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RESEARCH ARTICLE

Nutrient intake in aging infants and toddlers: 3-year follow-up of the Nutrintake study

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ABSTRACT

We performed a 3-year follow-up of the children enrolled into the Nutrintake Study to evaluate the changes of anthropometry and nutrient intake in aging infants and toddlers. Nutrient intake was assessed using a 7-day weighted food-diary. Of the 390 Nutrintake children, 164 (42%) participated in the present study. Their median (IQR) age was 54 (48; 66) months and their anthropometrical status, expressed as standard deviation scores, remained stable during the follow-up. During the same period, there was no biologically relevant change in the intake of macronutrients expressed as percentage of energy while median increases of 757 mg/day, 0.7 mg/day and 3.1 g/1000 kcal per day were detected for sodium, iron and fibre, respectively. As compared to the Italian reference standards, the Nutrintake children continued to show at the 3-year follow-up an excessive intake of simple carbohydrates, proteins, sodium, and a low intake of iron and fibre.

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Introduction

The promotion of healthy lifestyles during the first years of life is central to the prevention of obesity and its complications (Blake-Lamb 2016; Baur and Garnett 2018). Two of the six "key actions" recently identified by the World Health Organisation (WHO) to "end childhood obesity" are related to nutrition (WHO 2017). The first action is the implementation of comprehensive programmes to increase the intake of healthy foods and decrease that of unhealthy foods and sugar-sweetened beverages; the second action is the provision of guidance and support for a healthy diet to ensure appropriate growth (Blake-Lamb et al. 2016; Baur and Garnett 2018).

The rationale for the Nutrintake (NI) Study, performed between September 2012 and March 2013 in a convenience sample of 390 children living in Milan and Catania (Italy), was the lack of good-quality data on the nutrient intake of infants and toddlers (Zuccotti et al. 2014). Systematic reviews had in fact pointed out that weighted records were needed to accurately estimate nutrient intake, and especially micronutrient intake, in infants and children (Henríquez-Sánchez et al. 2009; Serra-Majem et al. 2009). Therefore, to evaluate the nutrient intake of the NI children (Zuccotti et al. 2014), we used the presently recognised reference method, i.e. the 7-day weighted food-record (7DWFR) (Martini et al. 2017). A systematic review performed two years after the publication of NI confirmed that a minority of studies of pre-school children had employed the weighted-food record method, which was a 2-day or 3-day weighted food-record (3DWFR) in all cases (Pereira-da-Silva et al. 2016). After the publication of NI, two other studies employing the 3DWFR have been performed in Italian children (Concina et al. 2018; Verduci et al. 2019).

Adult dietary habits are likely to be shaped in childhood (Scaglioni et al. 2018), and Nutrintake offered the possibility to evaluate the changes of nutrient intake and anthropometry in a cohort of aging infants and toddlers. In the present paper, we report the results of the Nutrintake 2 (NI2) study, which re-evaluated the Nutrintake 1 (NI1) children 3 years after their first visit, to assess the changes in their nutrient

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intake and anthropometric status. To the best of our knowledge, NI2 is the first study to evaluate the changes of nutrient intake in aging infants and toddlers using the 7DWFR.

Materials and methods

Study design

NI2 is the 3-year follow-up study of the NI1 cross-sectional study (Zuccotti et al. 2014). NI1 was a cross-sectional study aimed at assessing the energy and nutrient intake of Italian infants and toddlers living in North (Milan, Lombardy) and South (Catania, Sicily) Italy (Zuccotti et al. 2014). NI1 children were enrolled among the infants and toddlers cared for by a convenience sample of Italian family paediatricians (FPs). The inclusion criteria of NI1 were: (1) age within 6.0 ± 0.5, 9.0 ± 0.5, 12.0 ± 1.0, 18.0 ± 1.0, 24.0 ± 1.0 or 36.0 ± 1.0 months; (2) parents with a good command of the Italian language. The exclusion criteria for NI1 were: (1) any acute illnesses (e.g. influenza); (2) chronic diseases (e.g. food allergy) known to interfere with nutrition and growth. The sample size calculation for NI1 is described in detail elsewhere (Zuccotti et al. 2014). The study protocol of NI1 was approved by the Ethical Committee of the "Luigi Sacco" Hospital (Milan, Italy) and the parents or legal guardians of the children gave their written consent to participate. NI2 is a cohort study aimed at assessing the changes of energy and nutrient intake in the Nutrintake infants and toddlers 3 years after NI1 (Zuccotti et al. 2014). The only inclusion criterion was: (1) participation to NI1. The exclusion criteria were the same of NI1 (see above). There was no formal sample size calculation as our aim was to recall the greatest number of the children who took part to NI1. The study protocol of NI2 was approved by the Ethical Committee of the ASST "Fatebenefratelli-Sacco" Hospital and the parents or legal guardians of the children gave their written consent to participate. The study personnel and the methods of NI2 were the same of NI1 (see below), with two exceptions: (1) one instead of two dietitians followed-up the children in Catania and; (2) data entry was performed on a computer-based application rather than on a web-based application.

Anthropometry

The study dietitians (CC and AM in Milan and MCC in Catania) performed the anthropometric measurements using the same procedures employed for NI1 (Lohman et al. 1991; Zuccotti et al. 2014). Standard deviation scores (SDS) of weight, length (NI1) (Zuccotti et al. 2014), height (NI1 or NI2) and body mass index (BMI) were calculated using the WHO reference data (WHO Multicentre Growth Reference Study Group 2006). We also calculated the WHO ordinal classification of weight status based on BMI (underweight, normal-weight, over-weight and obese) (WHO Multicentre Growth Reference Study Group 2006).

Measurement of food intake

The study dietitians performed the dietary assessment using the same instruments and procedures employed for NI1 (Zuccotti et al. 2014). In detail, food intake was evaluated using a 7DWFR, which was administered to the parents of the children during a first encounter lasting 30 to 45 min. When the 7DWFR was returned one week later, the dietitians discussed its content with the parents, asked for clarifications when needed, and wrote their comments in a specific section of the 7DWFR. Single ingredients were always recorded on the 7DWFR. Detailed recipes were obtained for foods eaten at home and menus with detailed recipes were obtained from the canteen staff for children eating at kindergarten or school.

Data entry

The study dietitians recorded all data on anonymized case report forms and entered them into a purposefully developed database running under Windows or OS X (FileMaker Pro 11, FileMaker Inc., USA). The database application allowed the entry of new foods and recipes.

Calculation of nutrient intake

As for NI1 (Zuccotti et al. 2014), all the food records entered into the database were resolved into a working foodlist of unique items on the basis of food name, brand and description. Each item of the working foodlist was manually checked twice by both the dietitian in charge of food database management (ET) and the study methodologist (GB) and linked with food composition data to produce a definitive foodlist. The definitive foodlist was generated and merged with food composition data and the 7DWFRs using purposefully developed Stata 15.1 programmes (Stata Corp., College Station, TX, USA). Food composition data were obtained mostly from the Food

Composition Database for Epidemiological Studies in Italy used also for NI1 (Gnagnarella et al. 2014) and from a specifically developed infant food database. The NI2 infant food database differed from the infant food database developed for NI1 (Zuccotti et al. 2014) not only because it included additional foods but also because it recorded the updated composition of some foods. When a nutrient was not available in one of the above databases, we obtained it from the Italian Food Composition Database (Istituto Nazionale per la Ricerca sugli Alimenti e la Nutrizione 2000) or from the ingredients specified on the food label. As we did for NI1 (Zuccotti et al. 2014), we used the 7DWFR to calculate the intake of energy (E), total carbohydrates (CHO), simple carbohydrates (CHOS), fats (FAT), saturated fatty acids (SFA), proteins (PRO), sodium, iron and fibre.

Statistical analysis

Most continuous variables were expectedly not Gaussian-distributed (Zuccotti et al. 2014), and all are reported as median (50^{th} percentile) and interquartile range (IQR, 25^{th} and 75^{th} percentiles). Discrete variables are reported as the number and proportion of subjects with the characteristic of interest. The changes in anthropometry (weight, length/height, BMI) and energy and nutrient intake (E, CHO, CHOS, FAT, SFA, PRO, sodium, iron and fibre) between NI1 and NI2 were estimated using median regression with cluster confidence intervals (Koenker 2005). The change in the BMI status of the children as determined by the ordinal WHO classification was estimated using generalised ordinal logistic regression with cluster confidence intervals (Fullerton 2016). The change in the proportion of children whose nutrient intake was within or outside the current Italian reference values (Società Italiana di Nutrizione Umana 2019) was estimated using logistic regression with cluster confidence intervals (Hosmer et al. 2013). In all regression models, time was coded as discrete (0 = NI1; 1 = NI2) and the child was treated as cluster so that each child had two repeated measures corresponding to NI1 and NI2. Marginal estimates of nutrient intake at NI1 and NI2 and of their difference were obtained from all regression models and plotted and/or reported (Williams 2012; Grant 2019). Statistical analysis was performed using Stata 15.1 (Stata Corporation, College Station, TX, USA).

Protocol deviations

We planned to perform NI2 between 15 September 2015 and 1 March 2016. Our aim was to follow-up the NI1 children 3 years after their first evaluation, which was performed between 15 September 2012 and 24 February 2013 (Zuccotti et al. 2014). Between May and June 2015, the study dietitians contacted the families of the NI1 children to ascertain their availability to participate to NI2. 80% of the families gave their approval to participate to NI2. On June 2016, the principal investigator (GVZ) sent the study protocol to the Ethical Committee of the "Luigi Sacco" Hospital for approval. Unfortunately, the Ethical Committee, which also managed the study grant and the contracts of the study personnel (CC, AM, MCC, ET, GB), gave its approval only in January 2016. Such delay had nothing to do with the study protocol but was due to the fact that the "Luigi Sacco" and "Fatebenefratelli" Hospitals were undergoing fusion, causing delay in all the deliveries of the Ethical Committee. For the same reason, the research contracts of the study personnel could not be signed before January 2016 and the first visit of NI2 was performed on 23 January 2016. Moreover, because of the enrolment problems described in detail below, the last NI2 visit was performed on 1 December 2016 and the study database was made available to the study methodologist on 1 March 2016.

Results

Comparison of the NI1 children available and not available at the NI2 follow-up

NI2 recruited 164 (42%) of the 390 NI1 children (Zuccotti et al. 2014). Supplementary Table 1 reports the reasons for the loss at follow-up. The first reason (36%) was that the child and her/his family did not show up at one or more appointments taken with the study dietitians; the second reason (21%) was the retirement of one FP from the study because of personal reasons; the third reason (12%) was lack of time; the fourth reason (9%) was the change of the address of the family (implying that the child was not living anymore in the same city where NI1 was performed); the fifth reason (6%) was the unfortunate death of a FP. The first five reasons make up nearly 85% of all the reasons. Supplementary Table 2 compares the baseline features of the NI1 children available and not available at the NI2 follow-up. While the median of baseline age was slightly higher in the children available than in those not available at NI2, its

IQR was virtually the same. Likewise, the median and IQR of the anthropometric and dietary features were nearly the same on biological grounds. A possible exception is sodium intake, which had a larger median but a lower IQR in the children not available at NI2. Also the parents' features were similar among the children available and not available at follow-up.

Comparison of the NI2 children at the baseline and follow-up visits

Table 1 gives the features of the NI2 children at the baseline (NI1) and follow-up (NI2) visits. These cross-sectional values are given only for descriptive purposes, because the longitudinal changes were evaluated using regression models for repeated measures, as reported below. The median (IQR) time elapsed between NI1 and NI2 was 39 (37; 42) months. Such median is slightly higher than the planned follow-up time of 36 months.

Changes in anthropometry

Figure 1 plots the median (95%CI) values of weight, length/height and BMI at NI1 and NI2 as estimated by median regression for repeated measures. The median (cluster 95%CI) change of weight was 7.7 (7.1 to 8.3, $p < .001$) kg; that of length/height was 27.5 (25.7 to 29.3, $p < .001$) cm; and that of BMI was −1.1 (−1.4 to −0.8) kg/m^2. The median changes of weight, length/height and BMI expressed as SDS were neither statistically significant nor biologically relevant. As estimated by generalised ordinal logistic regression, the BMI status of the children remained stable from NI1 to NI2: 0.04 (cluster 95%CI 0.01 to 0.07) *vs.* 0.05 (0.02 to 0.08) for underweight; 0.77 (0.70 to 0.83) *vs.* 0.76 (0.70 to 0.83) for normal weight; 0.10 (0.06 to 0.15) *vs.* 0.07 (0.03 to 0.11) for overweight; and 0.09 (0.05 to 0.14) *vs.* 0.12 (0.07 to 0.16) for obesity. (Despite the apparent 3% decrease in overweight and 3% increase in obesity, the difference is minimal in terms of SDS and the estimation is obviously imprecise, as shown by the wide 95%CI, because of the low sample size).

Changes in nutrient intake

Figure 2 plots the median (95%CI) values of energy and nutrients at NI1 and NI2. It must be pointed out that, for the methodological reasons discussed in detail in the NI1 report (Zuccotti et al. 2014), we choose not to estimate nutrient intake from breast milk in the NI1 children so that the interpretation of the changes of energy and nutrient intake from NI1 to NI2 must take this fact into account. The median (95% cluster CI) change of energy intake was 471 (407 to 535, $p < .001$) kcal/day and −4 (−8 to 1) kcal per kg of weight. There was no biologically relevant change in the intake of macronutrients as a percentage of energy or weight: −0.01 (95% CI −1.5 to 1.5) %E for CHO; −1.9 (−3.1 to −0.7) %E for CHOS ($p < .01$); 0.3 (−1.0 to 1.5) %E for FAT; −0.4 (−1.0 to 0.2) %E for SFA; 0.2 (−0.5 to 0.8) %E for PRO; and −0.2 (−0.4 to 0.1) for PRO per kg of weight. The changes in the intake of micronutrients were however of potential biological relevance with increases of 757 (95%CI 596 to 919) mg/day for sodium ($p < .001$), 0.7 (0.3 to 1.2) mg/day for iron ($p < .01$), and 3.1 (2.4 to 3.8) g/1000 kcal of E per day for fibre ($p < .001$).

Table 1. Features of the NI2 children at the baseline and follow-up visits.

	NI1 ($N = 164$)	NI2 ($N = 164$)
Age (months)	17 (9;24)	54 (48;66)
Follow-up (months)	–	39 (37;42)
Weight (kg)	10.3 (8.9;12.6)	18.0 (15.9;20.5)
Weight (SDS WHO)	0.24 (−0.39;0.88)	0.07 (−0.63;0.72)
Length or height (cm)	79.6 (71.8;88.9)	107.5 (102.0;113.2)
Length or height (SDS WHO)	0.15 (−0.50;0.92)	0.09 (−0.53;0.73)
BMI (kg/m^2)	16.5 (15.6;17.7)	15.4 (14.6;16.6)
BMI (SDS WHO)	0.24 (−0.45;0.88)	0.10 (−0.51;0.89)
BMI class (WHO)		
Underweight	6 (3.7%)	8 (4.9%)
Normal weight	126 (76.8%)	125 (76.2%)
Overweight	17 (10.4%)	12 (7.3%)
Obese	15 (9.1%)	19 (11.6%)
E (kcal/day)	800 (629;1050)	1271 (1126;1441)
E (kcal/kg weight)	76 (61;88)	72 (61;80)
CHO (%E)	54 (51;58)	54 (51;57)
CHOS (%E)	21 (18;25)	20 (17;22)
FAT (%E)	31 (28;35)	31 (29;34)
SFA (%E)	11 (10;13)	11 (10;12)
PRO (%E)	14.3 (12.5;16.2)	14.4 (13.1;15.6)
PRO (g / kg weight)	2.7 (2.0;3.4)	2.6 (2.1;2.9)
Sodium (mg/day)	706 (299;1170)	1463 (1183;1723)
Iron (mg/day)	5 (3;6)	5 (5;7)
Fibre (g/1000 kcal E per day)	7 (5;9)	10 (8;12)

NI: Nutrintake; SDS: standard deviation score; WHO: World Health Organisation; BMI: body mass index; E: energy; CHO: carbohydrates; CHOS: simple carbohydrates; FAT: fats; SFA: saturated fatty acids; PRO: proteins. Continuous variables are reported as median and interquartile range (IQR). Discrete variables are reported as number and proportion. This table is reported only for descriptive purposes because the change in the measurement of interest was estimated by regression for repeated measures (see "Statistical analysis" for details).

Comparison of nutrient intake with reference values

Table 2 gives the proportion of children with nutrient intake within or outside the current Italian reference values (Società Italiana di Nutrizione Umana 2019). The proportion of children eating less than 15% of E

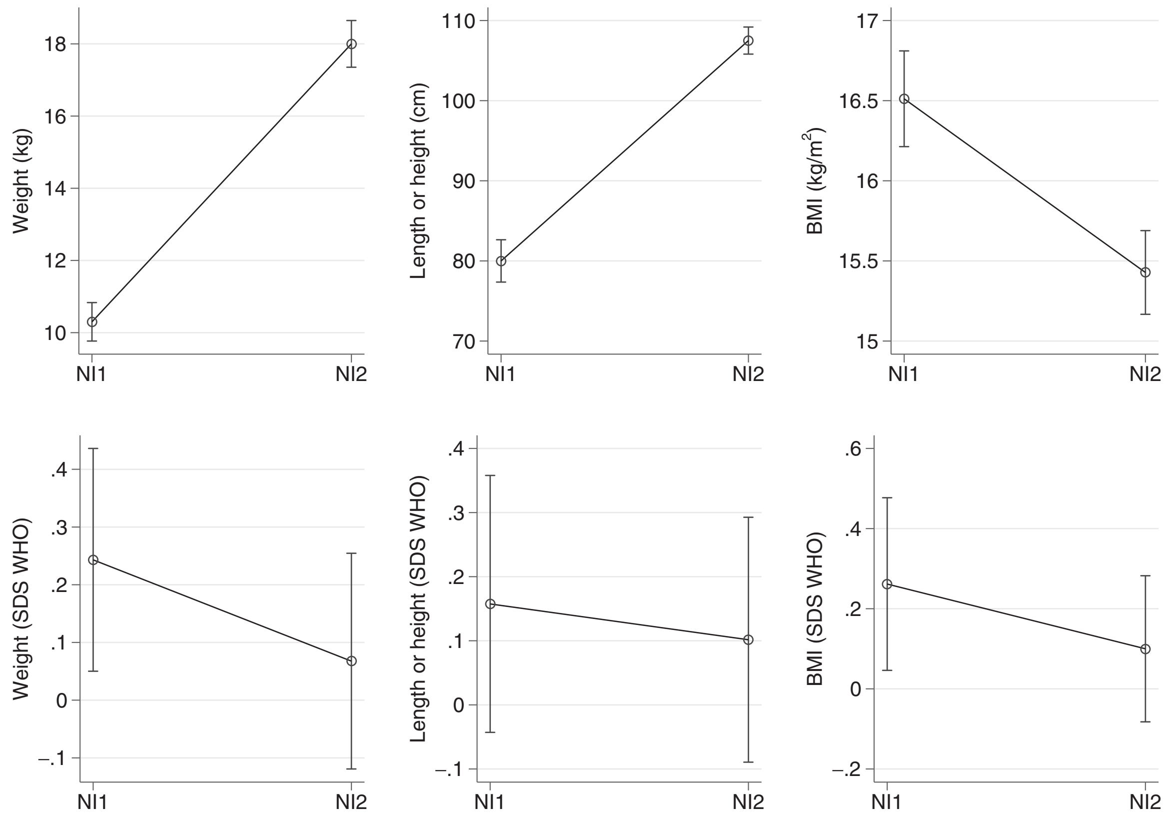

Figure 1. Changes of weight, length/height and body mass index from Nutrintake 1 to Nutrintake 2. The change was estimated using median regression with cluster confidence intervals (see text for details). Abbreviations: WHO: World Health Organisation; SDS: standard deviations scores.

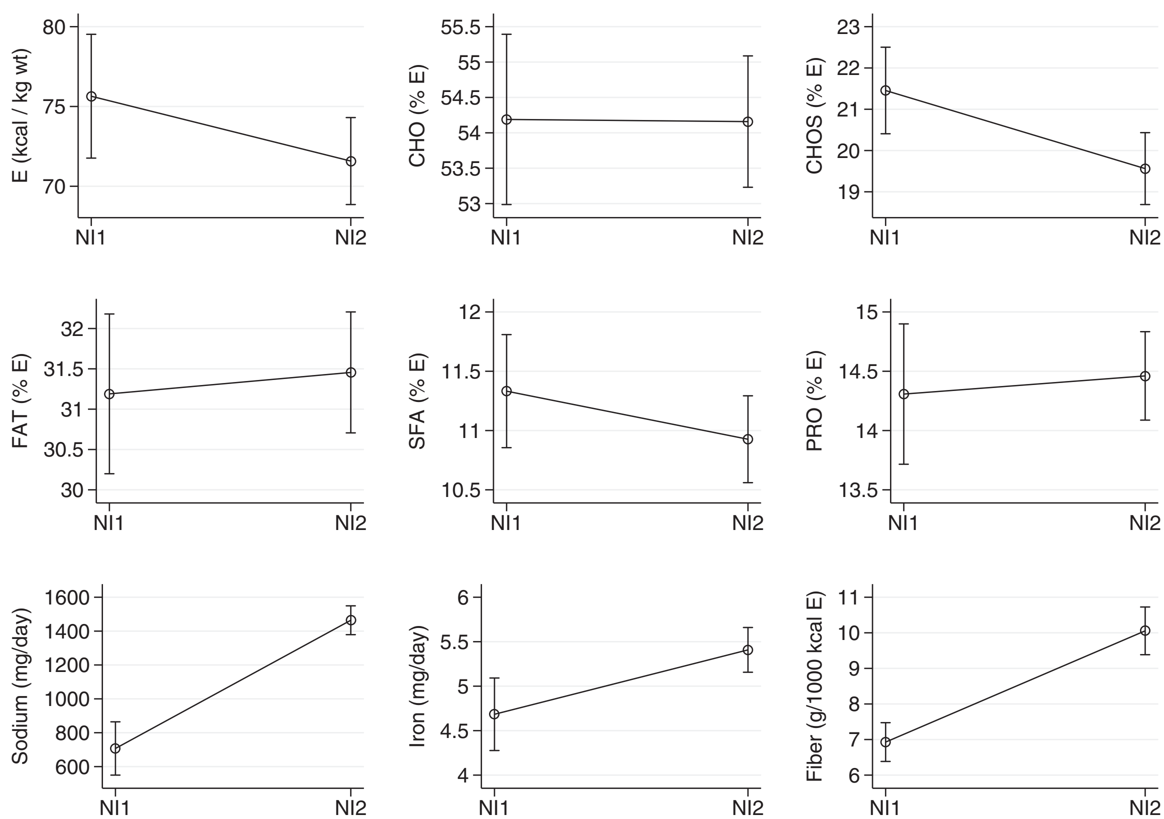

Figure 2. Changes of energy and nutrient intake from Nutrintake 1 to Nutrintake 2. The change was estimated using median regression with cluster confidence intervals (see text for details). Abbreviations: NI: Nutrintake; E: energy; CHO: carbohydrates; CHOS: simple carbohydrates; FAT: fats; SFA: saturated fatty acids; PRO: proteins.

Table 2. Proportion of children with nutrient intake within or outside the current Italian reference values.

Reference value	NI1	NI2
CHO < 45% E (LL)	0.07 (0.03 to 0.11)	0.02 (0.01 to 0.04)
CHO > 60% E (UL)	0.15 (0.10 to 0.21)	0.09 (0.04 to 0.13)
CHOS < 15% E	0.12 (0.07 to 0.16)	0.18 (0.12 to 0.24)
FAT > age-specific LL	0.27 (0.20 to 0.34)	0.80 (0.74 to 0.86)
FAT < age-specific UL	0.95 (0.91 to 0.98)	0.87 (0.82 to 0.92)
SFA < 10% E	0.30 (0.23 to 037)	0.28 (0.21 to 0.35)
PRO > age-specific PRI	0.91 (0.86 to 0.95)	1.00*
Iron > age-specific PRI	0.08 (0.04 to 0.12)	0.00**
Fibre > 8.4 g / 1000 kcal E†	0.37 (0.27 to 0.46)	0.41 (0.34 to 0.49)
Sodium > UL†	0.62 (0.53 to 0.72)	0.77 (0.70 to 0.83)

NI: Nutrintake; CHO: carbohydrates; CHOS: simple carbohydrates; FAT: fats; SFA: saturated fatty acids; PRO: proteins; LL: lower limit; UL: Upper limit; PRI: population reference intake.
Values are proportions and 95%CI (in brackets) estimated from logistic regression for repeated measures (*see* "Statistical analysis" for details).
*95%CI not estimable because all children have the outcome of interest.
**95%CI not estimable because all children do not have the outcome of interest.
†Not available for 63 children who were aged <12 months at NI1. Thus, the number of children in whom the (NI2–NI1) difference was calculated is 101 (i.e. 164-63), while is 164 for all other nutrients.

from CHOS increased slightly from 12 to 18% from NI1 to NI2; that of children eating less than 10% of E from SFA decreased very slightly from 30 to 28%; that of children eating PRO in quantity greater than the age-specific PRI increased from 91% to 100%; that of children eating iron in quantity greater than the age-specific PRI decreased from 8% to 0%; that of children eating fibre in quantity greater than 8.4 g/1000 kcal of E per day increased slightly from 37 to 41%; lastly, the proportion of children eating sodium in quantity greater than the age-specific upper-limit increased from 62 to 77%.

Discussion

NI2 is the first study aimed at assessing the changes of energy and nutrient intake in aging toddlers and infants by means of a 7DWFR. At 3 years from NI1, we found a remarkable stability of macronutrient intake expressed as percentage of energy and of anthropometric status expressed as SDS. Even if the children increased their intake of iron and fibre, such intake was still low according to current reference values (Società Italiana di Nutrizione Umana 2019). Lastly, we detected an absolute increase of sodium intake as compared to NI1.

When we performed NI1 (Zuccotti et al. 2014), there was a clear need of good-quality data on the nutrient intake of infants and toddlers obtained with weighted food records (Henríquez-Sánchez et al. 2009; Serra-Majem et al. 2009) and this holds true still today (Pereira-da-Silva et al. 2016). This is the reason why we chose the reference 7DWFR method to assess the food intake of NI children. Of course, the fact that the 7DWFR is the current reference method, does not imply that it is free from error (Martini et al. 2017). Moreover, the price to pay for using a weighted food-record is the selection of subjects whose interest in nutrition counterbalances the burden of using it (Leclercq et al 2009; Zuccotti et al. 2014).

Two recent studies employed the 3DWFR to assess nutrient intake in Italian children (Concina et al. 2018; Verduci et al. 2019). These studies are of great interest but they are not directly comparable with NI2 because one is a cross-sectional study (Verduci et al. 2019) and the other is a cohort study with a shorter follow-up explained by a different aim (Concina et al. 2018). Some comments are however in order. The cross-sectional study used a 3DWFR administered by FPs to assess nutrient intake in infants and toddlers (Verduci et al. 2019) and its results are in agreement with those of NI1 (Zuccotti et al. 2014). The cohort study evaluated infants at 6, 9 and 12 months of age at a Maternal and Child Health Centre (Concina et al. 2018). These researchers chose not to compare their results with those of NI1 because "they did not take into account breast milk intake" (Concina et al. 2018). However, they also point out that "the methodology adopted to estimate the consumption of breast milk… constitute a weakness of the study" (Concina et al. 2018). Thus, we are at least in accordance with these researchers on the potential noise added to an already noisy signal by using a completely indirect method to assess breast milk intake (Zuccotti et al. 2014; Concina et al. 2018).

Even if NI2 is the first study to report the changes of nutrient intake in aging infants and toddlers using the reference 7DWFR method, it is not without limitations. First, NI1 was performed in a convenience sample of the general population and its findings and those of NI2 are unlikely to extrapolate to the "true" general population (Zuccotti et al. 2014). Nutrintake may offer a sort of best-case scenario of the food habits of infants and toddlers because the families who participated to NI1 were highly interested in the dietary habits of their children (Zuccotti et al. 2014). Second, although the NI2 respondent rate of 42% is in line with current practice (Morton et al. 2012), it is much lower than that we had hoped to reach (80%) on the basis of the preliminary interview made by the study dietitians with the parents of the children. Third, the unavoidable events described under "Deviations from protocol" made it impossible to perform the NI2 follow-up in the same months of NI1. On the other hand, we believe that NI2 has some important strengths. First, NI2 used the current reference method for the assessment of energy and nutrient intake, i.e. the 7DWFR (Martini et al. 2017). Second, the NI2 measurements were taken by the same experienced dietitians who took the NI1 measurements. Third, the reasons for the loss to follow-up and the comparison of all the available features of the NI1 and NI2 children suggest a random pattern of missingness.

The Nutrintake children showed a remarkable stability of anthropometry expressed as SDS and macronutrient intake expressed as percent of energy during the 3-year follow-up. This can be partly attributed to the fact that Nutrintake enrolled families very interested into the diet of their children (Zuccotti et al. 2014). Recent data suggest that obesity starts as early as 5 years of age and that the most rapid increase of BMI occurs between 2 and 6 years of age (Baur and Garnett 2018). These data are in agreement with those obtained in a recent study of Italian children followed by FPs (Shashaj et al. 2014), where obesity started to increase at 6 years of age. Besides the selection of highly motivated families (Zuccotti et al. 2014), another reason why we may have not been able to detect such change is that only 28 (17%) of the 164 NI2 children had more than 6 years of age.

The stability of the macro-nutrient intake of the Nutrintake children during the 3-year follow-up does not imply, however, the lack of some potentially biologically relevant errors. The intake of CHOS was within the recommended limit in just 18% of NI2 children. This may be especially important in view of the fact that the decrease of CHOS intake is central to the current strategy of fighting childhood obesity (WHO 2017). However, randomised controlled trials are needed to test such hypothesis (Baur and Garnett 2018). The intake of FAT was lower than the age-specific upper limit in 87% of NI2 children. However, the intake of SFA was lower than recommended in just 28% of them. In reporting this finding, however, we are obliged to mention that good-quality evidence linking SFA with hard outcomes is lacking (Astrup et al. 2019). The fact that PRO intake was greater than the population reference intake (PRI) in 100% of NI2 children is of interest because excessive protein intake in infancy is considered a modifiable a risk factor for later obesity (Blake-Lamb et al. 2016), even if definitive evidence is also lacking for this nutrient. Only 41% of NI2 children had an appropriate fibre intake and 77% had a sodium intake greater that the recommended upper limit.

As iron is concerned, the fact that all NI2 children had an iron intake lower than the PRI is not necessarily biologically relevant (Zuccotti et al. 2014). First, the PRI corresponds to the 97.5th percentile of the reference distribution and as such is "appropriate" for only 2.5% of children (Zuccotti et al. 2014). Second, only the assessment of iron intake together with iron status can shed light on the association between iron intake and iron deficiency. Third, the expected error of iron assessment, even if it is obtained from a 7DWFR as in our study, is higher than that expected for macronutrients (Zuccotti et al. 2014).

There was a substantial increase in sodium intake from NI1 to NI2. Our findings are in agreement with those of most studies performed using mostly dietary recall methods not only in children but also in adults following a Western diet (John et al. 2016; Pereira-da-Silva et al. 2016). They are however in contrast with those of a recent study performed on Italian infants, whose sodium intake was nearly half that of the NI1 peers (Concina et al. 2018). Because these children were enrolled at birth at a Maternal and Child Health Centre, it is possible that, contrarily to NI1 children, their families received systematic nutritional advice since infancy (which, of course, is possibly the best way to reduce the burden of diet-related disease) (Concina et al. 2018). Although the relationship between sodium intake and cardiovascular events remains controversial (Williams et al. 2018), there is no doubt that the sodium intake of the Nutrintake children is excessive by current standards.

Conclusion

In conclusion, at the 3-year follow-up, the NI children continued to show an excessive intake of CHOS, SFA, PRO, sodium and a low intake of iron and fibre. Further cohort studies tracking dietary habits using weighted food records from infancy into adolescence and adulthood are needed to better envisage prevention strategies to be tested in randomised controlled trials.

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Authors' contributions

GVZ performed the study design, study coordination, manuscript revision. CC performed the study design, dietary and anthropometric assessment, manuscript revision. AM carried out the study design, dietary and anthropometric assessment, manuscript revision. MCC carried out the study design, dietary and anthropometric assessment, manuscript revision. CM worked on study design, manuscript revision. ET performed the study design, food database management, manuscript revision. SS performed the study design, manuscript revision. GB performed the study design, statistical analysis, software programming, manuscript drafting, manuscript revision.

Disclosure statement

The authors report no conflict of interest.

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