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Different patterns characterize Omega 6 and Omega 3 long chain polyunsaturated fatty acid levels in blood from Italian infants, children, adults and elderly

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ABSTRACT

Long chain polyunsaturated fatty acids (LC-PUFA), especially the Omega 3, modulate key functions in the body. Their circulating levels are representative of their "status", and may vary at different ages.

We have compared the FA status in Italian subjects from neonates to adulthood, assessed through FA analysis of blood drops from fingertips.

Data from four cohorts of Italian subjects (total number 1835), have been pooled in four age-groups: neonates (4 days, $n=81$), children (2–9 years, $n=728$), adults (40–59 years, $n=434$) and elderly (60–79 years, $n=592$).

LC-PUFA of both series (Omega 3 and 6) are higher in the blood of neonates than at subsequent ages, reflecting the efficient transfer of these FA from mothers to the fetus. In contrast, the lowest levels of Omega 3 PUFA, especially of DHA, are found in children, probably reflecting inadequate dietary intakes, with possible consequences on the health status at subsequent ages.

1. Introduction

Polyunsaturated fatty acids (PUFA) in animals are exclusively derived from the diet (the essential fatty acids, EFA): the long chain PUFA (LC-PUFA) of the Omega 3 ($n-3$) and of the Omega 6 ($n-6$) series, i.e. PUFA with more than 18C and more than 3 double bonds, are present mainly in the animal kingdom.

PUFA play major biological roles, being involved in the modulation of structural and functional properties in biomembranes and in highly specialized cellular compartments. Levels of PUFA, especially of the Omega 3, in circulating lipids (plasma, erythrocytes, whole blood), are representative of the fatty acid (FA) "status" in the organism [1–3], being the result of a balance between intakes and rates of utilization by cells and tissues. In studies relating plasma FA levels with food consumption [4], strong associations were reported for PUFA, and especially for those of the Omega 3 series, namely alpha linolenic acid (ALA, 18:3 $n-3$) and docosahexaenoic acid (DHA, 22:6 $n-3$). In contrast weak associations between dietary FA intakes and circulating FA (plasma or erythrocytes) have been found for saturated FA (SFA) and monounsaturated FA (MUFA) [4,5].

It should be considered, in the case of the Omega 3 PUFA, that their estimated intakes are highly different among populations on a global scale, with a 20 fold range [6]. As a consequence it is expected that also the Omega 3 FA levels should differ substantially within populations in relation to dietary intakes. The evaluation of the FA levels in the body may therefore represent a reliable index of the above balance and provide background information in order to define criteria for requirements and especially for recommendations concerning dietary intakes.

While data on FA profiles in representative biological samples, with special attention to those that are clearly affected by the

Abbreviations: AA, arachidonic acid; ALA, alpha-linolenic acid; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; FA, fatty acids; LA, linoleic acid; LC-PUFA, long-chain polyunsaturated fatty acids; MUFA, monounsaturated fatty acids; PL, phospholipids; SFA, saturated fatty acids; WB, whole blood.

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intakes, are available in the literature, information on differences in lipid and FA metabolism at different ages, from birth to senility, are rather limited.

The development of a simple and rapid method to assess the FA status [7,8], applied to different subjects and validated by other laboratories [9–13], has allowed our group to obtain data on blood FA profiles in different age-related cohorts of Italian subjects, during the last few years [8,11]. Now we present a comparative view of major differences in the blood FA status in different age-groups from birth to older age.

2. Patients and methods

The present data combine previously published results, concerning FA in neonates [11], with those obtained in studies which are being completed. FA data, not previously published, i.e. those of Italian children (2–9 years), were obtained in the IDEFICS (Identification and Prevention of Dietary and Lifestyle-induced Health Effects in Children and Infants) an European Union project [14], while those in adults and elderly in the AGE—MI (Acidi Grassi Essenziali—città di Milano) and in the CHECK (Cholesterol and Health Education and Control Knowledge) [15] projects, epidemiological studies carried out at the local and national levels, respectively.

All the studies were conducted in accordance to the Declaration of Helsinki, Guidelines for Good Clinical Practice and the Italian bioethics regulations and laws. They were approved by the local Ethic Committee and all subjects (or parents) gave written informed consent. Subjects participating to the CHECK study were enrolled following a random number list, generated by the coordinating Centre in Milan, while subjects participating to the AGE—MI study were enrolled on a voluntary basis following the invitation to the population under the control of their practitioners.

3. FA analysis

Blood drops collected from fingertips on special adsorbents were subjected to direct transmethylation and gas chromatographic analysis [7]. In the case of infants blood was collected from a heel prick at the same time of Guthrie neonatal screening test on day 4 of life. The relative percentages of FA were calculated considering the following FA in the analysis: 16:0, 16:1, 18:0, 18:1 $n-9$, 18:1 $n-7$, 18:2 $n-6$, 18:3 $n-6$,18:3 $n-3$, 20:0, 20:1, 20:3 $n-9$, 20:3 $n-6$, 20:4 $n-6$, 20:5 $n-3$, 22:0, 22:1, 22:4 $n-6$, 22:5 $n-6$, 22:5 $n-3$, 24:0, 22:6 $n-3$ and 24:1. The percentage levels of total Omega 6 and Omega 3 PUFA, of the major Omega 6 and Omega 3 PUFA, and those of total SFA, MUFA and PUFA were also evaluated.

Table 1
Characteristics of the study-cohorts.

Study-cohort[a]	*N*	%
Neonates	81	4.4
IDEFICS	728	39.7
AGE—MI	386	21.0
CHECK	640	34.9
Total subjects	1835	100

[a] The study-cohorts previously described are those of neonates [11] , IDEFICS [14], CHECK [15].

4. Statistical analysis

Data from the different cohorts were pooled in four age-groups (neonates, children, adults and elderly) for the analyses.

Continuous variables are presented as mean values [$\pm$ standard deviation, SD], while qualitative variables are presented as frequencies. Comparisons across age-groups were performed by using univariate analysis of variance (ANOVA) and Bonferroni post-hoc test. Univariate regression analyses (Pearson correlation coefficients = crude R) and multivariate stepwise regression analyses (adjusted R) were performed to estimate the associations of each FA/FA classes (dependent variables) with age-groups and sex (as categorical covariates), and BMI (as continuous covariate). The data were analyzed by using the software IBM SPSS (Statistical Package for Social Sciences) Version 19.0.

5. Results

Table 1 shows the number of subjects and their proportion with respect to total number of the participants from the 4 study-cohorts considered, whereas the characteristics of the four pooled age-groups (4 day neonates, 2–9 year children, 40–59 year adults and 60–79 year elderly) included in the analyses, are summarized in Table 2.

The selected individual FA, FA classes and series of the four age-groups are summarized in Table 3.

In general, major differences in FA levels occur, comparing neonates versus subsequent ages, especially for PUFA, such as higher levels of the LC-PUFA of the Omega 3 series (DHA) and of the Omega 6 (AA) series, associated with quite lower levels of the shorter chain compounds, LA in the Omega 6 and ALA, in the Omega 3 series. LA levels are very low in neonates, and increase markedly already in children, adults and elderly. An opposite trend concerns the levels of AA: the high values in neonates undergo a marked decline in children, remaining unchanged in adults and elderly. As a consequence the AA/LA ratios is significantly higher in infants than in children, adults and elderly ($3.04 \pm 0.99\%$, $0.48 \pm 0.09\%$, $0.47 \pm 0.12\%$ and $0.49 \pm 0.12\%$, respectively). The Omega 3 PUFA levels in the age-groups vary following a different trend with respect to those of Omega 6 PUFA. The lowest levels of ALA, as in the case of LA, are found in neonates with progressive, statistically significant, increments in children and even more in adults and elderly. Concerning EPA levels, there are no differences between neonates and children, while a significant increment

Table 2
Characteristics of age-groups for analyses.

	N	%	Age (years)		BMI (m^2/kg)		Male gender	
			Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	*N*	%
Neonates	81	4.4	0.0 ± 0.0	0.0–0.0	13.01 ± 1.15	10.69–16.45	41	50.6
Children	728	39.7	6.0 ± 1.6	2.0–9.0	19.22 ± 3.59	12.40–32.90	378	51.9
Adults	434	23.7	50.6 ± 5.9	40.0–59.0	26.20 ± 4.46	16.94–48.45	190	43.8
Elderly	592	32.3	67.4 ± 4.9	60.0–79.0	27.20 ± 4.20	15.06–43.16	278	47.0