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PROFILES OF SELECTED NUTRIENTS AFFECTING SKIN CONDITION IN CHILDREN WITH ATOPIC DERMATITIS

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ABSTRACT

Background. Atopic dermatitis (AD) is a chronic inflammation of the skin recognised to be one of the first clinical signs of allergy. In the first years of life, epidemiological evidence has demonstrated that common causative foods of a child's diet are: cow's milk, hen's eggs, wheat and soya. Children with AD being treated with elimination diets are at risk of nutritional deficiencies that include those nutrients required for ensuring proper skin structure and function.

Objective. The aim of the study was to assess dietary intake of nutrients which affect skin condition in children with AD being treated with a milk-free diet.

Materials and Methods. Subjects were 25 children aged 4-6 years with AD undergoing the milk exclusion diet and 25 age-matched healthy controls. The energy and nutritional value of diets were evaluated that included those components affecting skin condition; ie. vitamins A, D, E, B_2 and C; minerals iron (Fe) and zinc (Zn); polyunsaturated fatty acids (PUFAs). The Dieta 5.0 programme was used for dietary assessment and outcomes were then related to dietary recommendations.

Results. There were no significant differences between groups in mean energy values and mean intakes of protein, fats and carbohydrates ($p>0.05$). The percentage of subjects with low energy value were 44% and 36% in respectively Groups I and II. Deficiencies of fat intake were observed in 60% in Group I and 44% in Group II. There were however no risks in the dietary intakes of protein, carbohydrate, vitamins A, B_2 and C nor of Fe and Zn. Deficiencies of dietary intakes were observed in respectively Groups I and II in the following; vitamin E (24% vs 64%), vitamin D (36% vs 92%), linoleic acid (36% vs 72%), α-linolenic acid (36% vs 40%) and long chain PUFAs (96% in both groups).

Conclusions. Ensuring recommended dietary supply of those nutrients affecting skin condition is required for both groups of children. Children with AD had better balanced diets in respect of the studied nutrients that may reflect the influence of continuous healthcare received from physicians and dieticians.

Key words: *atopic dermatitis, children, cow's milk allergy, dietary intake, nutrients*

STRESZCZENIE

Wprowadzenie. Atopowe zapalenie skóry (AZS) to przewlekła choroba zapalna skóry będąca jedną z pierwszych manifestacji klinicznych alergii. Z danych epidemiologicznych wynika, że pokarmami, które najczęściej uczulają dziecko w pierwszych latach życia są: mleko krowie, jajo kurze, pszenica i soja. Dzieci z AZS leczone dietą eliminacyjną znajdują się w grupie ryzyka wystąpienia niedoborów pokarmowych, w tym także niedoborów składników niezbędnych do prawidłowej budowy i funkcjonowania skóry.

Cel badań. Ocena spożycia wybranych składników odżywczych wpływających na stan skóry przez dzieci z atopowym zapaleniem skóry leczonych dietą bezmleczną.

Materiał i metody. Badaniami objęto 50 dzieci w wieku 4-6 lat. Grupę I (n=25) stanowiły dzieci z AZS leczone dietą bezmleczną, grupę II – kontrolną (n=25) dzieci zdrowe. Oceniono wartość energetyczną i odżywczą ich diet, w tym podaż składników wpływających na stan skóry: witamin A, D, E, B_2 i C, składników mineralnych: Fe, Zn oraz niezbędnych nienasyconych kwasów tłuszczowych. Do oceny diet wykorzystano program żywieniowy Dieta 5.0, a uzyskane wyniki odniesiono do zaleceń żywieniowych.

Wyniki. Diety obu grup nie różniły się istotnie pod względem średniej wartości energetycznej oraz średniego spożycia białka, tłuszczu i węglowodanów ($p>0.05$). Odsetek dzieci o niskiej, w stosunku do normy, podaży energii w grupie z AZS i kontrolnej wyniósł odpowiednio 44% i 36%. U 60% dzieci z grupy I i u 44% z grupy II zaobserwowano niedoborowe spożycie tłuszczu. Nie stwierdzono ryzyka niedoboru białka, węglowodanów, witamin A, B_2, C oraz żelaza i cynku. Zaobserwowano deficyty spożycia: witaminy E (u 24% dzieci z AZS vs 64% w grupie kontrolnej), D (u 36% dzieci z AZS vs 92% w grupie kontrolnej), kwasu linolowego (u 36% dzieci z AZS vs 72% w grupie kontrolnej) i α-linolenowego (u 36%

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dzieci z AZS vs 40% w grupie kontrolnej) oraz długołańcuchowych wielonienasyconych kwasów tłuszczowych – u 96% dzieci w obu grupach.
Wnioski. Konieczne jest zapewnienie prawidłowej podaży niedoborowych składników wpływających na stan skóry w dietach obu grup dzieci. Diety dzieci z AZS były lepiej zbilansowane pod względem większości ocenianych składników odżywczych, na co wpływ mogła mieć stała opieka zarówno pediatry jak i dietetyka.

Słowa kluczowe: *atopowe zapalenie skóry, dzieci, alergia na białka mleka krowiego, dieta bezmleczna, składniki odżywcze*

INTRODUCTION

Atopic dermatitis (AD) is a chronic, relapsing inflammatory skin condition which constitutes one of the first clinical signs of allergy [16]. Recent years have witnessed a significant increase of AD cases [8, 33]. Studies also show that 2-3% of all children up to 3 years are affected by this condition. AD's aetiology arises from multiple factors. Major roles in its development are played by having a genetic predisposition, immunological disorders, epidermal barrier disruption and an abnormal skin reaction towards environmental factors [29].

For young children in particular, the allergic effects of foods in the pathogenesis of AD have been debated over many years. Epidemiological evidence has most frequently pointed to cow's milk, hen's eggs, wheat and soya as being the main culprit allergens during the first years of life [7]. Children with AD being treated with elimination diets are a group at risk of dietary deficiencies, including those nutrients responsible for "healthy" skin development and function such as some of the water- and fat- soluble vitamins: C, B_2 and A, D, E, respectively, along with certain minerals like Fe, Zn, Se, Cu and polyunsaturated fatty acids (PUFAs) of the n-3 and n-6 groups. The latter includes long chain polyunsaturated fatty acids (LCPUFAs); mainly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

Thus, ensuring an adequate supply of these nutrients may ameliorate the course of AD, together with its clinical symptoms. The presented work is thereby focused on analysing AD children's nutrition who are being treated with a milk-free diet; taking into consideration dietary intakes of those nutrients which are responsible for skin condition according to recommended dietary standards.

MATERIAL AND METHODS

Subjects were n=25 children (Group I), aged 4-6 years diagnosed with cow's milk allergy (CMA) suffering from AD, who were being treated with milk free-diet. All these subjects had been under the medical and dietetic care in the Gastroenterology Outpatient Clinic at the Warsaw Institute of Mother and Child. The controls, Group II (n=25) consisted of healthy children on traditional diet. According to the dietary assessment methodology [4, 10], the daily food rations (DFR) of children were estimated on the basis of 3 days record, randomly chosen from the dietary records (including one holiday), using the "Photograph Album of Food and Dishes" [28]. The energy and nutritional value of DFR was calculated using nutritional Dieta 5.0 programme [31].

Mean dietary intake of selected nutrients that affected skin condition was determined for vitamins C, B_2, A, D and E, minerals Fe and Zn as well as PUFAs from the n-3 and n-6 families in both subject groups and related to recommended dietary intake standards [12]. The proportions of children falling below the EAR (Estimated Average Requirement) and AI (Adequate Intake) were evaluated in both groups.

Nutritional status was assessed by Body Mass Index (BMI) which was standardised according to growth charts for Warsaw children [22] to obtain BMI z-scores independent of gender and age. Due to the fact that measured variables were not normally distributed, the *Mann-Whitney* U Test was used to assess the significance of differences between the studied groups using defined parameters of nutritional status and diet. A $p<0.05$ level was adopted as being significant. The analyses were performed by the Statistica 10 PL package.

RESULTS

The median, and mean age ± standard deviation (SD) for Group I subjects were 3.3; 3.5±1.7 years and

Table 1. Characteristics of study groups

Variables	Group I (n=25)			Group II (n=25)			P values (*Mann-Whitney* U test)
	Mean	SD	Median	Mean	SD	Median	ns
Age (years)	3.5	1.7	3.3	4.3	2.0	3.4	ns
Body weight (kg)	16.1	4.3	14.9	15.9	4.7	15.5	ns
Height (cm)	101.0	12.7	101.5	101.8	14.9	104.0	ns
BMI (kg/m^2)	15.6	1.5	15.6	15.1	1.6	14.6	ns
BMI z-score	-0.4	0.9	-0.5	-0.6	1.1	-0.9	ns

ns –statistically nonsignificant

3,4; 4.3±2.0 years in the Group II controls; this difference being nonsignificant (p>0.05). Likewise, mean body weight, height and BMI were not significantly different between the study groups. Nutritional status in all subjects can be considered as normal. The mean BMI z-score for Group I children being -0.4±0.9 whilst that for controls was -0.6±1.1. Subjects' age, anthropometric traits and indices are presented in Table 1.

The nutritional profiles in the diets in both groups of children were not significantly different for mean intakes of energy and macro-nutrients; protein fats and carbohydrates (p>0.05). The percentage of children with low caloric intakes compared to EAR were respectively 44% and 36% in Groups I and II. Deficiencies in fat intakes were observed in respectively 60% and 44% in Groups I and II. There was no risk of intake deficiencies seen for protein and carbohydrates (Table 2).

were found to be several – fold lower than those recommended, with lowered AI values in 96% of children from both study groups (Table 2).

Most of the dietary LA and ALA in both groups came from vegetable fats, whereas LCPUFAs were derived from meat, poultry, fish and eggs (Table 3).

The children's diet in both study groups covered the nutritional requirements for vitamins A, B_2 and C, with mean intakes of riboflavin being significantly lower (p<0.05) in Group I compared to Group II (Table 2). The main dietary sources of vitamins A and C in both groups were vegetables and juices along with extensively hydrolysed whey/casein formulas for the AD group and growing up milk, cow's milk and dairy products for the controls. Vitamin B_2 intake originated from extensively hydrolysed whey/casein formulas for children with AD and milk and dairy products including

Table 2. Dietary intakes of selected nutrients in respect of Polish nutritional recommendations 2012 [12] in children with AD (group I) and healthy controls (group II)

Energy /Nutrients	Group I			Group II			P values (*Mann-Whitney* U test)	EAR/AI*	Percentage of intakes below EAR/AI	
	Mean	SD	Median	Mean	SD	Median			Group I	Group II
Energy (kcal)	1235.8	347.1	1251.9	1308.2	392.3	1255.0	ns	1400 kcal	44%	36%
Protein (g)	43.1	17.7	36.7	49.8	20.8	46.5	ns	16 g	0%	0%
Fat (g)	42.1	13.9	41.0	48.5	18.0	43.8	ns	54 g	60%	44%
Cholesterol (g)	142.0	106.3	120.2	209.5	118.6	176.8	0.02	-	-	-
Polyunsaturated fatty acids (g) (PUFAs)	6.9	4.0	7.0	5.8	3.6	4.7	ns	-	-	-
Linoleic acid (LA) (g)	7.1	3.5	6.6	4.9	3.2	4.1	0.006	4% Energy*	36%	72%
α-linolenic acid (ALA) (g)	1.0	0.6	0.8	0.9	0.4	0.8	ns	0.5% Energy*	36%	40%
LCPUFAs (g)	0.04	0.06	0.02	0.07	0.18	0.03	ns	0.25 g	96%	96%
n-6:n-3 ratio	7.7	3.5	7.3	6.3	4.4	4.7	0.03	-	-	-
LA:ALA ratio	8.0	3.8	7.8	6.6	4.4	4.6	0.054	-	-	-
Total carbohydrates (g)	182.5	59.7	164.4	176.7	55.6	170.4	ns	130 g	--	-
-including those digestible (g)	169.3	54.4	152.0	166.6	51.8	164.0	ns	100 g	4%	8%
Iron (mg)	9.6	3.6	9.2	7.5	2.9	6.5	0.04	4 mg	0%	0%
Zinc (mg)	6.5	2.2	6.2	6.0	1.7	5.8	ns	4 mg	0%	0%
Vitamin A (μg)	1256.4	988.2	988.1	830.7	428.8	759.6	ns	300 μg	4%	0%
Vitamin E (mg)	8.6	3.3	7.3	5.5	2.4	5.3	0.0004	6 mg*	24%	64%
Vitamin D (μg)	5.8	3.0	5.7	2.8	2.6	2.1	0.0001	5 μg*	36%	92%
Vitamin B_2 (mg)	1.0	0.3	0.9	1.2	0.5	1.2	0.008	0.5 mg	0%	0%
Vitamin C (mg)	91.3	55.9	76.2	77.8	50.6	67.1	ns	40 mg	4%	4%

EAR – Estimated Average Requirement; AI – Adequate Intake; LCPUFA Long chain polyunsaturated fatty acids; ns – statistically non-significant

Children's dietary PUFAs levels demonstrated that recommended intakes of linoleic acid (LA) and α-linolenic (ALA) acid were not being met by 36% of the children with AD (Group I). The median, and mean dietary intakes ± standard deviation (SD) of LA in Group I and Group II were 6.6; 7.1±3.5 g and 4.1; 4.9±3.2 g, respectively. Furthermore, 72% of the control group children did not meet the AI levels for linoleic acid. Mean dietary intakes of LCPUFAs in the children

growing up milk for controls and was also provided to both groups from meat, poultry and cereals (Table 3).

Both groups demonstrated deficient intakes of the fat soluble vitamins E and D. When comparing median, and mean intakes ± standard deviation (SD) of these vitamins in Groups I and II, the following results were respectively observed: 7.3; 8.6±3.3 mg vs 5.3; 5.5±2.4 mg for vitamin E, 5.7; 5.8±3.0 μg vs 2.1; 2.8±2.6 μg for vitamin D, 24% vs 64% children below the recommended

Table 3. Sources, (expressed as percentage), of those selected nutrients affecting skin condition in diets of children from Group I and Group II (controls)

Nutrient	Study group	Cereals (calculated as flour)	Potatoes	Vegetables, fruit, seeds, juices and beverages	Milk & dairy products/ extensively hydrolysed whey/casein formulas	Meat, cold meats, poultry, eggs, fish	Fats	Others
Iron	I	**18.9%** Flour, pasta, groats, rice 12%, bread 4%, cereal flakes 2%	**3.3%**	**22.8%** Vegetables 9%, fruit 5%, juices 3%, legumes 6%	**35.0%** Extensively hydrolysed whey/casein formulas 35%	**18.0%** Meat, poultry 9%, cold meats 5%, eggs 4%	**0.3%**	**1.7%**
	II	**30.1%** Flour, pasta, groats rice 10%, bread 9%, cereal flakes 12%	**3.6%**	**21.8%** Vegetables 7%, fruit 7%, juices 5%, legumes 3%	**16.3%** Growing up milk 12%, milk and dairy products 4%	**22.6%** Meat, poultry 8%, cold meats 6%, eggs 8%	**0.4%**	**5.2%**
Zinc	I	**17.9%** Flour, pasta, groats, rice 11%, bread 6%	**3.2%**	**16.7%** Vegetables 8%, fruit 3%, legumes 4%	**28.7%** Extensively hydrolysed whey/casein formulas 28,7%	**31.8%** Meat, poultry 20%, cold meats 7%, eggs 4%	**0.2%**	**1.5%**
	II	**17.7%** Flour, pasta, groats, rice 8%, bread 9%	**2.7%**	**11.7%** Vegetables 5%, fruit 3%, legumes 2%	**32.2%** Growing up milk 12%, cheeses, cream cheeses 10%, milk 9%	**31.7%** Meat, poultry 14%, cold meats 9%, eggs 8%	**0.2%**	**3.9%**
Vitamin A	I	**1.5%**	**0.0%**	**68.4%** Vegetables 47%, juices 20%	**19.0%** Extensively hydrolysed whey/casein formulas 19%	**6.1%** Eggs 4%, cold meats 2%	**5.0%** Margarine 4%, butter and cream 1%	**0.0%**
	II	**1.4%**	**0.1%**	**56.8%** Vegetables 38%, juices 17%	**19.3%** Growing up milk 8%, milk 6%, cheeses, cream cheeses 5%	10.2% Eggs 9%, Cold meats 1%	12.2% Margarine 6%, butter and cream 6%	0.0%
Vitamin E	I	**5.3%**	**0.4%**	**19.5%** vegetables 10%, fruit 7%, juices 2%	**29.9%** Extensively hydrolysed whey/casein formulas 29.9%	**5.0%**	**39.8%** Oils 24%, margarine 15%	**0.1%**
	II	**9.5%**	**0.4%**	**22.8%** vegetables 11%, fruit 6%, nuts 3%	**12.5%** Growing up milk 8%, milk and dairy products 4%	**8.8%**	**45.8%** Oils 23%, margarine 20%	**0.2%**
Vitamin D	I	**5.1%**	**0.0%**	**0.4%**	**69.1%** Extensively hydrolysed whey/casein formulas 69.1%	**15.2%** Meat, poultry, cold meats 8%, eggs 5%, fish 2%	**8.3%** Margarine 8%	**1.9%**
	II	**5.0%**	**0.0%**	**1.0%**	**41.5%** Growing up milk 37%	**34.7%** Meat, poultry, cold meats 15%, eggs17%, fish 3%	**17.7%** Margarine 16%, butter and cream 2%	**0.0%**

Vitamin B_2	I	**10.3%** Flour, pasta, groats, rice 6%, cereal flakes 2%, bread 2.5%	**2.9%**	**19.3%** Vegetables 9%, fruit 7%	**30.7%** Extensively hydrolysed whey/casein formulas 28%	**30.8%** Meat, poultry, cold meats 21%, eggs 9%	**0.3%**	**5.5%**
	II	**14.5%** Flour, pasta, groats, rice 4%, cereal flakes 7.5%, bread 3%	**1.8%**	**11.5%** Vegetables 4%, fruit 5%	**45.9%** Milk 23%, cheese, cream cheese 14%, growing up milk 6%	**24.6%** Meat, poultry, cold meats 13%, eggs 12%	**0.4%**	**1.3%**
Vitamin C	I	**3.1%**	**8.7%**	**55.6%** Vegetables 28%, fruit 18%, juices 10%	**22.2%** Extensively hydrolysed whey/casein formulas 22%	**0.1%**	**0.0%**	**10.2%** Enri-ched food
	II	**4.8%**	**8.2%**	**76.2%** Vegetables 21%, fruit 29%, juices 26%	**10.2%** Growing up milk 7%, milk, yoghurt 3%	**0.1%**	**0.0%**	**0.5%**
PUFAs	I	**10.9%** Flour, pasta, groats, rice 5%, bread 5%	**0.5%**	**14.4%** Vegetables, fruit 5%, legumes 8%	**0.1%**	**16.5%** Meat, poultry, cold meats 14%, eggs 2%	**57.4%** Oils 33%, margarine 24%	**0.1%**
	II	**15.8%** Flour, pasta, groats, rice 5%, bread 9%	**0.5%**	**10.3%** Vegetables, fruit 4%, legumes3%, nuts, seeds 3%	**7.1%**	**20.8%** Meat, poultry, cold meats 16%, eggs 4%	**45.0%** Oils 24%, margarine 19%	**0.4%**
LCPUFAs	I	**3.6%**	**0.0%**	**0.0%**	**0.0%**	**96.4%** Meat, poultry, cold meats 22%, fish 47%, eggs 27%	**0.0%**	**0.0%**
	II	**2.1%**	**0.0%**	**0.0%**	**0.0%**	**97.8%** Meat, poultry, cold meats 14%, fish 54%, eggs 29%	**0.1%**	**0.0%**
LA	I	**9.8%** Flour, pasta, groats, rice 4,5%, bread 4,5%	**0.4%**	**11.3%** Vegetables, fruit 3%, legumes 7%	**16.8%** Extensively hydrolysed whey/casein formulas 16,8%	**13.3%** Meat, poultry, cold meats 11%, eggs 2%	**48.2%** Oils 26%, margarine 22%	**0.1%**
	II	**16.8%** Flour, pasta, groats, rice 5%, bread 10%	**0.5%**	**9.9%** Vegetables, fruit 3%, legumes 3%, nuts, seeds 3%	**9.2%** Growing up milk 7%, dairy products 2%	**19.4%** Meat, poultry, cold meats 15%, eggs 4%	**43.8%** Oils 22%, margarine 21%	**0.4%**

ALA	I	**5.1%**	**0.6%**	**18.4%** Vegetables, fruit 9%, legumes 8%	**15.2%** Extensively hydrolysed whey/casein formulas 15%	**9.1%**	**51.6%** Oils 47%, margarine 4%	**0.0%**
	II	**7.9%**	**0.6%**	**12.4%** Vegetables, fruit 8%, legumes 4%	**18.4%** Milk 7%, cheese, cream cheese 7%, growing up milk 3%	**11.5%**	**49.0%** Oils 38%, margarine 8%	**0.2%**
EPA	I	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%** Meat, poultry, cold meats 28%, fish 72%	**0.0%**	**0.0%**
	II	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%** Meat, poultry, cold meats 13%, fish 87%	**0.0%**	**0.0%**
DPA	I	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%** Meat, poultry, cold meats 62%, fish 38%	**0.0%**	**0.0%**
	II	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%** Meat, poultry, cold meats 45%, fish 55%	**0.0%**	**0.0%**
DHA	I	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%** Meat, poultry, cold meats 16%, fish 40%, eggs 44%	**0.0%**	**0.0%**
	II	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100.0%** Meat, poultry, cold meats 11%, fish 39%, eggs 50%	**0.0%**	**0.0%**

PUFAs– polyunsaturated fatty acids, LCPUFA – long chain polyunsaturated fatty acids, LA – linoleic acid, ALA – α-linoleic acid, EPA -eicosapentaenoic acid, DHA - docosahexaenoic acid, DPA – docosapentaenoic acid.

AI for vitamin E and correspondingly 36% vs 92% for vitamin D. In this respect, a more balanced diet is thereby seen in those children with AD subjected to a milk-free diet (ie. Group I). Significant dietary sources of vitamin E in both child groups were vegetable oils, vegetables and fruit, together with extensively hydrolysed whey/casein formulas for Group I subjects. The main source of vitamin D were extensively hydrolysed whey/casein formulas for Group I subjects and growing up milk in Group II subjects and meat and egg products for both groups (Table 3).

There were no dietary deficiencies seen for Fe and Zn intakes for both groups, although mean Fe intakes were significantly higher in the AD children's group ($p<0.05$) (Table 2). Dietary iron was mainly derived in Group I children from extensively hydrolysed whey/casein formulas, vegetables, fruit, cereals, meat, poultry and eggs, whereas the sources for the healthy controls (Group II) were mainly cereals, meat and its products and eggs (Table 3).

DISCUSSION

The basic method for treating CMA, which exhibits various clinical symptoms including those of AD, is by using milk-free diet. This type of diet is differently tolerated by children, particularly toddlers, that may thereby cause deficiencies in various nutrients to arise and that may include those important for a 'healthy' condition of the skin.

Amongst the many studies on atopic skin inflammation, only a few are focused on the intake of those dietary nutrients that are beneficial for skin condition. Of these, two studies [14, 20] showed lower energy values of diets in pre-school children with AD. In our study we found that mean daily energy intakes in 44% of AD children were lower than the EAR standards, which was linked to a lowered dietary fat intake in 60% children; a finding being adverse to health as this constitutes building block components vital for all cells, including skin cells.

Another important building block component for skin cells are amino acids originating from dietary proteins. Some are used in synthesising collagen or horn structures eg. keratins or elastins. The current study showed that the mean protein intake in children with AD significantly exceeded the EAR. Similar findings were observed by *Buczek* et al. [1], *Gołębiowska-Wawrzyniak* et al. [9] and *Paganus* et al. [21] in groups of children suffering from CMA. Similarly, the higher than recommended protein intakes of the presented study in the healthy children group is also in accordance with other studies [9, 30, 32].

Several dietary vitamins and minerals are necessary for skin cell growth and differentiation and are also required for skin regeneration and protection against harmful oxygen free radicals. Recent years have also witnessed greater awareness in the health benefits of anti-oxidants where, for example, they enhance the immune system especially in times of stress and so reduce disease risk. Studies by *Kim* et al. [14] and *Oh* et al. [20] have suggested that an adequate supply of dietary antioxidants may decrease the risk of atypical skin inflammation whilst also pointing out the existence of dietary deficiencies in the antioxidant vitamins A and C in children suffering from AD. Vitamin C is necessary for the normal construction of fibrous tissue for the skin. The dietary content of vitamins A and C found for the studied children with AD agreed with recommendations. Another dietary component with powerful antioxidant properties is vitamin E where it has been shown that high intakes reduce AD incidence. Furthermore, some authors consider that determining dietary vitamin E content is a better indicator of AD risk than measuring serum vitamin E concentrations [20]. The benefits of vitamin E in AD are, amongst others, its effect on the integrity of intercellular connections. This vitamin prevents membrane damage in cells making up skin through protecting cellular lipids, including PUFAs, from oxidation [34]. The current study however shows dietary intakes deficient in vitamin E for both children with AD and the healthy controls.

Ever more frequently, attention is focusing on the action of n-3 fatty acids, particularly the LCPUFAs in preventing or treating AD. It is also stressed that low intakes of PUFAs contribute towards the development of atopic diseases that include AD [5]. The role of n-3 fatty acids are important as anti-inflammatories [25]. They decrease the severity of skin inflammation helping to reconstruct the lipid mantle of the skin and thereby setting in order its protective physiological function. EPA is considered to be mainly responsible for the anti-inflammatory action competing with arachidonic acid (AA) in leukotrienes and prostaglandin formation, however DHA also possesses potential anti-inflammatory and immunomodulatory action [11]. Indeed, the beneficial effects of DHA supplementation on reducing inflammatory reactions have been proven [15, 18]. In the presented study, the dietary intakes of both child groups were found to be deficient in LCPUFAs as well as for PUFAs. The reason for this being a low consumption of marine fish, fish oils and seafood ('fruits of the sea'). In the AD child group, such behaviour arose from the concern that children might also demonstrate an allergic response to the fish protein parvalbumin allergen [23]. Low PUFAs intakes in AD children due to low consumption have also been observed by *Dunder* et al. [6].

For the healthy controls, it would seem that the low fish consumption merely reflects incorrect dietary practice.

In the development of atopic diseases, it is now recognised that the role of pro-inflammatory fatty acids of the n-6 group feature prominently, especially if there is an abnormal ratio with the n-3 ones [5, 15, 17, 19, 27]. According to *McAnulty* et al. [19] the correct PUFA n-6/n-3 ratio in traditional diets should vary between 1:1 to 2:1, however according to *Simopoulous* [27] this ratio should range between 2:1 to 3:1 to enable inflammation to become reduced. These findings are important when considering the fact that over recent years the dietary consumption of PUFAs in Europe has risen, but only for the n-6 ones [2, 6, 19, 27]. Many studies have also shown the n-6/n-3 ratio to now be abnormal, even rising up to 20:1 [19, 27].

The current study demonstrates that the ratios of n-6 to n-3 and LA to ALA in the Group I and healthy controls were 7.3:1 vs 4.7:1 and 7.8:1 vs 4.6:1, respectively. Current recommended dietary standards in Poland (2012) [12] provide reference values neither for the n-6/n-3 ratio nor for LA to ALA, where it is argued by expert opinion that the competition between these acids/family of acids for the same metabolic enzymes precludes defining a reference for their relative proportions. Earlier reference standards from 2008 in Poland [13] nevertheless defined the n-6 to n-3 and LA to ALA as ranging from 5:1 to 10:1. From dietary recommendations in 2001 [34], the optimal n-6 to n-3 ratios for fatty acids for children and adults ranged 4:1 to 6:1.

Vitamin D is an example of a fat soluble vitamin performing multi-functional roles. In addition to its effects on bone metabolism, it demonstrates immunomodulatory and indirect anti-bacterial action. Such effects may be particularly beneficial to children suffering from AD. This study showed deficient intakes of this vitamin for both groups. Nonetheless, it is worth noting that those with AD had a twofold higher dietary intake of vitamin D compared to the healthy controls and that the proportion of children with AD showing dietary intake deficiency of vitamin D was almost threefold lower compared to controls. Dietary deficiencies of vitamin D intakes in both, children allergic to cow's milk protein and healthy children were also observed by *Gołębiowska-Wawrzyniak* et al. [9]. Other studies by *Weker* et al. [32] and *Charzewska* and *Weker* [3] also showed Vitamin D deficiencies in the diets of Polish children aged 1-3 years and 4 years. The potentially beneficial effects of vitamin D for children suffering from AD is supported by *Rowicka* and *Riahi* [26] study who found lower serum concentrations of 25(OH)D (25-hydroxy vitamin D) in children with AD than healthy children, where in the former those with acute AD had the lowest 25(OH)D concentrations. Similar results were recorded by *Peroni* et al. [24].

An adequate dietary intake of Fe and Zn for children with allergies may be advantageous for immune system cells responsible for developing AD inflammation and for decreasing intestinal absorption of nutrients in those suffering from this condition. Such intakes are also vital in correct keratin formation and in preventing dry skin, which for AD sufferers is very relevant. AD children treated with a milk exclusion diet are vulnerable to dietary deficiencies of Fe and Zn [9, 14, 20], which is related, *inter alia*, to the inadequate nutritional consumption of some extensively hydrolysed whey/casein formulas [9]. Some children with CMA additionally require excluding veal and beef from their diets; these being rich sources of these minerals. However, the dietary intakes in AD children from the presented study were not deficient in either Fe or Zn, with the main sources being provided by extensively hydrolysed whey/casein formulas and meat products.

The current study highlights the role played by the main nutrients affecting skin condition in children allergic to cow's milk protein as well as in having adequate dietary intakes.

CONCLUSIONS

Our study has identified the need for ensuring an adequate dietary intake of key nutrients responsible for skin condition in children with AD as well as healthy children: vitamins E and D, PUFAs (ie. linoleic and α-linolenic acid and its derivatives) and LCPUFAs (ie. docosahexaenoic acid eicosapentaenoic acid).

Despite the observed deficiencies, the diets of children with AD were better balanced in respect to most of the assessed nutrients, probably due to receiving continuous healthcare from paediatricians and dieticians.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. *Buczek S., Karnet B., Pasowska R., Jabłoński E., Pyziak K., Kulig K., Furmanek J.*: Ocena sposobu żywienia niemowląt i małych dzieci z alergią pokarmową. Pediatr Współcz Gastroenterol Hepatol Żywienie Dziecka 2006;8:175-179.
2. *Calder P.C.*: Abnormal fatty acid profiles occur in atopic dermatitis but what do they mean? Clin Exp Allergy 2006;36:138-141.
3. *Charzewska J., Weker H.*: Ogólnopolskie badanie nad zawartością wapnia i witaminy D w dietach dzieci w wieku 4 lat. Pediatr Współcz Gastroenterol Hepatol Żywienie Dziecka 2006;8:107-109.

4. *Coulston A.M., Boushey C.J., Ferruzzi M.G. eds*.: Nutrition in the prevention and treatment of disease (3rd edition). Elsevier, 2013.
5. *Devereux G., Seaton A*.: Diet as a risk factor for atopy and asthma. J Allergy Clin Immunol 2005;115:1109-1117.
6. *Dunder T., Kuikka L., Turtinen J., Rasanen L., Uhari M*.: Diet, serum fatty acids, and atopic diseases in childhood. Allergy 2001;56:425-428.
7. *Eigenmann P.A., Sicherer S.H., Borkowski T.A., Cohen B.A., Sampson H.A*.: Prevalence of IgE-mediated food allergy among children with atopic dermatitis. Pediatrics 1998;101(3):e8.
8. *Flohr C., Mann J*.: New insights into the epidemiology of childhood atopic dermatitis. Allergy 2014;69:3-16.
9. *Gołębiowska-Wawrzyniak M., Rowicka G., Strucińska M., Markiewicz K.:* Ocena stanu odżywienia i sposobu żywienia dzieci z alergią na białka mleka krowiego. Alergoprofil 2012;8(3):20-28.
10. *Gronowska-Senger A. ed.:* Przewodnik metodyczny badań sposobu żywienia. Komitet Nauki o Żywieniu Człowieka Polskiej Akademii Nauk, Warszawa 2013.
11. *Jańczyk W*.: LC-PUFA oraz ich znaczenie dla zdrowia niemowląt i dzieci. Magazyn nowoczesnej pielęgniarki i położnej 2011;26:8-11.
12. *Jarosz M.* [red.]: Normy żywienia dla populacji polskiej- nowelizacja. Warszawa, Instytut Żywności i Żywienia 2012.
13. *Jarosz M., Bułhak-Jachymczyk B.* [red.]: Normy żywienia człowieka. Warszawa, Wydawnictwo Lekarskie PZWL 2008.
14. *Kim J., Kwon J., Noh G., Lee S.S*.: The effects of elimination diet on nutritional status in subjects with atopic dermatitis. Nutr Res Pract 2013;7:488-494.
15. *Koch C., Dölle S., Metzger M., Rasche C., Jungclas H., Rühl R., Renz H., Worm M*.: Docosahexaenoic acid (DHA) supplementation in atopic eczema: a randomized, double-blind, controlled trial. Br J Dermatol 2008;158:786-792.
16. *Krauze A., Peradzyńska J., Lange J., Krenke K., Kulus M*.: Czy to dalej alergia pokarmowa? Częstość występowania alergii na białko mleka krowiego u dzieci w 2. roku życia z atopowym zapaleniem skóry. Alergologia Info 2009,IV,4; 178-183.
17. *Kremmyda L.S., Vlachava M., Noakes P.S., Diaper N.D., Miles E.A., Calder P.C*.: Atopy risk in infants and children in relation to early exposure to fish, oily fish, or long-chain omega-3 fatty acids: a systematic review. Clin Rev Allergy Immunol 2011;41:36-66.
18. *Manley B.J., Makrides M., Collins C.T., McPhee A.J., Gibson R.A., Ryan P., Sullivan T.R., Davis P.G*.: High-dose docosahexaenoic acid supplementation of preterm infants: Repiratory and allergy outcomes. Pediatrics 2011;128(1) doi: 10.1542/peds.2010-2405.
19. *McAnulty S.R., Nieman D.C., Fox-Rabinovich M., Duran V., McAnulty L.S., Henson D.A., Jin F., Landram M.J*.: Effect of n-3 fatty acids and antioxidants on oxidative stress after exercise. Med Sci Sports Exerc 2010;42:1704-1711.
20. *Oh S.Y., Chung J., Kim M.K., Kwon S.O., Cho B.H*.: Antioxidant nutrients intakes and corresponding biomarkers associated with the risk of atopic dermatitis in young children. Eur J Clin Nutr 2010;64:245-252.
21. *Paganus A., Juntunen-Backman K., Savilahti E*.: Follow-up of nutritional status and dietary survey in children with cow's milk allergy. Acta Paediatr 1992;81:518-521.
22. *Palczewska I., Niedźwiecka Z*.: Somatic development indices in children and youth of Warsaw. Med Wieku Rozwoj 2001;2(Suppl 1):17-118.
23. *Pascual C.Y., Reche M., Fiandor A., Valbuena T., Cuevas T., Esteban M.M*.: Fish allergy in childhood. Pediatr Allergy Immunol 2008;19:573-579.
24. *Peroni D.G., Piacentini G.L., Cametti E., Chinellato I., Boner A.L.:* Correlation between serum 25-hydroxyvitamin D levels and severity of atopic dermatitis in children. Br J Dermatol 2011;164(5):1078-1082.
25. *Prescott S.L., Calder P.C*.: N-3 polyunsaturated fatty acids and allergic disease. Curr Opin Nutr Metab Care 2004;7:123-129.
26. *Rowicka G., Riahi A*.: Serum vitamin D levels in children with atopic dermatitis – a pilot study. 11th Congress of the Baltic Association of Dermatovenereologists 17-19 October 2013, Kaunas, Lithuania, Abstract Book p. 95.
27. *Simopoulous A.P*.: The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed Pharmacother 2002;56:365-379.
28. *Szponar L., Wolnicka K., Rychlik E*.: Photograph Album of Food Products and Dishes. National Food and Nutrition Institute, Warsaw 2011.
29. *Thompson M.M., Tofte S.J., Simpson E.L., Hanifin J.M*.: Patterns of care and referral in children with atopic dermatitis and concern for food allergy. Dermatol Ther 2006;19:91-96.
30. *Trafalska E*.: Assessing diets for energy and nutrients content in nursery school children from Lodz, Poland. Rocz Panstw Zakl Hig 2014;65:27-33.
31. *Wajszczyk B., Chwojnowska Z., Chabros E., Nasiadko D., Rybaczuk M*.: Manual of Dieta 5.0 Program for planning and current assessment of individual diet. National Food and Nutrition Institute, Warsaw 2011.
32. *Weker H., Barańska M., Dyląg H., Riahi A., Więch M., Strucińska M., Kurpińska P., Rowicka G., Klemarczyk W*.: Analysis of nutrition of children aged 13-36 months in Poland – a nation-wide study. Med Wieku Rozwoj 2011;15:224-231.
33. *Wrzyszcz M., Mazur K*.: Epidemiologia chorób alergicznych: alergiczne choroby skóry, alergia na leki, alergia pokarmowa, alergia na jad owadów żądlących. Alergia Astma Immunologia 1997;2:129-135.
34. *Ziemlański Ś.* [red.]: Normy żywienia człowieka. Fizjologiczne podstawy. Warszawa, Wydawnictwo Lekarskie PZWL, 2001.

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