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Original article

Finding the right balance: An evaluation of the adequacy of energy and protein intake in childhood cancer patients☆

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SUMMARY

Background & aims: Despite a widespread belief that adequate dietary intake is needed to maintain weight during childhood cancer treatment, conclusive data about adequacy of intake are lacking. Therefore, we aimed to assess the adequacy of energy and protein intake in a heterogeneous childhood cancer population against 3 different norms.
Methods: We conducted a prospective cohort study of 115 children diagnosed with cancer and assessed dietary intake after diagnosis and at 3, 6, and 12 months. Intake was assessed against recommended daily allowances (RDA), intake in healthy controls, and calculated individual requirements; and subsequently related to changes in nutritional status.
Results: Energy intake was lower than RDA and lower than in healthy controls at all measurement points; whereas energy intake matched individual requirements at 2 of the 4 measurement points. Protein intake in childhood cancer patients was lower than in healthy children. However, protein intake was almost twice the RDA and one and a half times the individual requirements. During the study period, weight and fat mass (FM) increased significantly while fat free mass (FFM) remained low. Energy intake was negatively associated with weight and FM, and protein intake was not associated with FFM.
Conclusions: The patients' weight increased; whereas their energy intake was lower than RDA and lower than in healthy controls. This indicates that the average intake was more than adequate. Percentage intake of individual requirements matched with increased weight. Therefore, the use of this norm is preferable to RDA or intake in healthy controls when determining the adequacy of dietary intake in both clinical practice and futures studies.

1. Introduction

During childhood, adequate energy and protein intake is of the utmost importance, since this phase of life is characterized by rapid growth and development. In children with cancer adequate intake is even more important, particularly because inadequate dietary intake increases both morbidity and mortality and impedes normal growth and development [1–3].

Our literature search [4] on intake in childhood cancer patients revealed that it was difficult to draw uniform conclusions about the adequacy of dietary intake because intake was assessed at different time points and because different norms were used. In some

Abbreviations: EAC, energy absorption coefficient; EIR_c, (calculated) individual energy requirement; $\%EIR_c$, percentage energy intake of (calculated) individual requirement; ESPEN, European Society for Clinical Nutrition and Metabolism; FCS, food consumption survey; FFM, fat free mass; FM, fat mass; GF, growth factor; HFA, height-for-age; PAL, physical activity level; PIR_c, (calculated) individual protein requirement; $\%PIR_c$, percentage protein intake of (calculated) individual requirement; RDA, recommended daily allowances; RMR, resting metabolic rate; SDS, standard deviation scores; WFA, weight-for-age.

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studies, for instance, energy intake was assessed against recommended daily allowances (RDA) whereas other studies used energy intake in healthy controls as a norm. Furthermore, since none of these studies tested the impact of energy intake on nutritional status, it remains unknown whether inadequate energy intake according to requirements of RDA or intake in healthy controls resulted in weight loss or undernutrition. Only one cross-sectional study assessed energy intake against calculated individual requirements. This study reported worse nutritional status in the group with the lowest intake [5].

It is questionable, however, whether RDA or intake in healthy controls are suitable norms to estimate energy requirements in children treated for cancer. An individual norm that includes specific patient characteristics might be a better alternative than group norms. In general, it is thought that energy requirements in cancer patients are elevated because of an increased metabolic rate due to tumor activity [6]. Therefore, it is recommended to increase energy intake in childhood cancer patients with 15–50% to compensate for this increased metabolic rate and for undernutrition [7]. However, the evidence for an increased metabolic rate in childhood cancer patients is inconclusive [4]. Moreover, since cancer patients are less active than healthy persons, increased energy needs for metabolic rate are often compensated by decreased needs for physical activity [8] Therefore, the ESPEN guidelines on nutrition in adult oncology patients state that “energy requirements in cancer patients should be assumed to be normal unless there are specific data showing otherwise” (p. 447) [9].

In contrast to the literature on energy intake, literature on protein requirements during childhood is scarce. Proteins are essential for growth and synthesis of lean body mass. During illness, protein requirements are assumed to be increased to compensate for muscle wasting which is caused by inflammation and inactivity [10]. Nevertheless, evidence for increased protein needs in children is scarce [11].

In view of the lack of conclusive data regarding the adequacy of dietary intake in children treated for cancer, we conducted a prospective cohort study and assessed adequacy of dietary intake against three different norms: calculated individual requirements, RDA, and intake in healthy controls. Dietary intake was measured at 4 time points: after diagnosis and at 3, 6, and 12 months. Our research questions were: 1) How are these three norms interrelated? 2) How are these norms related to changes in nutritional status?

2. Methods

2.1. Participants

In the period between September 2007 and December 2009, all children between 0 and 18 years of age who were consecutively admitted to the Pediatric Oncology Department of the University Medical Center Groningen (UMCG) and who were newly diagnosed with cancer were approached for the Pecannut (Pediatric Cancer and Nutrition) study. Exclusion criteria were: being unable to understand the Dutch language or receiving non-curative treatment. In total, 146 patients were eligible for inclusion. Twenty patients refused participation because they found the study too burdensome ($n = 17$) or because they experienced a lack of motivation ($n = 3$) (response rate 86%). After inclusion 11 patients left the study because they became too ill ($n = 1$), experienced too much burden ($n = 5$), or experienced a lack of motivation ($n = 5$). Finally, 115 patients participated in the study. Ethical approval was obtained from the Medical Ethics Committee of the UMCG, and both parents and children aged ≥12 years gave their written consent.

2.2. Measures

Dietary intake data were collected using 3-day food records (3 consecutive days, including 1 weekend day) within the first 1–3 weeks after diagnosis and at 3, 6, and 12 months. This method has been shown to be an accurate and valid method for assessment of dietary intake [12]. In addition to the amount of intake, it was registered whether the child received solely oral feeding or tube feeding (with or without additional oral feeding). Furthermore, data on vomiting and diarrhea were registered as well.

Weight was measured using a calibrated digital scale and recorded to the nearest 0.1 kg (for infants to the nearest 0.01 kg). During measurements children only wore underwear. Height was measured using a calibrated digital stadiometer or an infantometer for infants, and recorded to the nearest 0.1 cm. To adjust for age and gender, standard deviation scores (SDS) of weight, height, and weight-for-height (WFH) were calculated according to Dutch reference standards [13]. Undernutrition was defined as WFH < -2 SDS and overnutrition as WFH > 2 SDS. Body composition was determined by bioelectrical impedance analyses (BIA) using a 50 kHz frequency BIA (BIA 101, Akern, Italy). After calculating fat free mass (FFM) with the equation of Goran [14], fat mass (FM) and percentage fat mass (%FM) were calculated and expressed as SDS using Dutch reference values [15]. All measurements were taken after diagnosis and at 3, 6, and 12 months. The follow-up measurements were taken between courses of chemotherapy and in the absence of fever, intravenous hyperhydration, and edema.

2.3. Data analysis and statistics

Dietary intake of energy and protein was calculated using food calculation software (Eetmeter 2002, The Netherlands Nutrition Centre, The Netherlands). Data on vomiting and diarrhea were incomplete and therefore not included in the analysis. Individual energy requirements (EIR_c) were calculated with the prediction formula recommended by the Dutch Malnutrition Steering Group [16] and included metabolic rate (RMR) (calculated using Schofield's equations [17]), physical activity (PAL), growth (GF), and energy absorption coefficient (EAC) (for further details see Supplementary tables).

$$EIR_c = RMR \times PAL \times GF/EAC$$

The illness factor was omitted from the equation since the evidence for increased energy requirements due to an increased metabolic rate is inconclusive [4]. Furthermore, the first assessment of intake took place after the start of treatment, and in this particular patient group increased metabolic rate has never been demonstrated after the start of treatment. The PAL was based on Lansky Play Performance scale [18] and ranged from 1.0 to 1.5 depending on the activity level of the child (Supplementary Table 2); GF ranged from 1.02 to 1.3 depending on the age of the child (Supplementary Table 3), and EAC was age dependent as well and ranged from 0.60 to 0.98 (Supplementary Table 4). Subsequently, percentage energy intake of individual requirement ($\%EIR_c$ = measured energy intake/EIR × 100) was calculated. Individual protein requirements (PIR_c) were calculated by multiplying the child's weight with the recommended protein intake of the Dutch Malnutrition Steering Group [19] (Supplementary Table 5). In addition, percentage protein intake of individual requirement was calculated ($\%PIR_c$).

Data on RDA were derived from the recommendations of the Health Council of the Netherlands [20] (Supplementary Table 6). Data on intake of healthy children were derived from the Dutch National Food Consumption Survey Young Children 2005/2006 (FCS) [21] and from the Dutch National Food Consumption Survey