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Calculated vs analysed nutrient composition of weight reduction diets

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The aim of the study was to compare calculated values with analysed values of some nutrients in weight reduction diets. Ten obese adults were instructed to follow a balanced low-energy diet (5.0 MJ/1200 kcal per day) for 6 months. They were asked to collect samples of all food and beverages they consumed on 3 consecutive days in two phases. During these days, the subjects filled in food records. In addition, samples of a low-energy model diet were collected. The following nutrients were analysed: protein, fat, fatty acids, dietary fibre, calcium, magnesium, iron, zinc, copper, selenium, manganese, molybdenum, sodium, potassium, cadmium and lead. The composition of the diets was calculated from food records by using the Nutrica computer program. Fifteen food samples were included in the final analysis. For most nutrients, calculated values were higher than the analysed ones. Results of our study suggest that the calculation method using food records and the current Finnish database can provide: (1) a reasonably good estimation for the intake of protein, fat, fatty acids, dietary fibre, calcium, magnesium, potassium and manganese; (2) a moderate or uncertain estimation for the intake of iron, sodium, zinc and selenium; and (3) a poor estimation for the intake of copper, molybdenum, cadmium and lead. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

The majority of surveys evaluating nutrient intake rely on food composition table analyses. Food records are recommended (Streit *et al.*, 1991), and are frequently used to assess nutrient intake of obese persons. Calculations based on food records suggest that a varied and balanced low-energy diet guarantees adequate intake of most nutrients (Hakala & Karvetti, 1989). There are, however, many sources of error both in food records and calculations based on food composition tables.

The aim of this study was to compare calculated and analysed values of certain nutrient factors in weight reduction diets. Calculated values were based on 3-day dietary records and a Finnish food composition database, and analysed values on a chemical analysis of 3-day food samples.

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MATERIALS AND METHODS

Subjects and diets

The subjects of the study were obese adults participating in a weight reduction programme at the Social Insurance Institution (SII). They were instructed to follow a balanced weight reduction diet (about 1200 kcal/day; about 20 E% protein, 30 E% fat and 50 E% carbohydrate) for 6 months. Ten voluntary subjects, eight men and two women, were asked to collect samples of all food and beverages (except water) they consumed on 3 consecutive days twice, in December 1990 and March 1991. The subjects were reimbursed FIM 100 per day for the costs of the sampled food. During the same 3 days, they filled in food records principally by household measures.

In addition, a low-energy model diet for 3 days was planned. Duplicate samples were collected and weighed also from this diet. The diet included low-fat milk products, meat and fish dishes, wholemeal

bread, margarine, fruit and berries, and a lot of vegetables.

Food calculations

The nutrient contents of the diets were calculated on the basis of 3-day food records by using the Nutrica computer program developed at the SII. The Nutrica database contains data for 70 nutrient factors, for about 600 different food items and 600 dishes. More than half of the values are based on recent data analysed and published in Finland. Other data sources are Swedish, Danish, German, English and American food composition tables.

Chemical food analysis

All samples were collected in polyethylene boxes, stored in acid-washed containers in refrigerators and transported immediately after the collection period to the analysing laboratory. All sample handling was carried out in clean conditions using disposable gloves and acid-washed containers and equipment. The samples were homogenized with a processor equipped with titanium blades. Homogenized samples were freeze-dried, homogenized again and stored in the freezer until analysed.

Protein was analysed for nitrogen using a Kjeltec auto 1030 Analyzer (AOAC, 1980). Fat was hydrolysed by HCl and extracted by ether (AOAC, 1980). Fatty acids were analysed by gas chromatography as described by Saastamoinen *et al.* (1989). Dietary fibre was analysed in triplicate using the method introduced by Prosky *et al.* (1988). The intake of carbohydrate was calculated by 'difference method' (by subtracting the sum of ash, fat and protein from the dry weight of the samples).

For mineral analysis, the samples were digested in concentrated HNO_3 (Merck Suprapur). All glassware was washed with three acid treatments (10% HNO_3, followed by 10% HCl and 3% HNO_3 of suprapur grade) and rinsed with distilled water. Calcium, magnesium, iron, zinc, copper, manganese, sodium and potassium were determined by using flame AAS (Perkin-Elmer 2100) equipped with an AS autosampler. Lanthanum (0.09%) was used as an ionization suppressant for calcium, magnesium, sodium and potassium. Molybdenum, selenium, cadmium and lead were determined by electrothermal Zeeman AAS (Varian Spectraa 400 Z) employing the Zeeman effect for background correction, and platform atomization for selenium, cadmium and lead. The determinations were made by standard additions. $(NH_4)H_2PO_4$ was used for matrix modification for cadmium and lead (Koirtyohann *et al.*, 1982), platinum, $Mg(NO_3)_2$ for selenium (Kumpulainen & Saarela, 1992) and Na_2EDTA for molybdenum (Kumpulainen & Paakki, 1987). All samples were analysed in duplicate. Two blanks and two samples of reference material (ARC/CL total diet and IAEA H-9 mixed human diet) were digested and analysed as quality control samples with each set of samples.

The energy content of duplicate food samples (kcal) was calculated as follows:

$$4 \times \text{protein(g)} + 9 \times \text{fat(g)} + 4 \times \text{carbohydrates(g)}$$

calculated by 'difference method';

$$\text{protein(g)} = \text{nitrogen\%} \times \text{dry weight(g)} \times 6.25;$$

$$\text{fat(g)} = \text{fat\%} \times \text{dry weight(g)};$$

$$\text{carbohydrates(g)} = \text{dry weight(g)} - \text{ash(g)} - \text{protein(g)} - \text{fat(g)}.$$

RESULTS

Weight reduction diet

There was good agreement between the weights of 15 samples and the corresponding weights calculated from food records: the mean weight calculated from the records was 35 g (2%) per person per day higher than that of the samples. The highest accepted difference was 400 g/day. The remaining five samples were excluded because the recorded weight and the weight of food samples did not correspond each other sufficiently. In the excluded samples the difference between the weights of the collected samples and of the corresponding weights calculated from food records was over 1000 g/day.

For most nutrients, calculated values were slightly higher than the analysed values (Table 1). The difference between the values were within 4% for protein, fatty acids and dietary fibre, and 12% for total fat. The correlations between the methods for these nutrients were also relatively good, ranging from 0.50 to 0.68. Although it is not recommended to calculate the intake of carbohydrate by 'difference method', it was done in this way for this study because it was important to get some estimation of the energy intake. The differences between the values for carbohydrate and energy were greater than for most of the other nutrients, but the correlations were even better. Among minerals, the best correspondence was found for calcium. For sodium and potassium the difference between the methods was within 10%, and for magnesium, manganese, selenium, and cadmium within 20%. For these minerals, the correlations were also relatively acceptable ($r = 0.49–0.74$), except for cadmium. The greatest differences were found for iron, zinc, copper, molybdenum and lead.

Model diet

The mean weight calculated from the record was 69 g (3%) per day higher than that of the collected samples. Analysed values of energy-yielding nutrients were slightly higher than calculated (Table 2). The difference between the methods was within 10% for protein, dietary fibre and energy. For fat and fatty acids, the

Table 1. Analysed and calculated daily contents of some nutrient factors in the weight reduction diets (number of food samples analysed = 15)

Nutrient factors	Analysed content ($\bar{x} \pm$ SD)	Calculated content ($\bar{x} \pm$ SD)	Difference between the means (%)	*r*
Protein (g)	67 ± 13	70 ± 23	4	0.60*
Fat (g)	34 ± 12	38 ± 10	12	0.61*
SAFAs (g)	13.2 ± 5.0	13.6 ± 3.3	3	0.50
MUFAs (g)	13.8 ± 4.7	14.4 ± 4.1	4	0.55*
PUFAs (g)	6.7 ± 2.9	7.0 ± 2.0	4	0.68**
Dietary fibre (g)	19 ± 5	19 ± 5	0	0.60*
Carbohydrate (g)	152 ± 40[1]	213 ± 53[1]	40	0.75**
Energy (kcal)	1177 ± 255[2]	1499 ± 339[2]	27	0.70**
Calcium (mg)	776 ± 232	786 ± 292	1	0.80***
Magnesium (mg)	243 ± 60	284 ± 74	17	0.74**
Iron (mg)	8.8 ± 2.3	11.6 ± 5.7	33	0.23
Sodium (mg)	2346 ± 561	2513 ± 787	7	0.49
Potassium (mg)	2873 ± 735	3140 ± 783	9	0.72**
Manganese (mg)	3.6 ± 1.1	4.3 ± 1.4	20	0.68**
Zinc (mg)	7.9 ± 1.7	10.2 ± 3.2	29	−0.13
Copper (μg)	1659 ± 1539	1224 ± 1074	−26	−0.01
Selenium (μg)	89 ± 26	72 ± 27	−19	0.50
Molybdenum (μg)	54 ± 16	89 ± 45	65	−0.04
Cadmium (μg)	9.1 ± 7.5	10.8 ± 4.2	19	0.03
Lead (μg)	19.2 ± 18.9	40.3 ± 10.2	110	−0.05

SAFA, saturated fatty acids; MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids.
[1]Calculated by 'difference method'.
[2]Dietary fibre included. *r*, correlation coefficient. $^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

Table 2. Analysed and calculated contents of some nutrient factors in the model diet

Nutrient factors	Analysed content	Calculated content	Difference (%)
Protein (g)	83	77	−7
Fat (g)	45	38	−16
SAFAs (g)	14.3	11.3	−21
MUFAs (g)	19.8	14.3	−28
PUFAs (g)	10.7	8.7	−19
Dietary fibre (g)	32	30	−6
Carbohydrate (g)	172[1]	205[1]	19
Energy (kcal)	1423[2]	1491[2]	5
Energy (kcal)	—	1200[3]	
Calcium (mg)	796	948	19
Magnesium (mg)	310	338	9
Iron (mg)	11.1	11.8	6
Sodium (mg)	1797	2319	29
Potassium (mg)	3825	3999	5
Manganese (mg)	7.9	7.5	−5
Zinc (mg)	11.2	11.6	3
Copper (μg)	1527	1275	−16
Selenium (μg)	82	64	−22
Molybdenum (μg)	78	111	42
Cadmium (μg)	9.4	13.3	41
Lead (μg)	22.3	47.9	115

SAFAs, saturated fatty acids; MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids.
[1]Calculated by 'difference method'.
[2]Dietary fibre included.
[3]Dietary fibre not included.

difference was somewhat higher, ranging from 16 to 28%. Calculated values were relatively consistent (within 10%) with analysed values for magnesium, iron, potassium, manganese and zinc. The difference was slightly greater for calcium, sodium and selenium, and clearly greater for molybdenum, cadmium and lead.

Mineral content compared with the recommended dietary allowances

Analysed and calculated mineral values were also compared with the Recommended Dietary Allowances (RDAs) (National Research Council, 1989) (Table 3).

Table 3. Analysed and calculated mineral contents in the weight reduction diets and in the model diet, expressed as % of the RDAs[1]

Minerals	Weight reduction diets		Model diet	
	Analysed values	Calculated values	Analysed values	Calculated values
Calcium	97	98	100	119
Magnesium	69–87	81–101	89–111	97–121
Iron	58–88	78–116	74–111	78–118
Sodium[2]	469	503	359	464
Potassium[2]	144	157	191	200
Zinc	53–66	68–85	75–93	77–96
Manganese[3]	72–181	87–217	157–394	149–373
Copper[3]	55–111	41–82	51–102	43–85
Selenium	128–163	103–131	117–149	91–116
Molybdenum[3]	22–72	36–119	31–104	44–148

[1]Recommended dietary allowances for 25–50-year-old men and women (1989).
[2]Compared to estimated minimum requirements.
[3]Estimated safe and adequate daily dietary intakes (ESADDIs) for adults.

In weight reduction diets, mean analysed content of calcium, magnesium, iron, zinc and molybdenum, and mean calculated content of calcium, zinc and copper remained slightly below the lower limits of the RDAs. In the model diet only the analysed content of zinc and calculated content of copper remained slightly below the RDAs.

DISCUSSION

Among the subjects there was one man for whom the calculated intake of almost all nutrients was clearly higher than analysed intake. When he was excluded from the analysis, the mean analysed and calculated values were much closer to each other and the correlations were also better (e.g. 0.81 for protein, 0.80 for dietary fibre, 0.82 for sodium and 0.79 for selenium). However, there was no well-founded motivation to exclude him from the final analysis.

There are many potential sources of error in this study. Firstly, there were probably errors in the estimated portion sizes and the quality of foodstuffs given in food records. In addition, because relevant codes and nutrient contents were not available for all recorded foods, codes and values for related foods were applied. Secondly, it is possible that duplicate samples were not collected carefully enough because it was laborious and time-consuming. Thirdly, wide variation is often reported in the nutrient contents of foodstuffs. Nutrient values given in food composition tables represent average nutrient contents. In reality, the values may vary greatly owing to geographical origin, season, etc. There is, for example, a high variability of dietary fibre content even within small, homogeneous food groups (Plaami & Kumpulainen, 1994). Processing has its effects on nutrient contents, too (Nyman *et al.*, 1994). Variations have been found even in pooled food samples (Tahvonen, 1993). In addition, most nutrient values in the food tables are based on the contents of raw foodstuffs, while diets are, at least partly, composed of cooked food in which the nutrient content may be affected by the preparation.

Furthermore, concentrations of many trace elements, for example lead and cadmium, may vary significantly due to environmental contamination and because they usually exist in ultratrace concentrations (Kumpulainen, 1991). Nutrient content of food may also vary in the long run. According to Tahvonen (1995), cadmium and lead content in food have decreased in Finland. Inconsistency between the calculated and analysed values may be partly due to old data in the Nutrica database. Similarly, the salt content has decreased in many foodstuffs during the last years. It is obvious that many sodium values in the Nutrica database are too high compared with the actual values. It is also possible that salt was added to food at the table. If this added salt was not noted in the food record it was not taken into consideration in the calculation of sodium intake.

When variation within foodstuffs and other sources of error discussed above are taken into consideration, many of the discrepancies observed between calculated and analysed values are not surprising. It was, however, difficult to find a clear explanation for higher calculated values for fat and iron in both diets, and for zinc in the weight reduction diets. In the study by Kumpulainen (1991) the difference between analysed and calculated values was only 4.7% for iron and 3.3% for zinc in the diets of Finnish men. In conclusion, the results of our study suggest that the calculation method based on food records and current database provides a reasonably good estimation for the intake of some but not all nutrients studied here.

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