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Energy and nutrient intake of patients with mild-to-moderate chronic renal failure compared with healthy children: an Italian multicentre study

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Abstract. Nutritional counselling is important in the management of children with chronic renal failure (CRF). In 1988, a controlled European multicentre study was started to evaluate the effects of a low-protein diet on the progression of CRF in children. To assess the energy, macro- and micronutrient intake, 4-day weighed dietary records were obtained from 50 children with low to moderate CRF (creatinine clearance 65 to 15 ml/min per 1.73 m^2) and from 93 healthy children. The mean energy intake was 90%–93% of the recommended dietary allowance for Italian children in controls and 76%–88% in CRF patients. The mean protein intake was 2.1–3.1 g/kg per day in controls and 1.6–2.7 g/kg per day in CRF patients. Overall, the energy intake was 10% and the protein intake 33% lower in CRF patients than in healthy children. Children with CRF consumed less cholesterol, calcium and phosphorus than healthy children. The lower spontaneous intake of energy, protein and other nutrients should be taken into account when planning the nutrition of children with CRF.

Key words: Nutritional survey – Dietary record – Chronic renal failure – Energy and nutrient intake

Introduction

Nutritional counselling plays an important role in the management of children with chronic renal failure (CRF) [4, 6, 18]. Animal studies have suggested that protein-induced hyperperfusion and hyperfiltration in remnant nephrons could accelerate the rate of deterioration of renal function while restricting protein intake delays the progression of renal failure [13, 19]. Data supporting the beneficial effects of a low-protein diet in the treatment of non end-stage CRF are not yet conclusive [2, 3, 23, 26]. This is especially true for children because of the risk of a negative influence on growth from a low-protein diet and the low prevalence of low-to-moderate CRF in children.

We describe the spontaneous diet of 50 Italian CRF children who took part in a European multicentre study on the effect of a low-protein diet on the progression of CRF. The energy, macro– and micronutrient intakes of these patients were compared with those of 93 healthy controls.

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Abbreviations: CRF = chronic renal failure; RDA = recommended dietary allowance; RDA-I = recommended dietary allowances for the Italian population

Patients and methods

CRF children

The study group included 50 patients (41 boys and 9 girls), aged 3–17 years, who participated in the run-in period of the European Study Group for nutritional treatment of CRF in childhood between March 1988 and December 1990. The protocol of this multicentre study has been previously described in detail [30]. Briefly, criteria for entry into the study included an age ranging from 2 to 18 years, and CRF with creatinine clearance ranging from 65 ml/min per 1.73 m^2 to 15 ml/min per 1.73 m^2. Patients who already followed a strict low-protein diet were excluded from the protocol.

In this study group the primary renal diseases were: (1) glomerular disease (2 cases); (2) uropathy, renal hypoplasia or dysplasia or oligomeganephronia (33 cases); (3) congenital and hereditary nephropathy (13 cases); (4) nephropathic cystinosis (2 cases). The mean creatinine clearance during the study-period was 44.6 ± 18.5, 40.7 ± 13.8, and 36.9 ± 14.0 ml/min per 1.73 m^2 in age-group I (3.2–6.9 years), II (7.3–9.9 years) and III (10.5–17.2 years), respectively.

Control subjects

The control group included 93 healthy children (48 males and 45 females) aged from 3 to 12 years. These were subjects attending

Table 1. Anthropometric data of healthy (C) and CRF children

Age group		*n*	Age (years)	Weight (kg)	Height (cm)	H-SDS	Body mass index
I	C	33	4.6 ± 0.7	18.5 ± 3.2	107 ± 6	0.4 ± 1.3	16.0 ± 2.0
	CRF	12	4.7 ± 1.1	16.0 ± 2.1	103 ± 5	−0.5 ± 1.2	15.1 ± 1.6
II	C	29	7.5 ± 1.2	27.2 ± 5.0	126 ± 7	0.5 ± 1.3	17.2 ± 2.1
	CRF	18	8.5 ± 1.0	26.7 ± 6.0	125 ± 8	−0.6 ± 1.3	16.9 ± 2.7
III	C	31	9.7 ± 0.8	38.2 ± 6.8	140 ± 9	0.9 ± 1.4	19.4 ± 2.5
	CRF	20	12.7 ± 1.9	40.9 ± 10.0	147 ± 13	−0.7 ± 1.1	18.8 ± 2.8

H-SDS, Standard deviation score for height

Table 2. Energy and protein intakes in healthy (C) and CRF children

Age groups		Energy		Protein	
		(Kcal/kg)	(% RDA-I)	(g/kg/day)	(% RDA-I)
I	C	81 ± 15	90 ± 17	3.1 ± 0.8	200 ± 50
	CRF	88 ± 17	88 ± 21	2.7 ± 0.6	152 ± 34 **
II	C	67 ± 13	93 ± 15	2.5 ± 0.5	189 ± 49
	CRF	65 ± 15	82 ± 8 **	2.2 ± 0.6 *	144 ± 32 **
III	C	51 ± 12	93 ± 12	2.1 ± 0.5	177 ± 31
	CRF	48 ± 14	76 ± 24 **	1.6 ± 0.5 **	107 ± 38 **

* $P < 0.01$; ** $P < 0.05$

school in Ancona who took part in an educational dietary programme between February and June 1989.

Nutritional data collection and analysis

Dietary information was obtained by a 4-day weighed dietary record. This procedure was performed once by healthy children and every 2–3 months over a period of 6 months by CRF children. One weekend was included in the 4-day period for both groups so as to provide the most representative data on the habitual food intake. Each food item was weighed and recorded by the parents or by the dietitian. Plate waste was also recorded.

Individual daily energy and nutrient intake was calculated using a previously described computer program [5]. The data bank on the composition of food was up-dated with more than 500 items [14, 17, 27]. The composition of commercial food was supplied by the manufacturers. The following food characteristics were stored in the data bank: energy, energy distribution between macronutrients, protein, animal/vegetable protein ratio, lipids, polyunsaturated and saturated fatty acids, polyunsaturated/saturated fatty acid ratio, cholesterol, cholesterol-saturated fatty acid index [15], carbohydrates, sucrose, fibre, potassium, calcium, phosphorus, magnesium, iron, and zinc. The energy and nutrient intake of each subject was compared with the 1989 recommended dietary allowances for the Italian population (RDA-I); such recommendations are similar to those of other Western countries [16].

Statistical analysis

Anthropometric indices were compared with the Tanner growth standards [28]. Results were expressed as mean and SD. Statistical analysis included the Student-*t*-test and one-way analysis of variance. The relationship between the mean energy and protein intake was evaluated by linear regression analysis.

Results

Table 1 shows the demographic and anthropometric data of the subjects divided into three age-groups.

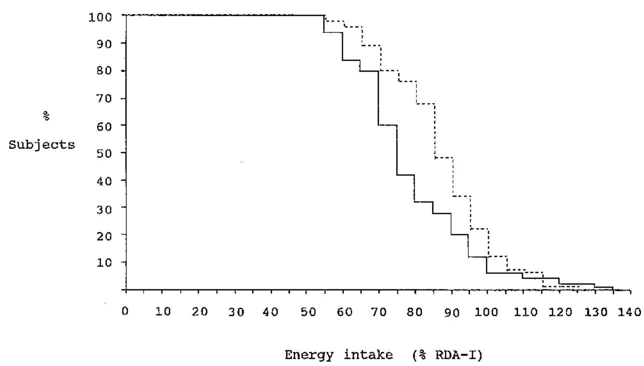

Fig. 1. Individual energy intakes in healthy (----) and CRF children (——)

The mean energy and protein intakes of CRF and control children are shown in Table 2. No significant difference was found between the percentage RDA-I energy intake of control males and females. The energy intake of the CRF children was about 10% lower than the controls (Fig. 1). Compared with controls, the CRF children had a lower protein intake, either per kg/real body weight or percentage RDA-I, the percentage difference between the control and CRF children being about 33% (Fig. 2). The animal/vegetable protein ratio was ca. 2 in all groups. In CRF patients, a correlation ($r = 0.65$) was found between the percentage RDA-I energy and percentage RDA-I protein intake. One-way analysis of variance for the energy and protein intake of CRF children showed: (1) no statistical difference between the consecutive rounds of the survey (absence of "training effect"); and (2) no statistical difference related to the origin of patients (North, Middle or South Italy, respectively).

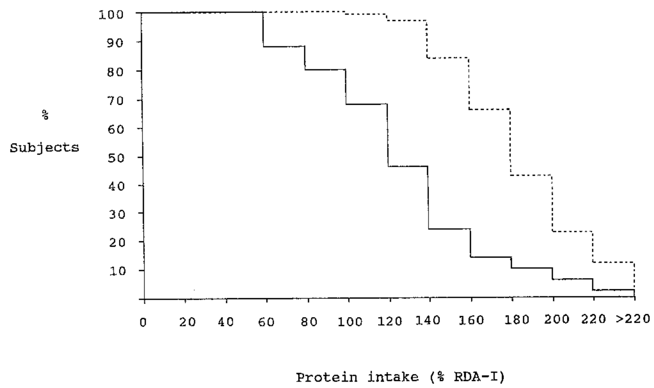

Fig. 2. Individual protein intakes in healthy (----) and CRF children (——)

The energy distribution between macronutrients was in controls 16.2% from proteins, 34.3% from lipids, and 49.5% from carbohydrates and in CRF subjects 13.2% from proteins ($P<0.01$), 36.1% from lipids ($P<0.05$), and 50.7% from carbohydrates. Tables 3 and 4 show the mean intakes of lipids, carbohydrates and micronutrients.

Figure 3 expresses the percentage of subjects who are statistically at risk from nutrient deficiency (less than 66% of the recommended intake).

Discussion

The adequacy of the diet in CRF children has usually been checked against the recommended daily allowance (RDA), i.e. the levels of intake of nutrients that carry a low risk of inadequacy to the healthy individual. However this approach may be misleading when it entails that energy and nutrient intakes of healthy subjects correspond to the RDA. For example, the evaluation of an energy intake lower than the RDA in a group of patients should take into account that many nutritional surveys have also found similarly low energy intakes in healthy individuals [20, 21]. In the present study the food intakes of CRF children were compared with those of control subjects studied by the same technique.

Overall, the characteristics of the diet of our 93 control subjects were similar to those reported by others in healthy children from Western countries [11, 20, 21]. The finding of a mean energy intake lower than the RDA-I (by about 10%) might be unexpected in a population with a high prevalence of overweight. This confirms previous studies which showed a negative gap between the observed and the recommended energy intake of infants, children, and adolescents [10, 20]. The RDA-I are formulated for people with a moderate physical activity while a sedentary life-style is common in Italian children. Studies of food intake are, however, subject to errors since a tendency to underrecord is a potential problem of the weighing technique [1, 25]. For nutrients, the most striking findings in controls were: (1) the high intake of animal protein; (2) the high intake of fat and cholesterol with a low polyunsaturated/saturated fatty acid ratio due to high consumption of animal fat; and (3) the marginal intake of calcium, iron and zinc.

Compared with healthy controls, the energy intake of the CRF children was slightly lower, especially in the

Table 3. Lipid and carbohydrate intakes in healthy (C) and CRF children

Age-groups		Lipids				Carbohydrates		
		Total (g)	Cholesterol (mg)	P/S	CSI	Total (g)	Sucrose (g)	Fibre (g)
I	C	56 ± 16	244 ± 116	0.2 ± 0.1	31 ± 10	192 ± 44	32 ± 13	11 ± 5
	CRF	66 ± 19	173 ± 92	0.22 ± 0.07	28 ± 14	189 ± 59	27 ± 7	10 ± 4
II	C	67 ± 16	292 ± 100	0.19 ± 0.05	36 ± 10	235 ± 42	41 ± 16	14 ± 4
	CRF	59 ± 12	176 ± 50 **	0.22 ± 0.08	27 ± 7 **	230 ± 55	44 ± 19	15 ± 6
III	C	71 ± 13	340 ± 135	0.18 ± 0.04	41 ± 11	240 ± 51	35 ± 16	15 ± 3
	CRF	68 ± 11	250 ± 125 *	0.27 ± 0.13 **	32 ± 11 **	245 ± 54	31 ± 17	14 ± 4

* $P<0.01$; ** $P<0.05$

P/S, Polyunsaturated/saturated fatty acid ratio; CSI, cholesterol saturated fatty acid index

Table 4. Micronutrient intake

Age-groups		K (mg)	Mg (mg)	Ca (mg)	P (mg)	Fe (mg)	Zn (mg)
I	C	1557 ± 366	155 ± 44	639 ± 216	939 ± 205	7.2 ± 2.6	5.6 ± 1.4
	CRF	1769 ± 526	152 ± 45	516 ± 214	779 ± 246 *	6.3 ± 1.8	5.0 ± 1.5
II	C	2047 ± 566	196 ± 54	692 ± 234	1060 ± 227	8.7 ± 2.5	6.2 ± 1.3
	CRF	1889 ± 561	167 ± 52	505 ± 191 **	808 ± 196 **	7.8 ± 2.0	5.5 ± 1.2
III	C	2115 ± 409	199 ± 44	760 ± 213	1168 ± 209	9.8 ± 2.7	6.9 ± 1.6
	CRF	1930 ± 453	166 ± 38 **	454 ± 168 **	915 ± 255 **	8.5 ± 1.8	6.0 ± 1.9

* $P<0.01$; * $P<0.05$

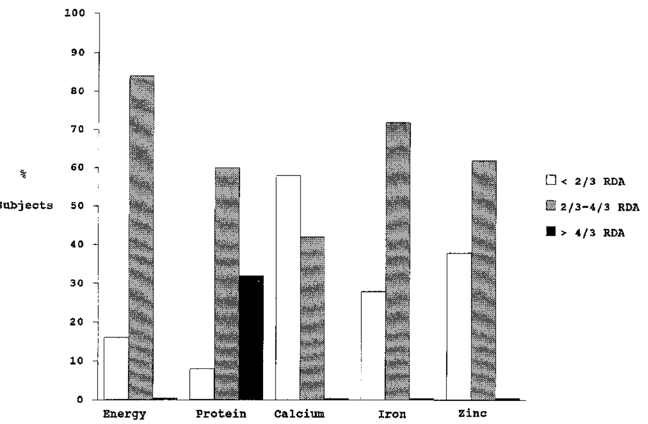

Fig. 3. Adequacy of individual energy and nutrient intakes in CRF children

older children, but the difference was not noticeable when the mean daily energy intake is expressed per kg body weight since CRF children were also stunted. The lower energy intake of the CRF patients is evident from the mean percentage RDA-I and from Fig. 1. Recently, surprisingly similar percentage RDA energy intakes were reported in a North American multicentre study on 82 children with mild-to-moderate CRF [29]. The causes of reduced food intake in our CRF children are not clear. These patients frequently reported a lower level of physical activity than control children, a finding that could account for a reduced energy requirement. Anorexia, a common symptom of CRF, could also play a role in the reduced energy intake. Growth retardation in CRF children has been related to the low energy intake [7, 22]. On the other hand the spontaneously reduced food intake could represent a form of adaptation to a growth which is impaired because of non-nutritional factors.

The average diet of children in developed countries tends to supply an excess of protein. Patients with CRF on conservative treatment who are not on controlled diets are reported to have similarly high protein intakes [12]. We found that protein intake was significantly lower in CRF children than in controls, especially in older children. Although the intake data were collected before any specific nutritional counselling was given, it should be noted that the centres participating in this study are specialized departments where patients often arrive after a diagnosis has already been made. The subjects could therefore have already received some dietary advice (by the family doctor, mass-media, etc.), the true "spontaneousness" of their diet thus being reduced. Treatment of CRF with a low protein diet is deep-rooted among doctors in Italy because of some pioneer Italian reports [9]. On the other hand the lower protein intake of CRF children could well be related to a spontaneous avoidance of protein-rich food such as meat or dairy products.

As regards other nutrients, it is worth noting (1) the lower cholesterol intake in CRF children which is probably related to reduced consumption of foodstuffs of animal origin. The reduced atherogenicity of the diet of these patients is of interest considering that hyperlipidaemia is a common finding in CRF [24]; (2) the lower phosphorus intake in the CRF children also appears to be a consequence of reduced protein intake; (3) the low-to-marginal intake of calcium, iron and zinc in the CRF children which is more evident when the proportion of patients with a critically low (< 66% RDA-I) intake is considered rather than the mean values of the group. The deficient calcium intake is supposed to be overcome by pharmacological supplementation (not considered in the present intake data). The marginal intake of iron, which could be associated with iron malabsorption and chronic blood loss from the gastro-intestinal tract [8], could contribute, at least in some cases, to the anaemia present in many CRF patients.

In conclusion, this study shows that the diet of Italian children with CRF has some distinctive features such as the lower energy and protein intakes. The characterization of the diet of these patients enables the individuation of areas of nutritional inadequacy and represents the basis for dietary intervention strategies.

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References

1. Bandini L, Schoeller DA, Cyr HN, Dietz W (1990) Validity of reported energy intake in obese and non obese adolescents. Am J Clin Nutr 52: 421–425
2. Barsotti G, Morelli E, Giannoni A, Guiducci A, Lupetti S, Giovannetti S (1983) Restricted phosphorus and nitrogen intake to slow the progression of chronic renal failure: a controlled trial. Kidney Int 24 [Suppl 16]: 278–284
3. Brenner BM, Meyer TW, Hostetter TH (1982) Dietary protein intake and the progressive nature of kidney disease. N Engl J Med 307: 652–695
4. Brouhard BH (1986) The role of dietary protein in progressive renal disease. Am J Dis Child 140: 652
5. Catassi C, Guerrieri A, Natalini G, Oggiano N, Coppa GV, Giorgi PL (1988) Computerized dietary analysis in children aged 6–30 months. I. Method of the survey and energy intake. Riv Ital Pediatr 14: 702–706
6. Chantler C, Holliday MA (1973) Growth in children with renal disease with particular reference to the effects of calorie malnutrition: a review. Clin Nephrol 1: 230–241
7. Claris-Appiani A, Bianchi ML, Bini P, et al (1989) Growth in young children with chronic renal failure. Pediatr Nephrol 3: 301–304
8. Eknoyan G (1988) Effects of renal insufficiency on nutrient metabolism and endocrine function. In: Nutrition and the kidney. Mitch WE, Klahr S (eds) Little, Brown and Company, Boston, pp 29–58
9. Giovannetti S (1986) Low protein diet in chronic uremia: a historical survey. Contr Nephrol 53: 1–6
10. Hackett AF, Rugg-Gunn AJ, Appleton DR, Coombs A (1986) Dietary sources of energy, protein, fat and fibre in 375 English adolescents. Hum Nutr Appl Nutr 40A: 176–184
11. Hoffmans AF, Obermann-De Boer GL, Florack EIM, Van Kampen-Donker M, Kromhout D (1986) Energy, nutrient and

food intake during infancy and early childhood. The Leiden preschool children study. Hum Nutr Appl Nutr 40A: 421–430
12. Holliday M (1986) Nutrition therapy in renal disease. Kidney Int 30: 3–6
13. Hostetter TH, Olson JL, Rennke HG, Venkdatachalam MA, Brenner BM (1981) Hyperfiltration in remnant nephrons: a potentially adverse response to renal ablation. Am J Physiol 241: 85–93
14. Carnovale E, Miuccio F (1989) Tabelle di composizione degli alimenti Istituto Nazionale della Nutrizione, Roma
15. Lewis B, Mann JI, Mancini M (1986) Reducing the risks of coronary heart disease in individuals and in the population. Lancet I: 956–959
16. Società Italiana Nutrizione Umana (1989) Livelli di assunzione giornalieri raccomandati di energia e nutrienti per la popolazione italiana. Istituto Nazionale della Nutrizione, Roma
17. McCance RA, Widdowson EM (1978) The composition of foods, 4th edn. Elsevier, North Holland Biomedical Press
18. Mehls O, Ritz E, Schärer K (1984) Diet in renal diseases: old practice, new concepts. In: Broedehl J, Ehrlich JH (eds) Paediatric nephrology, 76–80. Springer, Berlin Heidelberg New York, pp 76–80
19. Motomura K, Okude S, Sanai T, Ando T, Onoyam K, Fujistui M (1988) Importance of early initiating of dietary protein restriction for the prevention of experimental progressive renal disease. Nephron 49: 144–149
20. Paul AA, Whitehead RG, Block AE (1990) Energy intake and growth from 2 months to three years in initially breast-fed children. J Hum Nutr Diet 3: 79–92
21. Person LA (1984) Dietary habits and health risk in swedish children. Hum Nutr Clin Nutr 38C: 287–297
22. Rizzoni G, Basso T, Setari M (1984) Growth in children with chronic renal failure on conservative treatment. Kidney Int 26: 52–58
23. Rosman JB, Ter Wee PM, Meyer S, Piers-Brecht TD, Sluiter WJ, Danker AJ (1984) Prospective randomised trial of early dietary protein restriction in chronic renal failure. Lancet II: 1291–1296
24. Sanfelippo MI, Swenson RS, Reaven GN (1977) Reduction of plasma triglycerides by diet in subjects with chronic renal failure. Kidney Int 11: 54–61
25. Schoeller DA (1990) How accurate is self-reported dietary intake. Nutr Rev 48: 373–379
26. Sigström L, Altman PO, Jodal U, Odenman I (1984) Growth during treatment with low protein diet in children with renal failure. Clin Nephrol 21: 152–158
27. Souci SW, Fachmann W, Kraut H (1989) Food composition and nutrition tables 1989/90 4th edn. WV GmbH, Stuttgart
28. Tanner JM, Whitehouse RH (1966) Standards from birth to maturity for height, weight, height velocity and weight velocity; British children. Arch Dis Child 41: 454–471; 613–615
29. Watson C, Abitbol C, Warady B, et al (1990) Linear growth and anthropometric and nutritional measurements in children with mild to moderate renal insufficiency: a report of the growth failure in children with renal diseases study. J Pediatr 117: 46–54
30. Wingen AM, Fabian-Bach C, Mehls O (1991) Low protein diet in children with chronic renal failure – 1-year results. Pediatr Nephrol 5: 496–500