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The accuracy of estimating calcium, sodium and potassium intake with a food record

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ABSTRACT

The underreporting of energy intake by food recording is well known, but less is known about accuracy of micronutrient assessment by food records. The purpose of this study was to determine whether the underreporting of calcium, sodium and potassium intake is associated with energy underreporting as assessed by food diary. The subjects were 94 healthy, non-smoking premenopausal women. They kept a 3-day food diary. The mean basal metabolic rate (BMR) was estimated by the equation of FAO/WHO/UNU. The ratio of BMR to reported energy intake (EI) was calculated, the selected limit for underreporting being 1.27. During the last day of the recording period the participants collected a 24-hour urine sample by which the electrolyte excretion was assessed and used as the criterion for the accuracy of the food recording. The ratio between excretion and intake (EIR) was calculated as the percentage of the intake.

The average daily intakes of all the nutrients were lower for the low energy reporters (LER≤1.27 * BMR) than for the control reporters (CR>1.27 * BMR). The total median EI was 6430 kJ/d compared with 8989 kJ/d ($P<0.001$) (P for group differences). The median daily intake was 27.9 and 30.5 mmol ($P=0.12$) for calcium, 112.9 and 142.1 mmol ($P<0.001$) for sodium, and 75.6 and 90.2 mmol ($P<0.001$) for potassium for the LERs and the CRs, respectively. The median calcium/creatinine excretion values were 0.42 and 0.40, sodium/creatinine 11.0 and 11.6, and potassium/creatinine 5.8 and 6.5 for LERs and CRs, respectively. Even though the intake values were significantly lower for sodium and potassium and somewhat lower for calcium in the group of LERs compared to CRs, neither the excretion nor EIR values differed. This gives reason to suspect that low energy and nutrient intake of the LERs was partly due to underreported food intake but also due to decreased eating during the recording period.

Key words: Calcium, electrolyte excretion, food recording, potassium, sodium, women

Introduction

Measuring the dietary intake of free living people generally relies on self-reporting, which, for the most part, is the only reasonable method to use. Several studies have examined the association between energy expenditure and reported energy intake, and they have established a systematic energy underreporting. Not only obese people, but also those of normal weight, and even lean, athletic women underreport their energy intake or eat less as usually during food recording (1-3). However, in contrast to energy underreporting, less is known about the accuracy of assessing mineral intake by food record.

Calcium is the most abundant mineral of bone. However, the results of the association between calcium intake and bone mass are contradictory (4, 5). One reason could be that calcium intake is difficult to estimate accurately (5). In some studies, the bone mineral density of specific bone sites of subjects with low reported calcium intake has been found to be at least as high as those of controls. One possible explanation for this discrepancy may be underreported energy intake, and subsequently underreported calcium intake, because subjects with low calcium intake have been shown to have also a low energy intake (6,7). Sodium and potassium are two other micronutrients known to have an effect on calcium metabolism, and thus they could potentially confound the association between calcium intake and bone mineral density. The ratio of nutrient excretion and intake is relatively constant. The premise for the present study was that if the real intake is higher than the reported intake, the ratio of excretion/intake ratio is higher than ex-pected. If underreporting is due to undereating the ratio should not change.

The purpose of the present study was to determine whether the underreporting of calcium, sodium and potassium intake is associated with energy underreporting as assessed by food records. We used the ratio between measured urinary excretion and self-reported intake of these minerals as the basis for evaluating the accuracy of their intake.

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Subjects and methods

The subjects were 94 premenopausal women (from 34 to 45 years of age). They were healthy, non-smokers, and with no prior injuries or medication use that might have affected their bones or calcium metabolism.

Height was measured without shoes to the nearest centimetre, and weight was determined in light clothing to the nearest 0.1 kg using an electronic scale. All the participants kept a dietary record with household measures for three consecutive days. Detailed oral and written instructions were given to each subject. The nutrient intake data were calculated with Micro-Nutrica software (Social Insurance Institution, Helsinki). The dietary analyses included intakes of total energy, energy yielding nutrients, calcium, sodium and potassium.

The subjects collected a 24-hour urine sample during the last day of the recording period. To minimise the loss of urine, they were given detailed oral and written instructions concerning the collection. The completeness of the specimen was assessed by a standardised interview at the end of the collection period. The subjects returned the urine sample to the laboratory in the morning after the collection, together with

Table 1. Descriptive statistics of the daily nutrient intake (mean value and standard deviation).

		Low energy reporters (n=25)			Control reporters (n=69)			
Variable		Mean	SD	Median	Mean	SD	Median	P[1]
Height	cm	164	6	164	164	6	164	0.98
Weight	kg	64.8	5.9	62.6	61.0	7.0	60.1	0.01
Body mass index	kg/m^2	24.2	2.0	23.9	22.7	2.5	22.3	0.007
Age	years	39.0	2.4	39.0	38.9	2.7	39	0.88
EI/BMR[2]		1.12	0.10	1.10	1.63	0.27	1.59	<0.001
Energy	kJ	6502	590	6430	9264	1549	8989	<0.001
Proteins	g	67	10	68	82	17	78	<0.001
Fats	g	67	16	63	101	27	97	<0.001
Carbohydrates	g	158	22	158	221	40	220	<0.001
Alcohol	g	4.4	7.1	0.1	9.4	13.0	4.4	0.06
Calcium intake	mmol	27.2	6.3	27.9	30.8	9.9	30.5	0.12
Sodium intake	mmol	114.3	20.0	112.9	145.0	33.3	142.1	<0.001
Potassium intake	mmol	77.8	17.5	75.6	91.9	18.9	90.2	<0.001
Calcium intake	mmol/MJ	4.2	1.0	4.2	3.3	0.9	3.4	<0.001
Sodium intake	mmol/MJ	17.6	2.8	16.8	15.7	2.7	15.6	0.005
Potassium intake	mmol/MJ	12.0	2.8	11.9	10.0	1.8	10.1	0.001

[1] P=P-value for the significance of the group difference (Mann-Whitney U test)
[2] Ratio of energy intake in MJ to basal metabolic rate calculated by the FAO/WHO/UNU equation

the food diary. Urine was collected with the addition of 6 mmol/l HCl as required. Samples were divided to aliquots and stored at -20°C until the analysis. Urinary creatinine excretion was used to assess the completeness of the urine collection, even though the intake of collagen-containing foods was not restricted. Because creatinine is excreted at a relatively constant rate, the ratio of urinary calcium to creatinine was calculated to correct possible errors in the timing of the urine collections.

The calcium, sodium and potassium levels in the urine were measured with an automatic emission flame photometer with a Litium reference line (EFOX 5053, Eppendorf, Germany). The method used for urinary creatinine was enzymatic dry chemistry (Vitros 250, Johnson & Johnson, Clinical Diagnostics, Rochester, NY, USA).

Statistical analyses

Means, medians and standard deviations were used as the descriptive statistics. The basal metabolic rate (BMR, kcal/day) was estimated by the equation [4.184 x 8.7 x weight + 829] (7). The ratio of BMR to reported energy intake (EI) was used for dividing the subjects into low energy reporters (LER) and control reporters (CR). The selected limit for underreported energy intake was 1.27, which is theoretically the lowest acceptable value for free living people (7). Non-parametric statistics were used because of the skews of the distributions of variables describing intake and excretion of analysed nutrients. Spearman's rank correlations were used to describe the associations between energy intake and calcium, sodium and potassium intake and excretion. The excretion/intake

Figure 1. Plot of daily intake of calcium, sodium and potassium vs. 24-h excretion with regression line. r = correlation coefficient; R^2 = multiple correlation squared; SEE = Standard Error of Estimate

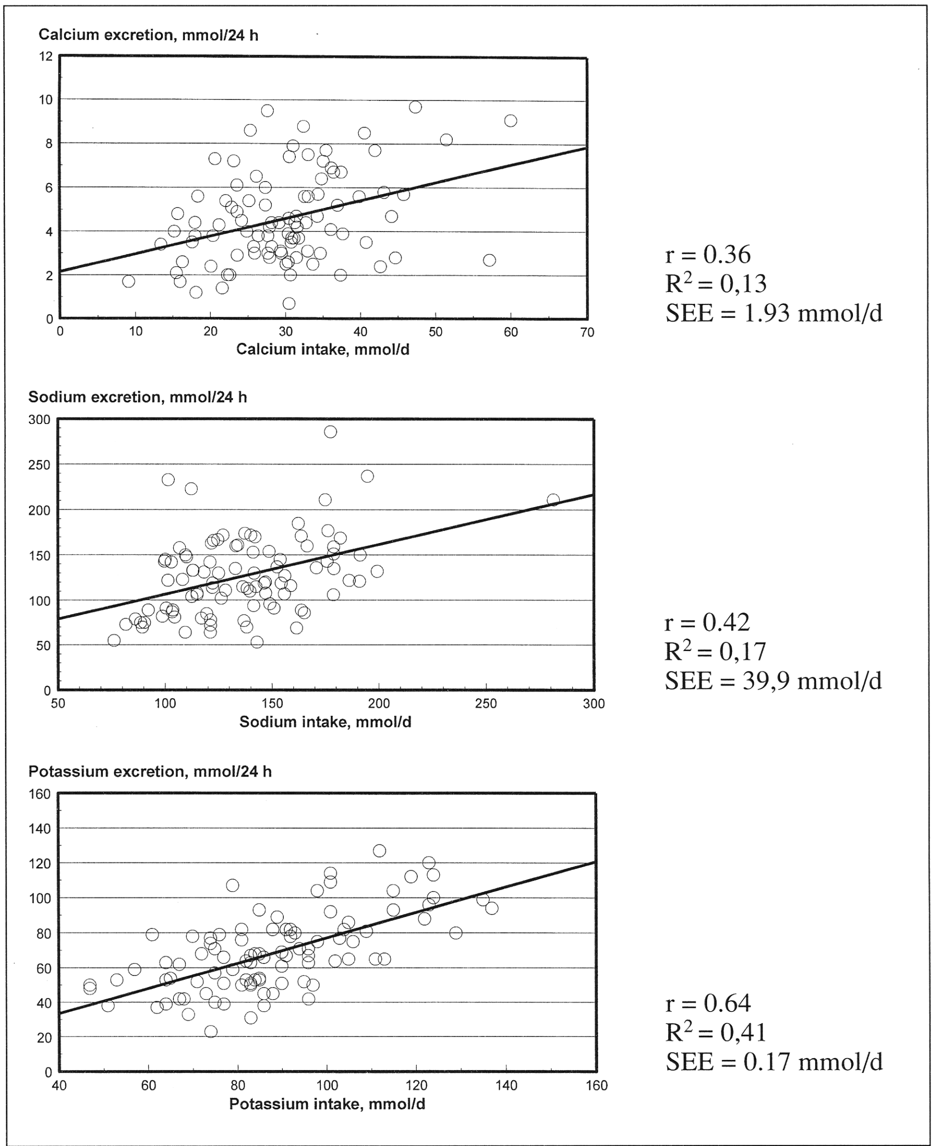

Table 2. Descriptive statistics of the urinary excretion of calcium, sodium and potassium (Mean values and standard deviations)

Variable	Low energy reporters (n=25)			Control reporters (n=69)			P[1]
	Mean	SD	Median	Mean	SD	Median	
Urine volume, ml	1437	515	1420	1725	618	1675	0.04
Urinary creatinine, mmol	10.4	1.9	10.3	10.9	1.6	11.1	0.32
Ca excretion, mmol/24 h	4.3	1.7	4.2	4.7	2.2	4.3	0.55
Na excretion, mmol/24 h	117.2	47.3	108.0	130.4	42.1	130.0	0.12
K excretion, mmol/24 h	65.6	20.7	63.0	69.7	22.6	67.0	0.41
24-h Ca/Cr[2]	0.43	0.19	0.42	0.44	0.21	0.40	0.94
24-h Na/Cr[2]	11.4	4.3	11.0	12.0	3.7	11.6	0.38
24-h K/Cr[2]	6.5	2.5	5.8	6.4	1.8	6.5	0.54
Urinary excretion % of Ca intake	16.1	6.7	15.1	16.1	7.3	15.2	0.94
Urinary excretion % of Na intake	102.6	39.6	90.4	91.9	28.4	88.9	0.33
Urinary excretion % of K intake	85.2	22.3	80.6	75.8	19.0	75.5	0.10

[1] P-value for the significance of the group difference (Mann-Whitney U test).
[2] Molar concentration ratio.

ratio (EIR) of each nutrient was expressed as the percentages of the intake. The differences between the LERs and CRs were tested with the non-parametric Mann-Whitney U test.

Results

The anthropometric data and average daily nutrient intakes are presented in Table 1. Twenty-five (27%) subjects reported their energy intake to be below the ratio (EI/BMR) selected as the limit of underreporting (1.27 * BMR). The reported intake of energy and energy yielding nutrients was significantly lower ($P<0.001$) for the LERs. The difference was more quantitatively than qualitatively, while the percentage difference was significant for proteins only. There was no difference between the groups in age or height, but the LERs were heavier than the CRs.

Intakes of energy and micronutrients were moderately correlated ($P<0.001$). The correlation coefficients between energy intake and intakes of calcium, sodium, and potassium were 0.50, 0.72 and 0.55, respectively. The correlation coefficients (r) between electrolyte intake and excretion were 0.36 for calcium ($p<0.001$), 0.42 ($P<0.001$) for sodium and 0.64 for potassium ($P<0.001$). For the total group the mean (SD) intake of calcium was 29.8 (9.2) mmol/d, that of sodium 136.8 (33.2) mmol/d and that of potassium 88.2 (19.5) mmol/d. The respective excretion values were 4.6 (2.1) mmol/24 h for calcium, 126.9 (43.6) mmol/24 h for sodium and 68.6 (22.1) mmol/24 h for potassium. The individual values are shown in Figure 1.

Urine volume and urinary creatitine were lower in LERs, the difference was significant for urinary volume only (Table 2). The mean and median 24-h urinary calcium/creatinine, sodium/creatinine and potassium/creatinine in molar concentration ratios and their relationship in percentage between intake and excretion are presented in Table 2. The differences between the two groups were significant for intake values only (Table 1). Even though the reported total mineral intake of the LERs was lower compared with the CRs, the mineral density expressed per unit of energy was higher.

Discussion

The underestimation of energy intake is well known from earlier studies. Twenty five (27%) of our subjects showed an apparent underestimation in their energy intake, which is in agreement with other studies with short recording periods (8). In some studies the number of low energy reporters has been found to be even higher. In a recent study in the Finnish population (9) the proportion of suspected female underreporters, against the WHO cut-off point was as high as 47%. Underreporting was more prevalent in overweight women, as reported early by others (2,10). This phenomenon was to be seen in the present study, too. The LERs were heavier compared with the CRs, even though the mean body weight was normal in both of the study groups. In the study of *Mertz* et al. (1) 81% of the subjects underreported their energy intake, and in the study of *Livingstone* et al. (10) it was over 50%. In these studies, the reported energy expenditure was compared with the actual energy expenditure, not with the estimated minimum as in our study.

The cut-off point separating LERs from CRs is obviously a matter of debate. The lowest limit for survival (excluding short periods of intentional weight loss) has been defined as 1.27 * BMR (7). We accepted all dietary records with energy intake above the critical level as valid, but we also realise that the chosen level probably did not disclose all "real" LERs.

The 3-day food-recording period was short for estimating energy intake. A longer period would have decreased the individual variation in nutrient intake and also decreased the number of subjects classified as LERs. However, it is difficult to collect several complete 24-hour urine samples from all subjects. Because the objective of the study was to compare the intake and excretion ratios of electrolytes, a longer period of food recording was not regarded as necessary. It was also reasonable to assume that healthy adults were in micronutrient balance, at which intake and output are equal.

Less than 20% of calcium is excreted in urine, and real sodium intake is difficult to estimate by the food composition tables, because of the large variability of salt in foodstuffs. Therefore, neither calcium nor sodium excretion can be used to verify the accuracy of food intake. 24-hour urine potassium is acceptable as a validation measure, as is nitrogen. Potassium has an advantage because it is found in a greater variety of foods than protein, for example in vegetables (11).

We used creatinine to show the completeness of the urine collection, even though it is not as valid a marker as, for example, para-amino-benzoic acid (PABA). However, creatinine excretion of our subjects agree with the results of studies, in which the urine collection was known to be complete because of the use of PABA as the marker of complete collection (12,13). In those two studies the total daily creatinine excretion was 11.1 mmol and 10.8 mmol, respectively.

It is generally accepted that sodium and potassium are almost completely absorbed in the gut and excreted through the kidney. In carefully performed balance studies, the absorption of sodium and potassium was 98% and 85% of intake, respectively, and the urinary excretion was 86% and 77%, respectively (14), while the present median values were 89% and 76% for the CRs. The metabolism of calcium is more complex. With the intake of 1000 mg of dietary calcium, urinary excretion has been estimated to vary between 15% to 18% for adults (15). The EIRs of calcium, sodium and potassium were in agreement on these relative excretion rates. The differences between the two groups were not significant, even though the mean EIR values of sodium and potassium were higher for LERs.

The mean 24-h urinary excretion of calcium, sodium and potassium of the LERs was at the same level as the CRs, which was quite opposite to the reported intake. When the intake is significantly lower, but the excretion at the same level in both of the groups, the result supports the explanation that the subjects were underreporting their energy intake, not eating less, during the recording period. On the other hand, the average EIR values of electrolytes did not differ between the two groups. Therefore, some subjects may have decreased their eating during the record keeping. The difference in EIR of calcium between the groups was even smaller than that of sodium or potassium, which suggests that calcium intake was estimated quite accurately at the group level. Milk products are the most important sources of dietary calcium and are easy to estimate, while the sources of sodium and potassium are more variable. However, the intake of all the minerals was higher in the group of the LERs when expressed per unit of energy. This may indicate that there was a selective underreporting of certain foods. Hence, the underestimation can not be corrected simply by adjusting for energy intake.

Conclusions

The difference between the LERs and CRs was significant for the reported energy and nutrient intake but not for 24-h urinary excretion or ratio of intake/excretion. This suggests that at the reported low energy intake level the intake of calcium, sodium and potassium were more probably underreported than at medium or high levels of reported energy intake.

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