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Self-reported food intake decreases over recording period in the National Diet and Nutrition Survey

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Abstract

From 2008, the UK's National Diet and Nutrition Survey (NDNS) changed the method of dietary data collection from a 7-d weighed diary to a 4-d unweighed diary, partly to reduce participant burden. This study aimed to test whether self-reported energy intake changed significantly over the 4-d recording period of the NDNS rolling programme. Analyses used data from the NDNS years 1 (2008/2009) to 8 (2015/2016) inclusive, from participants aged 13 years and older. Dietary records from participants who reported unusual amounts of food and drink consumed on one or more days were excluded, leaving 6932 participants. Mean daily energy intake was 7107 kJ (1698 kcal), and there was a significant decrease of 164 kJ (39 kcal) between days 1 and 4 ($P < 0{\cdot}001$). There was no significant interaction of sex or low-energy reporter status (estimated from the ratio of reported energy intake:BMR) with the change in reported energy intake. The decrease in reported energy intake on day 4 compared with day 1 was greater ($P < 0{\cdot}019$) for adults with higher BMI (>30 kg/m^2) than it was for leaner adults. Reported energy intake decreased over the 4-d recording period of the NDNS rolling programme suggesting that participants change their diet more, or report less completely, with successive days of recording their diet. The size of the effect was relatively minor, however.

Key words: Diet records: Energy intake: Nutrition assessment: Diet surveys

The burden on participants of completing food diaries has long been recognised. In one of the earliest dietary studies to use the weighed intake method, conducted 100 years ago, Moss commented that 'It is extremely difficult to induce even the best men to undertake the required task for seven to ten days'[1]. Despite the advantages of 7-d dietary records capturing a complete cycle of human behaviour[2], shorter recording periods are frequently used because of the lesser commitment needed from study participants, and because it is assumed that recording completeness diminishes as the recording period progresses[3]. Indeed, there is some evidence that calculated energy intake from self-reported food intakes decreases over a 7-d recording period. In an earlier examination of the effect of recording period on low-energy reporting in the National Diet and Nutrition Survey (NDNS), mean reported energy intake decreased by 49 kJ (12 kcal) (SE 22 kJ) per d between day 2 and 7 ($P = 0{\cdot}026$) after accounting for the effect of day of the week on reported energy intake[4]. Until 2003, the NDNS used a 7-d weighed intake diary method, with recording starting on different days of the week. From 2008, the NDNS became a rolling programme of annual surveys using 4-d estimated food diaries, which were considered much less burdensome for participants[5]. In year 1 of the rolling programme (2008/2009), participants started recording their food intake on Thursdays, Fridays or Saturdays, resulting in an unbalanced representation of days of the week and no recording on Wednesdays. This was addressed in the following years of the programme with the first recording day being balanced over all days of the week. Data collection for the rolling programme differs significantly from the earlier NDNS and is less work for participants to complete, and this may reduce the effect of decreasing reported energy intake over the recording period.

The present study aimed to compare the effects of recording period on reported energy intake in the NDNS rolling programme data, and specifically to test whether reported energy intake decreased as recording period progressed, and whether any effect was different for males *v.* females, or between low-energy reporters and presumed valid reporters.

Methods

Data from the NDNS rolling programme years 1 (2008/2009) to 8 (2015/2016)[6,7] were used to test for any effects of day of recording of dietary intake on reported energy intake.

Abbreviation: NDNS, National Diet and Nutrition Survey.

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Participants in the NDNS rolling programme complete an unweighed food diary, recording household measures, or weights of foods from labels, for four consecutive days. Participants are a representative sample from the UK and were aged from 1 to 96 years.

Parents or carers completed the food diaries of children aged 12 years and younger[7], and these were not included in this study.

Food diary data were examined to identify any that were likely to have been unusual. Data from some participants were excluded where participants had only 3 d's dietary data (*n* 160) or had recorded for non-consecutive days (*n* 5). When completing the diet record, participants note if they ate or drank more or less than usual, and the reason why this was so. Participants were excluded from these analyses where they reported unusual intakes because of illness or medical reasons (*n* 699), observing Ramadan (*n* 3), conscious effort such as being on a weight-loss diet (*n* 197) or reported an unusual intake but gave no reason (*n* 175). Of the remaining 6932 participants, 4060 reported an unusual intake on at least 1 of the 4 d, but the reason given was considered part of the normal day-to-day variability in food and drink consumption, such as 'at friends', 'working', 'with family' and 'weekend'. These data were not excluded, and 4-d diet records from 6932 participants were analysed.

BMI was calculated from height and weight measurements taken by NDNS interviewers using standard protocols. Adults (≥18 years old) were classified into six groups by BMI[8].

BMR was estimated using the equations of Henry[9], using sex, age and body weight and, where a measurement was performed during the NDNS interview (*n* 6877), height.

Low-energy reporters were identified where the mean reported energy intake from the 4-d food record was less than 1·06 × BMR[10].

Statistics

Daily energy intake data were analysed by fitting a linear mixed model with fixed effect terms for the recording day (days 1–4), day of the week (Monday–Sunday), sex (male or female), age group and low-energy reporter status as a categorical variable (low-energy reporters or assumed valid reporters) and random effect terms for variation between and within individuals. Two-way interactions between fixed effects were also included. Significance of fixed effects was assessed by *F* tests with estimated denominator df. Change in reported energy intake between day 1 and 4 across groups by BMI category was compared using ANOVA, and least squares distance *post hoc* tests. Analyses were conducted using Genstat 17th edition.

Results

Reported energy intake differed by day of the week ($P < 0·001$) and by recording day ($P < 0·001$; Table 1). Reported energy intake decreased significantly with progressive day of recording after accounting for the day-of-the-week effect, with the mean difference in adjusted energy intake between day 1 and 4 being −164 kJ (−39 kcal).

Mean daily reported energy intake was 7107 kJ (1698 kcal), equal to 1·18 × BMR, and 2509 (36·2 %) respondents were identified as low-energy reporters. Mean reported energy intake of the low-energy reporters was, obviously, lower than that of the presumed valid reporters (5759 kJ (1376 kcal) and 8703 kJ (2080 kcal), respectively, $P < 0·001$), and there was no significant interaction between low-energy reporter status and the difference in reported energy intake over the recording period. The mean difference in adjusted energy intake between recording days 1 and 4 was −116 kJ (–28 kcal) and −124 kJ (−30 kcal) ($P = 0·144$), equal to −3·7 and −2·4 % ($P = 0·182$) of mean daily energy intake, for low-energy reporters and assumed valid reporters, respectively.

There was no significant interaction between sex and recording day on reported energy intake between males and females ($P = 0·702$).

The interaction between age group and recording day on reported energy intake was statistically significant ($P < 0·001$). The youngest age group (13–20 years) had the biggest decrease, while the older adults (>61 years) generally increased energy intake over the recording period. Table 2 shows the mean unadjusted reported energy intake values by age group and sex.

Table 1. Mean unadjusted and adjusted reported energy intakes by day of week and by recording day

	Proportion of diaries started on this day (%)	Proportion of total number of recorded days (%)	Unadjusted energy intake		Adjusted energy intake*	
			kJ/d	kcal	kJ/d	kcal
Monday	12	14	7240	1730	6920	1654
Tuesday	14	13	7398	1768	7054	1686
Wednesday	13	13	7352	1757	6983	1669
Thursday	18	14	7363	1760	7002	1674
Friday	16	15	7767	1856	7169	1713
Saturday	13	15	8122	1941	7536	1801
Sunday	14	15	7534	1801	7078	1692
Recording day 1			7627	1823	7186	1717
Recording day 2			7593	1815	7108	1699
Recording day 3			7572	1810	7108	1699
Recording day 4			7419	1773	7022	1678

*Adjusted daily energy intake has accounted for effects of sex, age group, low-energy reporter status as a categorical variable, and recording day (for the day of week means) or day of the week (for the recording day means).

Table 2. Mean unadjusted reported energy intake (kJ and kcal) and difference in reported energy intake between days 4 and 1 by age group and sex

	Female										Male									
	Day 1		Day 2		Day 3		Day 4		Difference		Day 1		Day 2		Day 3		Day 4		Difference	
Age group (years)	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal
13–20	6960	1663	6828	1632	6685	1598	6479	1549	−481	−115	8746	2090	8503	2032	8547	2043	8251	1972	−495	−118
21–30	6895	1648	6832	1633	7045	1684	6866	1641	−29	−7	9431	2254	9426	2253	9244	2209	9146	2186	−285	−68
31–40	6870	1642	6975	1667	6910	1652	6672	1595	−198	−47	9263	2214	8999	2151	9265	2214	8947	2138	−316	−76
41–50	6914	1652	6905	1650	6739	1611	6838	1634	−76	−18	9017	2155	9172	2192	8952	2140	8714	2083	−303	−72
51–60	6767	1617	6677	1596	6801	1625	6721	1606	−46	−11	8754	2092	8696	2078	8739	2089	8466	2023	−288	−69
61–70	6383	1526	6666	1593	6655	1591	6554	1566	171	41	8520	2036	8572	2049	8435	2016	8454	2021	−66	−16
71–80	6121	1463	6142	1468	6207	1484	6215	1485	94	22	7596	1815	7676	1835	7649	1828	7676	1835	80	19
81–90	6210	1484	6242	1492	5978	1429	6069	1451	−141	−34	7503	1793	7278	1739	7686	1837	7186	1717	−317	−76
91–100	4456	1065	4632	1107	4453	1064	4540	1085	84	20	6010	1436	6612	1580	6718	1606	6639	1587	629	150

Table 3. Mean daily energy intake and difference in energy intake between days 1 and 4 by BMI category

		Mean daily energy intake		Difference in daily energy intake between days 1 and 4	
BMI group	n	kJ	kcal	kJ	kcal
Underweight, <18·5 kg/m^2	85	7346	1756	63	15
Normal weight, 18·5–24·9 kg/m^2	1701	7720[a,b,c]	1845	−282[a]	−67
Pre-obesity, 25–29·9 kg/m^2	1874	7632[d,e,f]	1824	19[a,b]	4
Obesity class I, 30–34·9 kg/m^2	954	7368[a,d]	1761	−80[c]	−19
Obesity class II, 35–39·9 kg/m^2	357	7071[b,e]	1690	−163	−39
Obesity class III, ≥40 kg/m^2	135	7147[c,f]	1708	−635[b,c]	−152

[a,b,c,d,e,f] Mean values within a column with the same superscript letters were significantly different ($P<0{\cdot}05$).

Finally, there was a statistically significant, but quantitatively negligible, association between body weight status and the change in reported energy intake over the recording period. Participants with lower BMI tended to have a more negative difference in reported energy intakes on day 4 compared with day 1 than did participants with higher BMI. The correlation between BMI and difference in reported energy intake between recording days 1 and 4 was $R^2=0{\cdot}001$ ($P=0{\cdot}014$).

BMI is not a good measure of body weight status in children and excluding participants <18 years old removed the correlation ($R^2=0{\cdot}000$, $P=0{\cdot}870$). Grouping adults (≥18 years old) by BMI category, however, suggested that those with higher BMI reduced their energy intake, or reported less energy, over the recording period to a greater extent than did leaner adults ($P=0{\cdot}019$; Table 3).

Discussion

This analysis of self-reported food and drink consumption in the NDNS rolling programme suggests that changing to a shorter recording period and an easier (for participants) recording method has not removed the tendency for energy intake to decrease over the recording period seen in 7-d weighed food records. The effect is still present but remains quantitatively minor at about 2 % of mean daily energy intake over 4 d.

Reported energy intake was significantly lower on day 1 than on other days in the 2000/2001 NDNS and decreased by 49 kJ (12 kcal) per d between days 2 and 7[4]. The adjusted energy intake was 350 kJ (84 kcal) higher on day 4 compared with day 1, whereas in the present analysis, it was 164 kJ (39 kcal) lower. Therefore, the magnitude of any effect of recording period (and the change in recording method from weighed to unweighed) on reported energy intake appears to have decreased slightly between the NDNS and NDNS rolling programmes, mainly because of lower intakes on day 1 in the 2000/2001 NDNS. When recording their food intake using food diaries, study participants tend to change their diets. They also misreport the foods that they consume, to varying degrees depending on the recording method[11]. If asked, around half will admit to altering their diet for various reasons, when completing a 7-d weighed food record, including being more conscious of what they were eating[12]. Quantifying this effect is difficult because of the need to record food intake without the participants' awareness. In one study that achieved this by using covert weighing of subjects' food when they were resident in the Rowett's Human Nutrition Unit under conditions that were as close to free-living as practicable, subjects ate less when recording their diets compared with when they were not recording their diets, to the extent that energy intake decreased by 5 % (the observation[11] or reactivity[13] effect). Reported energy intake was an additional 5·1 % lower than actual energy intake when participants recorded their intakes using a weighed dietary record (the recording effect). The decrease in reported energy intake over the 4-d period of the NDNS was relatively small and comes from an increase in the observation effect, or an increase in the recording effect (or both) over the recording period. This decrease in the completeness of dietary recording over time is an additional error to the combined observation and recording effects that may need to be considered in study design to avoid introducing bias[4].

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Although the size of change in reported energy intake is similar in the 2000/2001 NDNS and combined NDNS rolling programme (2008/2016), reported energy intakes, and energy intakes relative to estimated energy requirements, in the present analysis appear to have fallen between the two. Mean daily reported energy intake was 8368 kJ (2000 kcal), equivalent to 1·29 × BMR (BMR recalculated using the using the equations of Henry[9]) in our previous analysis[4] compared with 7107 kJ (1698 kcal) (1·18 × BMR) in the present study. However, our previous study did not include participants <19 years old or >64 years old, and this difference in energy intake between the two studies decreased when the present analysis was repeated using the same age range as in the previous study, being a mean of 7705 kJ (1842 kcal) per d (1·19 × BMR). When comparing nutrient intakes of the first year of the NDNS rolling programme with the 2000/2001 NDNS and 1997 NDNS of young people, Whitton *et al.*[14] found no significant differences in reported energy intakes. However, the authors did not exclude records from participants reporting unusual days because of illness, etc. Additionally, year 1 of the NDNS rolling programme always included both weekend days in the 4-d diet recording, which will have tended to elevate reported energy intakes, a feature that was acknowledged and addressed in subsequent years of the rolling programme. Numerous studies have reported an association between higher BMI and an increased likelihood of low-energy reporting (e.g. Refs. 15 and 16). The prevalence of low-energy reporting in studies with similar methodology to the NDNS was 12–16 % for 3-d records, 31 % for 4-d records and 21–37 % for 7-d records. Across the National Health and Nutrition Examination Survey (NHANES), which assesses diet by 24-h recalls, from 2003 to 2012, the prevalence of low-energy reporting was 17 % for underweight adults, 14 % for normal weight, 23 % for overweight and 37 % for obese adults[17]. However, the few studies that have used a covertly measured food intake as the reference, rather than estimated or measured energy expenditure, have produced inconsistent findings, with no effect of BMI on the degree of misreporting[18,19], that obese subjects are more accurate in reporting their food intake than are overweight or lean subjects[20], or that obese subjects are less accurate[21]. The difference in the apparent effect of BMI on the degree of misreporting when using estimated energy requirements compared with actual food intake may reflect a difficulty in estimating energy requirements in individuals with higher BMI. BMR is often estimated using well-established linear regression equations[9,22], which tend to over-estimate at higher body weights. Overestimating BMR will lower the ratio of reported energy intake:BMR and result in subjects with higher BMI being more likely to be identified as low-energy reporters than are lean subjects. Despite this, the overweight and obese still appear more likely to be classified as low-energy reporters than others after accounting for differences in body composition by estimating BMR from estimated fat-free mass[23]. Irrespective of whether or not overweight people under-report their food intake more, or change their diet more while recording it, than do lean people, the present study provides some evidence that the obese (BMI > 30 kg/m^2) do change their diet, or under-report more, over the recording period. This is consistent with participants becoming more conscious of their diet as they record it. A greater concern with social approval, or social desirability, appears to be related to increased under-reporting of food intake, probably through the biased under-reporting of less healthy foods[24]. The effect is reported across most common dietary assessment methods, including food diaries, and tends to be greater in females than males. It is possible that social desirability is related to a greater decrease in reporting over the recording period.

Asking overweight people to record their food intake is a method used to help change behaviour and food choice to create a negative energy balance[25,26]. Completing a food diary results in a significant weight loss over 7 d even in participants who are not aiming to lose weight[27,28]. The results of this study suggest that the effect is similar in lean people also.

The results of this study might be interpreted as evidence that even shorter recording periods, such as 24-h recalls, would reduce the prevalence of low-energy reporting in dietary surveys. The benefit of less inaccurate diet records must be balanced against the need to capture intakes of foods that are infrequently consumed, such as oil-rich fish[29] and nutrients with large day-to-day variations in intake[30]. Additionally, 7 d is a full cycle of eating behaviour[2], and energy and macronutrient intakes vary over the days of the week[31,32].

It is possible that the observation and recording effects on reported energy intake vary over the recording period. Some participants may have eaten less than usual on each of the 4 d, but with the same reporting accuracy (food records were an accurate description of an atypical diet), or food intake may have not greatly changed but recording accuracy decreased over the recording period (food records were an inaccurate record of a typical diet). Weighing participants before and after completing the diet records could be used to elucidate this, although change in body weight is not a good indicator of change in energy balance over such a short period. The data collection of the NDNS rolling programme does not allow these two effects to be separated.

Using ratios of reported energy intakes:estimated energy requirements to identify probable low-energy reporters is not without its problems, and participants with relatively high energy intakes may have changed their diet and under-reported their food intake to some degree.

The strengths of this study come from the strengths of the NDNS, which has amassed dietary data from a large nationally representative sample of the UK population, and which is broadly representative of the UK population for socio-economic classification. Because diet records were started on different days of the week, the present study was able to separate the effects of day of the week, and recording day, on reported energy intake.

The results of this study show that estimated energy intake from self-reported food intake decreased by a mean of 164 kJ (39 kcal) over the 4-d recording period of the NDNS rolling programme, suggesting that participants change their diet or report less completely over time.

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