acids) in the lipids of erythrocytes, plasma, and breast milk. This was accomplished by using gas-liquid chromatography after lipid extraction (18) and boron trifluoride methylation (19). For breast-milk samples, lipase activity was inactivated by heating samples rapidly to 80°C for 1.5 min (20) before extraction and methylation. The gas chromatograph (model 5890 series II; Hewlett-Packard, Palo Alto, CA) was equipped with an autosampler and flame ionization detectors. Separation was achieved on an SP2330 (Supelco, Bellefonte, PA) 30-m capillary column with an internal diameter of 0.2 mm and a 0.25-μm film thickness. The split ratio was 50:1. The oven temperature was held at 100°C for 1 min and increased to 190°C at a rate of 3°C/min, after which it was held at this temperature for the remainder of the run. Individual fatty acids were identified against standards (Supelco) by using retention times.

Visual acuity testing

Each infant’s binocular visual acuity was tested by a trained examiner (JMK) with Teller acuity cards (Vistech Consultants,
showed each card the infant’s threshold card could be determined. The examiner began by showing the infant the start card (0.32 cycles/cm) and proceeded to show finer gratings until the infant either detected or did not detect the grating on that card. The examiner remained unaware of the right or left position of the grating on each card until she made a final judgement that the infant’s threshold or acuity. Reliability between examiner and manufacturer. The examiner began by showing the infant the start card. In the set, there are 16 cards, each containing a grat- 0.5-octave steps.

The adequacy of infant growth was assessed by calculating z scores for weight, length, and head circumference. Weight and length z scores were calculated by using World Health Organization reference values by sex (23), which are presented as medians at monthly intervals. Head circumference reference data were obtained from Roche et al (24). Other anthropometric data were not compared with reference values.

Statistical analyses

Before the statistical analyses, all visual acuity data were transformed to obtain values in an octave scale rather than a linear scale, because behavioral sensory functions are linear with the logarithm of stimulus intensity (22). The mean and SD of the log₂ values for acuity were used in the analyses. For reporting, the mean was transformed back to the linear value in cycles/degree, whereas the SD remained in the log₂ octave scale (22).

All statistics were performed with SAS, version 6.12 (SAS Institute Inc, Cary, NC). All continuous data were evaluated for the presence of outliers and for normality. This procedure was done for each variable in 1) the entire subject population, 2) the group that was exclusively breast-fed, 3) the group that was not exclusively breast-fed, 4) the group that was not followed after birth (baseline data only), and 5) the group that was followed after birth. Variables for which potential outliers were indicated on boxplot printouts were further assessed by using the extreme studentized deviate procedure for the detection of single or multiple outliers (25). To assess whether the lack of normality for some variables resulted from the presence of outliers, the test for normality was performed after the outliers were removed. Variables were considered not normally distributed if the Wilke statistic had a P < 0.05. Because some variables were not normally distributed even after outliers were removed, analyses of certain variables were performed with nonparametric methods. Correlations in non-normally distributed data were performed by using Spearman correlations and Wilcoxon rank-sum tests in lieu of t tests for non-normally distributed variables.

Unpaired student t tests were used to compare differences in continuous descriptive variables between the group of subjects...
that attended the 2-mo appointment and the group that did not. The relations between EFA profiles and infant visual acuity were assessed with correlations; separate analyses were done for the entire subject population, the group that was exclusively breast-fed, and the group that was not exclusively breast-fed (ie, the 2 feeding groups). Individual EFAs, groups of EFAs, and ratios of EFAs in infant plasma and erythrocytes were also correlated with age- and sex-standardized anthropometric measures to assess whether any EFA was related to growth. Visual acuity and standardized infant anthropometric measures were also correlated with EFA profiles of maternal tissues for the exclusively breast-fed infants. For variables that had outlying values as assessed by the extreme studentized deviate procedure (25), all correlations were calculated both with and without those subjects’ values to assess whether they were influential (26). To further explore whether exclusive breast-feeding had an effect on the data, unpaired t tests were performed to compare the 2 feeding groups; variables tested in this manner were the fatty acid concentrations in infant plasma and erythrocytes, visual acuity, and anthropometric measures standardized for age and sex.

RESULTS

Descriptive data and anthropometry

Of the 73 mothers enrolled, 56 returned for the 2-mo visit (the followed group) and 17 did not return (the not-followed group). Descriptive data for these 2 groups of women and infants are shown in Table 1. Because some of the data were obtained from the medical histories, and not all the histories were complete, there are missing data for some subjects. The followed group was generally representative of the initial group of 73 subjects.

Among the mothers and infants who returned at 2 mo, anthropometric data were not obtained from 3 subjects at birth and 1 subject at 2 mo because the subjects were not present when the anthropometrists were in the hospital. For all infants who were measured at 2 mo, box plots of percentiles for z scores for length, weight, and head circumference are shown in Figure 1. Comparisons with the reference data indicate that these infants achieved adequate growth for age and sex, as a group, at birth and 2 mo postpartum.

Fatty acid profiles of breast milk

All subjects, including those with values that were outliers, were included in the analyses of measures of central tendency for breast-milk and blood fatty acid profiles (Tables 2, 3, and 4). However, all fatty acids were not normally distributed, and therefore medians and ranges are shown along with the means and SDs. A total of 52 mature human milk samples obtained at 63 ± 4 d postpartum were analyzed for total fat content and fatty acid profile. Of the 53 mothers who were lactating, it was possible to obtain 52 samples; 1 mother refused because she was afraid to use the breast pump. The total lipid content of the milk samples was 53 ± 18 g/L (range: 35–140 g/L). Measures of central tendency

![Figure 1](https://academic.oup.com/ajcn/article-abstract/76/4/834/4677463/figure1)
and ranges for the 18 fatty acids identified in breast milk are shown in Table 2. DHA and AA contents of breast milk were 0.43 ± 0.26 and 0.67 ± 0.15% by wt of total fatty acids, respectively, with an average ratio of AA to DHA of 1.99. Maternal breast milk DHA and AA contents were compared with values measured in other countries (13–15, 27–45); these comparisons are shown in Figures 2 and 3, respectively.

Fatty acid profiles of maternal plasma and erythrocytes

A total of 55 maternal plasma samples and 50 maternal erythrocyte samples were analyzed for fatty acid composition. The reasons for missing samples included that 1 blood sample was not obtained and technical errors occurred for 5 erythrocyte samples. The fatty acid profile of the maternal plasma and erythrocyte samples is shown in Table 3. In maternal plasma, the DHA and AA contents were 2.56 ± 0.84 and 8.74 ± 1.69% by wt of total fatty acids, respectively, with an average ratio of AA to DHA of 3.78. In maternal erythrocytes, the DHA and AA contents were 2.82 ± 0.84 and 6.35 ± 1.81% by wt of total fatty acids, respectively, with a ratio of AA to DHA of 2.41. Maternal erythrocyte EFA contents are compared with values reported in the literature (13, 48) in Table 6.

Visual acuity data

To assess intraexaminer reliability of measured visual acuity, we completed a test-retest protocol with 12 infants. Eleven of the 12 were retested within 12 h of the initial test, whereas 1 infant returned the following week to be retested. Test scores on retest were identical for 6 of the 12 infants, a one-card difference (0.5 octave) was obtained for 1 infant. Thus, 92% of the retest scores were within 1 card of the initial test result, which is considered acceptable test-retest reliability (49). Attempts were made to test all the study infants for visual acuity, yet it was only possible to test 54 of the 56 because of persistent sleepiness and irritability (infant blood samples were drawn before visual acuity testing). The scores for all tested infants fell within the 99% prediction
limits for 2.5-mo-old infants (49) and were normally distributed. The group mean (±SD) of 2.00 ± 0.68 cycles/degree is within the range of binocular acuity data obtained from full-term, normally developing infants (49, 50).

There were no significant correlations between either visual acuity scores or infant anthropometric measurements and any individual EFA concentration, ratio of EFA concentrations, or concentrations of groups of EFAs in infant tissues. This was the case when assessing the entire subject group and also when assessing each feeding group separately. There were no relations between EFA profiles of maternal tissues for exclusively breast-feeding infants and visual acuity or infant anthropometric measurements and any fatty acid profiles between exclusively breast-feeding infants and infants not exclusively breast-feeding. Conversely, 18:3n−3 concentrations were lower in exclusively breast-fed infants than in infants not exclusively breast-fed. However, concentrations of long-chain n−3 and n−6 fatty acids (AA and DHA) were similar in the 2 feeding groups. No differences in anthropometric measurements between the feeding groups were found.

**DISCUSSION**

The present data suggest that EFA deficiencies were exceedingly rare, if they existed at all, in breast-feeding women and their infants in Havana in 1998. The blood and breast-milk DHA concentrations found in Cuban infants and their mothers correspond to the higher end of the range of values reported in the literature (Tables 2–4).

In the current study, breast-milk fatty acid profiles were indicative of a population that eats a balanced diet in terms of energy, fat, and carbohydrate contents. Breast-milk EFA profiles were similar to those of other populations (46, 51), and their placement within the spectrum of values from other countries (Figures 2 and 3) indicates that Cuban concentrations were slightly above average. Cuban DHA concentrations were higher than those found in many developed countries (29–31, 33). Concentrations of intermediate- and medium-chain (IMC) saturated fatty acids (SFAs; 8:0–14:0) fell between values measured in Western countries and significantly higher in exclusively breast-fed infants than in infants not exclusively breast-fed. Conversely, 18:3n−3 (α-linolenic acid; ALA) concentrations were lower in exclusively breast-fed infants than in infants not exclusively breast-fed. However, concentrations of long-chain n−3 and n−6 fatty acids (AA and DHA) were similar in the 2 feeding groups. No differences in anthropometric measurements between the feeding groups were found.

**Effect of infant feeding method**

To evaluate any possible effect of feeding method (ie, exclusive or not exclusive breast-feeding) on visual acuity, infant plasma or erythrocyte fatty acid contents, or anthropometric measurements, visual acuity scores were compared between the 2 feeding groups. Mean values for binocular acuity of the 2 feeding groups were not significantly different, as shown in **Figure 4**.

Differences in n−6 and n−3 fatty acid profiles between exclusively breast-fed infants and infants not exclusively breast-fed (ie, at least partially weaned to different milks) are shown in **Table 7**. Note that concentrations of 18:2n−6 (linoleic acid; LA) were significantly higher in exclusively breast-fed infants than in infants not exclusively breast-fed. Conversely, 18:3n−3 concentrations were lower in exclusively breast-fed infants than in infants not exclusively breast-fed. However, concentrations of long-chain n−3 and n−6 fatty acids (AA and DHA) were similar in the 2 feeding groups. No differences in anthropometric measurements between the feeding groups were found.

**Table 4** Fatty acid composition of total lipids in plasma and erythrocytes from Cuban infants at 2 mo of age.

<table>
<thead>
<tr>
<th>Fatty acid</th>
<th>Infant plasma (n = 31)</th>
<th>Infant erythrocytes (n = 33)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x ± SD</td>
<td>Range</td>
</tr>
<tr>
<td>12:0</td>
<td>0.56 ± 0.56</td>
<td>0.0–2.0</td>
</tr>
<tr>
<td>14:0</td>
<td>3.28 ± 1.13</td>
<td>1.4–5.4</td>
</tr>
<tr>
<td>16:0</td>
<td>22.98 ± 2.84</td>
<td>18.3–29.7</td>
</tr>
<tr>
<td>18:0</td>
<td>7.03 ± 1.17</td>
<td>5.0–9.1</td>
</tr>
<tr>
<td>16:1−7</td>
<td>3.68 ± 1.96</td>
<td>1.5–11.0</td>
</tr>
<tr>
<td>18:1n−9 + 18:1n−7</td>
<td>26.03 ± 5.47</td>
<td>18.7–35.0</td>
</tr>
<tr>
<td>18:2n−6</td>
<td>23.11 ± 7.71</td>
<td>6.7–36.3</td>
</tr>
<tr>
<td>18:3n−6</td>
<td>0.48 ± 0.21</td>
<td>0.1–1.0</td>
</tr>
<tr>
<td>20:3n−6</td>
<td>1.27 ± 0.40</td>
<td>0.6–2.2</td>
</tr>
<tr>
<td>20:4n−6</td>
<td>6.35 ± 1.81</td>
<td>3.1–9.7</td>
</tr>
<tr>
<td>22:4n−6</td>
<td>1.06 ± 0.57</td>
<td>0.4–2.3</td>
</tr>
<tr>
<td>18:3n−3</td>
<td>0.56 ± 0.35</td>
<td>0.2–1.7</td>
</tr>
<tr>
<td>20:5n−3</td>
<td>0.41 ± 0.17</td>
<td>0.1–0.9</td>
</tr>
<tr>
<td>22:5n−3</td>
<td>0.29 ± 0.17</td>
<td>0.1–0.7</td>
</tr>
<tr>
<td>22:6n−3</td>
<td>2.82 ± 0.84</td>
<td>1.1–4.9</td>
</tr>
<tr>
<td>Total PUFAs</td>
<td>35.91 ± 9.54</td>
<td>17.3–46.8</td>
</tr>
<tr>
<td>Total n−6 FAs</td>
<td>31.84 ± 9.58</td>
<td>13.3–44.3</td>
</tr>
<tr>
<td>Total n−3 FAs</td>
<td>4.08 ± 0.92</td>
<td>2.4–6.4</td>
</tr>
<tr>
<td>Total n−6/total n−3 FAs</td>
<td>8.28 ± 3.49</td>
<td>2.5–18.5</td>
</tr>
<tr>
<td>ΣLC n−6 FAs²</td>
<td>8.66 ± 2.10</td>
<td>4.6–12.1</td>
</tr>
<tr>
<td>ΣLC n−3 FAs³</td>
<td>3.52 ± 0.35</td>
<td>1.9–6.1</td>
</tr>
<tr>
<td>ΣLC n−6/ΣLC n−3 FAs⁴</td>
<td>2.57 ± 0.72</td>
<td>1.4–4.5</td>
</tr>
<tr>
<td>Total SFAs</td>
<td>34.08 ± 3.91</td>
<td>28.1–42.5</td>
</tr>
<tr>
<td>Total MUFAs</td>
<td>29.90 ± 7.19</td>
<td>20.8–44.2</td>
</tr>
</tbody>
</table>

¹ND, not detectable; PUFAs, polyunsaturated fatty acids; FAs, fatty acids; LC, long chain (20–22 carbons); SFAs, saturated fatty acids; MUFAs, monounsaturated fatty acids.

²Sum of all LC n−6 FAs.

³Sum of all LC n−3 FAs.

⁴Ratio of the sum of all LC n−6 FAs/sum of all LC n−3 FAs.
values measured in developing countries (28, 34, 35), being closer to those of populations consuming Western diets (37, 40, 42). If dietary DHA is important in the development of the brain and the retina, then it is apparent that Cuban infants whose mothers received a daily ration of fish had considerable advantage over American and Australian infants. The DHA concentration in milk of Cubans was 0.43 ± 0.26% of total fatty acids, which is higher than any US value (Figure 2). Cuban mothers also had higher

### TABLE 5

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18:2n-6</td>
<td>11.50 ± 1.91</td>
<td>8.2 ± 2.6</td>
<td>9.6 ± 1.2</td>
<td>NA</td>
</tr>
<tr>
<td>20:4n-6</td>
<td>15.67 ± 1.48</td>
<td>12.9 ± 5.2</td>
<td>14.6 ± 1.3</td>
<td>NA</td>
</tr>
<tr>
<td>18:3n-3</td>
<td>0.35 ± 0.12</td>
<td>0.09 ± 0.06</td>
<td>0.03 ± 0.04</td>
<td>NA</td>
</tr>
<tr>
<td>22:6n-3</td>
<td>6.80 ± 1.24</td>
<td>4.5 ± 1.7</td>
<td>5.6 ± 1.1</td>
<td>4.08 ± 1.13</td>
</tr>
<tr>
<td>Total n-6 FAs</td>
<td>35.35 ± 2.10</td>
<td>26.7 ± 9.2</td>
<td>30.0 ± 0.8</td>
<td>5.97 ± 1.19</td>
</tr>
<tr>
<td>Total n-3 FAs</td>
<td>10.20 ± 1.36</td>
<td>6.2 ± 2.2</td>
<td>9.2 ± 1.6</td>
<td>NA</td>
</tr>
<tr>
<td>n-6 FAs/n-3 FAs</td>
<td>3.51 ± 0.56</td>
<td>4.3 ± 0.3</td>
<td>3.3 ± 0.6</td>
<td>NA</td>
</tr>
</tbody>
</table>

\(^1\text{SD. FAs, fatty acids; NA, not available.}\)

\(^2\text{Baseline, before fish oil supplementation.}\)

\(^3\text{After fish oil supplementation.}\)

\(^4\text{At delivery, before fish oil supplementation.}\)

\(^5\text{At delivery, after fish oil supplementation.}\)
erythrocyte DHA: 6.80 ± 1.24% compared with 4.08% ± 1.13% of total fatty acids (Table 5). The DHA content of erythrocytes in Cuban breast-fed infants 2-mo postpartum was 7.4% of total fatty acids (Table 5). The DHA content of erythrocytes in Cuba Makrides et al (13) reported that trans fatty acids. It has been reported that trans fatty acids limit the formation of the precursors than people consuming typical Western diets. The Cubans may have been ingesting higher amounts of long-chain EFAs than is typical of Western diets. The Cubans may also have had a better capacity to form long-chain EFAs from their precursors than people consuming typical Western diets, which are known to be high in trans fatty acids. It has been reported that trans fatty acids limit the formation of the precursors of long-chain EFAs (30). Because all the women in the current study received 454 g of a high-fat fish, Trachurus mediterraneus, each week, a dietary source of long-chain EFAs was readily available.

Blood samples obtained from the Cuban infants indicated that their EFA status appeared normal at 2 mo of age. Their plasma and erythrocyte EFA profiles appeared similar to those of infants receiving formula enriched with DHA and AA or breast milk in Western countries (Table 6) and appeared higher than EFA profiles of infants fed standard formula (13, 48, 57). This may have been because most infants were receiving some breast milk, and for those with complete records, weaning was generally initiated shortly (1–4 wk) before sample collection. In most cases, infants not exclusively breast-fed received a milk preparation containing vegetable oil that the mothers received through the ration system.

Differences between feeding groups in fatty acid profile included significantly higher amounts of n−6 fatty acids in exclusively breast-fed infants (Table 7). This is logical because the fatty acid profile of the skim milk powder preparation (data not shown) was

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18:2n−6</td>
<td>10.33 ± 1.93</td>
<td>8.7 ± 0.9</td>
<td>11.7 ± 1.0</td>
<td>10.5 ± 0.6</td>
<td>8.44 ± 1.08</td>
<td>11.02 ± 0.86</td>
<td>10.52 ± 0.93</td>
<td>6.43 ± 0.31</td>
</tr>
<tr>
<td>20:4n−6</td>
<td>16.48 ± 1.82</td>
<td>15.1 ± 1.4</td>
<td>12.9 ± 1.3</td>
<td>10.2 ± 1.0</td>
<td>17.15 ± 0.90</td>
<td>14.81 ± 0.99</td>
<td>14.53 ± 0.76</td>
<td>13.37 ± 1.05</td>
</tr>
<tr>
<td>18:3n−3</td>
<td>0.36 ± 0.15</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.11 ± 0.08</td>
<td>0.24 ± 0.04</td>
<td>0.44 ± 0.07</td>
<td>0.37 ± 0.04</td>
</tr>
<tr>
<td>22:6n−3</td>
<td>7.41 ± 1.16</td>
<td>5.5 ± 1.0</td>
<td>2.5 ± 0.3</td>
<td>6.3 ± 0.7</td>
<td>6.55 ± 1.23</td>
<td>3.47 ± 0.46</td>
<td>4.78 ± 0.45</td>
<td>4.48 ± 0.49</td>
</tr>
<tr>
<td>Total LC n−6 FAs</td>
<td>24.17 ± 2.52</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>24.71 ± 1.73</td>
<td>22.24 ± 1.21</td>
<td>20.92 ± 0.62</td>
<td>19.52 ± 1.03</td>
</tr>
<tr>
<td>Total LC n−3 FAs</td>
<td>8.88 ± 1.20</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>8.59 ± 1.58</td>
<td>5.97 ± 0.76</td>
<td>8.98 ± 0.65</td>
<td>9.30 ± 0.95</td>
</tr>
</tbody>
</table>

\*x ± SD. LC, long chain; FAs, fatty acids; NA, not available.

*Breast-fed infants at 4 mo.

†Infants fed standard formula at 4-mo.

‡Infants fed enriched formula at 4 mo.

§Infants fed formula at 10 wk.

Infants fed formula with a high ratio of linoleic acid to α-linolenic acid at 10 wk.

Infants fed formula with a low ratio of linoleic acid to α-linolenic acid and a high linoleic acid content at 10 wk.

Infants fed formula with a low ratio of linoleic acid to α-linolenic acid and a low α-linolenic acid content at 10 wk.

**TABLE 6**

Contents of selected essential fatty acids in total lipids of erythrocytes obtained from 33 Cuban infants at 2 mo postpartum, in comparison with values reported in the literature

*FIGURE 4.* Effect of feeding method on Teller visual acuity scores of Cuban infants at 2 mo of age: ■, exclusively breast-fed (n = 31); □, not exclusively breast-fed (n = 23). There was no significant difference in visual acuity score between the groups.
consistent with soy oil, or a blend of soy and other oils, and contained less LA than did breast-milk samples (12% compared with 19% of total fatty acids, respectively). Because Cuba primarily imports soy, palm, and sunflower oil (58), the amounts of fatty acids in the milk preparation seemed logical. Also, the LA contents of other milks fed to the infants, such as evaporated milk, are known to be even lower (15), which could have contributed to the differences between feeding groups. Conversely, of the n−3 EFAs, ALA concentrations were lower in exclusively breast-fed infants than in infants not exclusively breast-fed. However, long-chain n−3 EFA concentrations were similar in the 2 groups. Breast milk contained a source of long-chain PUFAs including DHA, and the skim milk powder preparation did not, but it had greater amounts of ALA and a higher ratio of ALA to LA than did breast milk (data not shown). Therefore, it is logical that ALA concentrations would be higher in partially weaned infants and DHA concentrations would be similar for the 2 feeding groups in that most infants in both groups were receiving some breast milk, and therefore some DHA. However, only those infants fed supplemental milk received a higher amount of ALA. Average EFA concentrations of infants in both feeding groups appeared similar to those in the other populations discussed above (13, 48, 57).

One limitation of this study is that the feeding groups were divided crudely (ie, exclusively versus not exclusively breast-fed). Differences could have existed between infants fed different milks. However, such analyses could not be carried out because detailed information about weaning practices was not collected, and only a small number of infants was fed milk other than the cow milk formulation readily available through the ration system.

In addition to the evidence that infant EFA status was adequate, infant anthropometric data suggest adequate growth and therefore sufficient energy intake. Thus, there was probably no underlying deficiency, which could have otherwise aggravated an EFA deficiency. Binocular visual acuity scores of infants did not differ from normative scores (49, 50). Also, no differences in visual acuity were found between feeding groups, most likely because EFA concentrations were generally similar in the 2 groups. Consistent with many other studies, no relations were found between concentrations of any individual EFA or ratio of EFAs in infant plasma or erythrocytes and visual acuity when assessed in the entire group or in the separate feeding groups (32, 59–61).

A potential reason for the lack of a relation between EFA concentrations and visual acuity may be that Teller acuity cards are not sensitive to differences among infants with DHA status above some unknown critical threshold. The only investigation that reported on the retinal fatty acid profile of healthy term infants fed breast milk or standard formula (62) may be of help in understanding these findings. Retinal DHA content was similar in the 2 groups, despite lower erythrocyte DHA concentrations in the formula-fed group (62). Therefore, different amounts of circulating n−3 fatty acids may not affect retinal DHA content as long as they are above some unknown critical level, leading to similar visual acuity responses. However, the functional implications of lower blood DHA concentrations should not be disregarded, because the investigation by Makrides et al (62) found that DHA was reduced in the cortex of formula-fed infants, and this may cause other developmental limitations. The role of EFAs in immune response (63) also exemplifies the possible functional importance of differences in circulating EFA concentrations between infants fed breast milk and infants fed standard formula.

In the current study, data were collected in the city of Havana. Therefore, the results cannot be generalized to reach a conclusion that EFA status or general nutritional status of women and infants in all areas of Cuba are adequate. However, Cubans across the country do consume similar diets because most of their food is provided through the food ration system, which is similar in all regions. Also, we attempted to select women from areas with relatively low socioeconomic status, as identified by Instituto Nacional de Nutricion e Higiene de los Alimentos, namely Old and Central Havana. Thus, it was more likely that nutritional deficiencies would have been detected in these areas, compared with other parts of Havana.

One limitation of this investigation was that records of eligible women who refused to participate and of ineligible women were not kept. Many people were involved in subject recruitment, making it difficult to obtain this information. For example, doctors and nurses would ask women to participate when they had a free moment. Therefore, selection bias cannot be ruled out. Another limitation was that a substantial number of infant blood samples were not obtained or were not included in the set of samples sent out of the country for analysis.

In summary, the biochemical and functional data suggest that EFA deficiency was most likely not a problem in breast-feeding women and term infants in Havana. Average EFA concentrations in all sampled tissues were similar to those of persons living in Western countries and consuming diets enriched with n−3 fatty acids. This suggests that instead of being deficient, the Cuban women had superior EFA status to women consuming typical Western diets and their infants had better EFA status than do infants fed standard formula.

### Table 7

<table>
<thead>
<tr>
<th>Fatty acid</th>
<th>Exclusively breast-fed (n = 18)</th>
<th>Not exclusively breast-fed (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% by wt of total fatty acids</td>
<td>% by wt of total fatty acids</td>
</tr>
<tr>
<td></td>
<td>Range Median</td>
<td>Range Median</td>
</tr>
<tr>
<td>18:2n−6</td>
<td>11.28 ± 1.47 8.3–14.2 11.1</td>
<td>9.20 ± 1.82 6.0–12.5 9.9</td>
</tr>
<tr>
<td>18:4n−6</td>
<td>16.87 ± 1.52 14.7–18.9 17.4</td>
<td>16.37 ± 1.48 14.5–19.0 16.3</td>
</tr>
<tr>
<td>18:3n−3</td>
<td>0.30 ± 0.12 0.1–0.5 0.3</td>
<td>0.41 ± 0.12 0.2–0.7 0.4</td>
</tr>
<tr>
<td>22:6n−3</td>
<td>7.66 ± 1.00 6.0–9.4 7.8</td>
<td>7.12 ± 1.30 5.3–8.8 6.8</td>
</tr>
<tr>
<td>AA-DHA</td>
<td>2.24 ± 0.36 1.7–2.9 2.2</td>
<td>2.28 ± 0.40 1.7–3.0 2.2</td>
</tr>
</tbody>
</table>

1AA, arachidonic acid; DHA, docosahexaenoic acid. For 20:4n−6, one outlying subject in each feeding group was excluded from the analysis.

2Significantly different from the exclusively breast-fed group: *t* test, *P* < 0.05 (Wilcoxon rank-sum test).
REFERENCES


34. van Beusekom C, Martini IA, Rutgers HM, Boersma ER, Muskiet FA. A carbohydrate-rich diet not only leads to incorporation of medium-chain fatty acids (6:0–14:0) in milk triglycerides but also in each milk-phospholipid subclass. Am J Clin Nutr 1990:52:326–34.


