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Original article

A simple method for identification of misreporting of energy intake from infancy to school age: Results from a longitudinal study

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SUMMARY

Background & aims: Misreporting is a major source of reporting bias in nutritional surveys. It can affect the analysis of associations between diet and disease. Although various methods have been proposed to identify misreporting, their application to infants and young children is difficult. We identify misreporting of energy intake in infants and young children and propose a simplified approach.
Methods: 1199 children were enrolled in the Childhood Obesity Programme (CHOP) based in 5 European countries (Belgium, Germany, Italy, Poland and Spain) with repeated measurements of 3-day weighed food protocol and anthropometric indices at 10 time points between ages 1–96 months. Individual cut-offs for the ratio of reported energy intake and estimated energy requirement were calculated to identify misreporters. Misreporting was studied according to age, gender, BMI z-scores and country.
Results: We identified a higher proportion of over-reporters (18.9%) as compared to under-reporters (10.6%). The proportion of over-reporting was higher among infants while under-reporting was more prevalent in school-aged children. Under-reporting was higher in boys (12.0%) and in obese/over-weight children (36.3%). Mean values for upper and lower cut-offs for the ratio of reported energy intake and estimated energy requirement in children ≤12 months were 0.80 and 1.20, and 0.75 and 1.25 for children >12 months, respectively. Using these fixed (mean) values, 90.4% (kappa statistic: 0.78) of all misreporters could be identified.
Conclusions: Despite intensive measures to obtain habitual intake of children, an essential proportion of nutritional reports were found to be implausible. Both over- and under-reporting should be carefully analysed, even in studies on infants. Fixed cut-offs can be applied to identify misreporting if no individual variation in energy intake can be calculated.
Clinical trial registry: This trial was registered at https://clinicaltrials.gov/: NCT00338689.

1. Introduction

There are different dietary recall methods used in nutrition related studies, which are based on the assumption that reported dietary intake reflects habitual intake. However, it is well-known that obtaining accurate dietary data is difficult due to a number of reasons such as difficulties in recalling foods consumed, food recognition, estimation of portion size and consumption frequency [1]. The process of obtaining the habitual intake becomes more

List of abbreviations: BMI, body mass index; BMR, basal metabolic rate; CHOP, European Childhood Obesity Programme; CV, coefficient of variation; DLW, doubly labelled water technique; ED, energy needed for deposition; EER, estimated energy requirement; EI, energy intake; HRM, heart rate monitoring; SEM, standard error of the mean; TEE, total energy expenditure.

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complex in young children, for whom dietary recall methods are conducted on proxy-reporters such as parents or care-givers.

Even though parents can report accurately about their child's food intake in the home setting [2], misreporting of dietary intake is a major issue in dietary recall methods. Misreporting which comprises of under- and over-reporting leads to reduced validity of self-reported dietary recall methods and distorted analysis of relationships between nutrient intake and health [3,4]. Identification of misreporting is crucial in paediatric based nutritional studies on which policies, guidelines and programmes are set with a focus on optimal growth and development of children.

Several methods have been suggested to identify misreporting. The method given by Goldberg, known as ‘CUT-OFF 2’, is based on the principles of energy physiology, which includes basal metabolic rate (BMR) and physical activity levels (PAL) and is a modification of the original Goldberg method known as ‘CUT-OFF 1’ [5]. It gives equations to derive lower cut-offs to identify under-reporting based on the assumption of sedentary lifestyle. This method was developed for identification of energy intake (EI) misreporting in adults and has been modified for use in children. It compares the ratio of EI:BMR against the estimated cut-offs based on PAL at a confidence level of 95% and takes into consideration both the biological variability and measurement errors in EI, BMR and PAL [6]. However, it requires the use of appropriate PAL values which may not always represent the true activity level of an individual [7]. The BMR can also have different values depending upon the method used for its estimation. While Schofield's BMR equations [8] have been applied widely, its validity has been questioned. They tend to underestimate BMR [9] and do not have a good agreement between measured and predicted BMR at early ages [10]. Alternatively, misreporters can be identified by comparing EI directly with the measured or predicted total energy expenditure (TEE) or simply by using previously published cut-off values to identify misreporting. While the original Goldberg formula and most former reports on misreporting focused on under-reporting, the upper cut-off limit could also be calculated to identify over-reporting.

The method to identify energy intake misreporting in the paediatric population is important and can be complicated due to the various required components. Most methods to identify misreporting are based on data of an adult population and may not be applicable for young children. For infants and school age children, TEE can be estimated using equations given by Butte [9] and Torun [11] to which additional energy needs have to be added to compensate for energy deposition in new tissues. This results in estimated energy requirements and can be compared to the energy intake to identify misreporting at young ages.

In this study, we identify misreporting in a multicentre European cohort study with nutritional records at multiple time points between 1 and 96 months of age based on the individual ratio of reported energy intake and estimated energy requirement. We also recommend misreporting cut-off values based on mean population ratios for infants and young children for simple and direct identification of both under- and over-reporters that can be applied in studies with food protocols of less than 3 days or with food frequency protocols.

2. Materials and methods

2.1. Study design

The European Childhood Obesity Programme (CHOP) is an originally double-blind, randomized controlled trial which compared childhood risk of obesity in two groups of children fed cow-milk formula with either higher (n = 550) or lower (n = 540) protein content for the first year of life. Additionally, a group of breast-fed children was also included in the study (n = 588). Children were followed from birth until 8 years of age. A detailed description of the study has been published previously [12].

2.2. Study population

Healthy, singleton, term infants were recruited shortly after birth between 1 October 2002 and 31 July 2004 from birth clinics in 8 urban areas of 5 European countries (Belgium, Germany, Italy, Poland, and Spain). All study centres used standardised procedures to follow children. Data on dietary intake was collected at time points 1, 3, 6, 12, 24, 36, 48, 60, 72 and 96 months of age. Anthropometric measurements were taken during study visits at recruitment (0–8 weeks of life) and otherwise at the same time points as the dietary protocols. Details of the study population have been described elsewhere [13].

A total of 1358 children enrolled in CHOP had at least one food protocol at any given time point. We excluded all protocols of children of the breastfed group up to six months of age and those breastfeeding thereafter as human milk intake was not measured. It has been shown that 3 day food protocols are required to estimate the usual dietary intakes [14]. Therefore, excluding also children with food protocols of less than 3 days, we had nutritional information of 1212 children with 6318 3-day food protocols. Since estimation of energy requirements requires a weight measurement, we excluded food protocols without concurrent weight (n = 120 of 113 children). Sixty protocols of 46 children were excluded because exactly the same intakes were reported for all days resulting in a standard deviation of energy intake over the three food protocols equal to zero. Hence, we conducted this study on a total of 6137 food protocols at ten follow-up time points from 1199 children. Detailed participant flow diagram is available in Supplemental Fig. 1.

2.3. Study procedures

Food intake was collected using weighed food record conducted on 3 days, including 1 weekend day and 2 weekdays, at ages 1, 3, 6, 12, 24, 36, 48, 60, 72 and 96 months. Parents of the enrolled children were instructed to weigh each single food item given to their child with a digital scale (Soehnle Unica, no. 66006, Murrhardt, Germany) before consumption and also weigh and record leftover food items. From 36 months onwards, parents had the possibility to fill out an alternative dietary record by comparing consumed food with pictures of standardized and weighed portion sizes, if weighing was not possible. Quality check of the reported data was done using standard operating procedures [15]. It contained information on how to code a large range of ethnically and regionally differing foods, ingredients of recipes and their portion sizes, and how to add additional food items into the database. Each food protocol was checked by a nutritionist, who also discussed them with the parents before the details were entered into a database for further processing. The database was based on the BLS 2.3 (Bundeslebensmittelschluessel; German food database) [16] and was enriched by foods that were not found with their nutritional information based on manufacture information or other nutritional databases.

2.4. Estimated energy requirements

Energy requirement is the amount of energy needed to balance energy expenditure and includes energy needed for optimal growth and development in children [17]. We estimated the energy requirement according to age and gender for each child at a given follow-up time point as [18]: