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ORIGINAL COMMUNICATION

Validity of reported energy expenditure and reported intake of energy, protein, sodium and potassium in rheumatoid arthritis patients in a dietary intervention study

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Objectives: The aim of the study was to validate a diet history interview (DHI) method and a 3-day activity registration (AR) with biological markers.
Subjects and study design: The reported dietary intake of 33 rheumatoid arthritis patients (17 patients on a Mediterranean-type diet and 16 patients on a control diet) participating in a dietary intervention study was assessed using the DHI method. The total energy expenditure (TEE), estimated by a 3-day AR, was used to validate the energy intake (EI). For nine subjects the activity registration was also validated by means of the doubly labelled water (DLW) method. The excretion of nitrogen, sodium and potassium in 24-h urine samples was used to validate the intake of protein, sodium and potassium.
Results: There was no significant difference between the EI and the TEE estimated by the activity registration or between the intake of protein, sodium and potassium and their respective biological markers. However, in general, the AR underestimated the TEE compared to the DLW method. No significant differences were found between the subjects in the Mediterranean diet group and the control diet group regarding the relationship between the reported intakes and the biological markers.
Conclusion: The DHI could capture the dietary intake fairly well, and the dietary assessment was not biased by the dietary intervention. The AR showed a bias towards underestimation when compared to the DLW method. This illustrates the importance of valid biological markers.
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Keywords: rheumatoid arthritis; Mediterranean diet; diet history interview; biological markers; doubly labelled water; energy expenditure

Introduction

A number of studies have been carried out in order to investigate the potential beneficial effects of different types of diet and individual nutrients on rheumatoid arthritis (RA) (Mangge *et al*, 1999; Rennie *et al*, 2003). However, even though information about dietary intake would be most valuable when interpreting the results, the dietary intake of the subjects participating in these studies has often not been presented or even investigated. For instance, in studies on supplementation with specific nutrients, the background diet of the subjects may be different in the experimental

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group from that of the control group. Moreover, the supplementation may influence the participants to change their diet, voluntarily or involuntarily, which may partly account for the effects seen. Furthermore, in dietary intervention studies where a change of the entire diet is tested, it is important to monitor the degree of compliance with the prescribed experimental and control diets in order to be able to draw the right conclusions regarding the potential dietary effects.

At present, a method that accurately assesses the habitual dietary intake does not exist and will probably never exist since different methods suit different people. There are several reasons for this. For instance, people are affected differently by participating in a dietary survey, they remember the foods they have eaten to a different degree, and they have varying abilities to estimate portion sizes, etc. Because of psychological reasons, changes in food habits during the dietary assessment period may also occur. This, in turn, will lead to a reported diet, which is different from the subject's habitual diet, often healthier and lower in energy. The use of food databases for the conversion of consumed food items into values representing energy and nutrient intake may introduce further errors. Consequently, there is a need to validate dietary assessments using methods that are independent of the reported dietary intake (Bingham, 2002; Westerterp & Goris, 2002; Livingstone & Black, 2003).

The validity of the reported energy intake (EI) can be evaluated by means of comparing the total energy expenditure (TEE) with the EI under conditions of energy balance. The doubly labelled water (DLW) method is currently the most accurate and precise method for estimating TEE in real-life conditions (Speakman, 1997; Schoeller, 2002). In this method, the TEE is measured over a period of about 2 weeks. Thus, it is not affected by day-to-day fluctuations. Furthermore, it causes minimal interference with the subjects' everyday life. However, this method is expensive and requires specialized equipment and personnel. Cheaper and less technically demanding methods, such as activity registration (AR), heart rate monitoring, physical activity interviews/questionnaires and the use of accelerometers, together with a measured or estimated basal metabolic rate (BMR), can provide an estimate of the TEE. Since some of these methods depend on self-reported physical activity and others on instruments measuring variables related to the TEE, it is important to validate these techniques against a reference method, preferably the DLW method.

The validity of the reported protein, sodium and potassium intake can be evaluated by biological markers in 24-h urine samples (Bingham, 1987, 2002; Johansson *et al*, 1992). One major problem concerning these markers is the necessity to obtain complete 24-h urine samples. Therefore, the *para*-aminobenzoic acid (PABA) method (Bingham & Cummings, 1983; Jakobsen *et al*, 1997), used to verify the completeness of the samples, and the equations, by which it is possible to compensate for incomplete collections (Johansson *et al*, 1999), are invaluable tools when using these markers. Studies using these biological markers (as well as markers for EI) demonstrate that mis-reporting is a serious problem in dietary surveys and may, at the worst, lead to wrong conclusions being drawn regarding the relationship between diet and disease/risk factors/biological outcome (Bingham, 2002).

In a recent randomized controlled study, we have shown that a modified Cretan Mediterranean diet has a beneficial effect on patients with RA (Sköldstam *et al*, 2003). Therefore, it is interesting to investigate the food intake of the experimental and control group in the study presented earlier. To be able to do this, it is necessary to study the validity of the dietary information as well. The aim of the present study was to validate the dietary assessment (diet history interview (DHI)) used in the study with biological markers for food intake. A further aim was to validate the AR by means of DLW measurements on a limited number of subjects, in order to be able to use a cheaper and simpler method than the DLW method to assess the TEE.

Methods

Subjects and study design

The subjects were RA patients participating in a 3-month dietary intervention study, which has been described in detail elsewhere (Sköldstam *et al*, 2003). In total, 51 subjects randomized to either a Mediterranean diet (MD) group or a control diet (CD) group completed the dietary intervention trial. The DHI, which are evaluated in the present paper, were conducted with 34 patients from both the MD group and the CD group. The only selection criterion for taking part in the DHI was that the subject was included in the study on February 15 1999, or later. Measurements of energy expenditure by means of the DLW method were performed on nine of the 33 subjects (three women and two men from the MD group and three women and one man from the CD group). The criterion for taking part in the DLW measurement was that the subject was included in the study on October 18 1999, or later. Exclusion criteria for this part of the study were: (a) the subject would not be staying in his/her home community the entire time of the DLW measurements; (b) it was difficult for the subject to participate in this part of the trial because of other practical reasons, for instance if the subject lived far from the Rheumatology Unit.

One CD subject was identified as an extreme outlier regarding the reported dietary intake, with a food intake level (FIL = EI/BMR) of 3.66. Since this would correspond to a physical activity level (PAL = TEE/BMR) of 3.66, which is high even for athletes in rigorous training (Black *et al*, 1996), this subject was excluded from all the analyses.

The study was approved by the ethics committee of the Faculty of Health Sciences at Linköping University and followed the ethical principles of the Helsinki Declaration.

Dietary assessment
The energy and nutrient intake were assessed by means of DHI. The interviews were performed between study weeks 7 and 12 and concerned the intake during the preceding month. The interview started with questions about the subject's meal patterns on weekdays and weekends. Subsequently, each meal and between-meal snack was discussed in detail, with questions about food choices, frequencies and portion sizes. To estimate the average portion size, household measures, validated food portion photographs (Håglin *et al*, 1995), bags of rice of different sizes or standard weights of food items (Swedish National Food Administration, 1999) were used. Most of the interviews were performed by the first author (LH), but two other specially trained dietitians interviewed five patients each. The interviews were either conducted in the subject's home or at the Rheumatology Unit, Kalmar Hospital.

To convert the food intake into the intake of energy and nutrients, the nutritional analysis package MATs 4_03e was used. This program is based on the Swedish National Food Administration's food composition database, PC-kost (version 2_97). For composite food items and supplements not listed in the database, the nutrient content was entered manually. The energy and nutrient intake were calculated both including and excluding dietary supplements. However, including dietary supplements only changed the energy intake marginally for two subjects and had no effect on the intake of protein, sodium and potassium. Therefore, only the dietary intake excluding supplements will be presented.

Assessment of TEE
Doubly labelled water method. For nine subjects, the TEE was measured over 14 days by means of the DLW method (Speakman, 1997). This was performed during the last weeks of the study period. After collecting three background urine samples, the subjects ingested an oral dose of 0.12 g ^2H_2O and 0.25 g H_2 ^{18}O per kilo estimated body water (Schoeller, 1988; Deurenberg *et al*, 1991). After ingestion of the DLW, the dose bottle was rinsed with 50 ml tap water, which was also consumed. One urine sample was taken 24 h after the dose was consumed and again 5, 8 and 14 days after ingesting the dose. The samples were stored at $-20°C$ until analysis took place. The subjects were instructed to drink only the water of their home community and not to change their eating or drinking habits during the time of the TEE measurement. The time of dosing and voiding times were recorded and body weight was measured to the nearest 0.1 kg at the time of the dose and after the final voiding. The isotopes deuterium (^2H) and oxygen-18 (^{18}O) in the urine were analyzed by isotope ratio mass spectrometry (Optima, VG Isogas Ltd, Middlewich, Cheshire, UK). The carbon dioxide (CO_2) production rate was calculated from the elimination rates of the two stable isotopes using the equation of Schoeller *et al* (1986). The respiratory quotient (RQ) of the diet was taken as 0.85 (Black *et al*, 1986) and the TEE was calculated based on the CO_2 and the RQ. The food quotient (FQ) was, however, calculated from the diet history interviews for comparison. The FQ was calculated according to the following equation:

$$FQ = (p0.81) + (f0.71) + (c1.00) + (a0.67)$$

where p, f, c and a represent the fraction of the total metabolizable energy contributed by protein, fat, carbohydrates and alcohol, respectively (Black *et al*, 1986).

The PAL was calculated by dividing the TEE by the estimated BMR. The BMR was estimated based on body weight, age group and sex, according to standard equations (Department of Health, 1991).

Activity registration. For all subjects who completed the DHI, the TEE was estimated using a 3-day AR, a method first described by Bouchard *et al* (1983). However, one subject lacked an AR; thus, 32 subjects completed both the DHI and the AR. The AR was performed on two weekdays and on one day on the weekend, consecutively. During these days, the subjects recorded their activities at 15-min intervals by means of predetermined codes for different types of activities. The PAL was calculated from the AR using physical activity ratios (PARs), which are multiples of the BMR, for different activities (Table 1). The PARs used in the present study were developed for the Swedish Obese Subjects (SOS) reference study, which is a substudy of the SOS intervention study (Lissner *et al*, 1998), and were based on the gross energy expenditure in specified activities presented by the World Health Organization (1985). The TEE was calculated by multiplying the PAL obtained from the AR by the estimated BMR (Department of Health, 1991).

Validation of DHI
Energy intake. The reported EI was compared with the TEE assessed by the AR and the DLW method. Furthermore, the FIL was calculated by dividing the reported EI according to the DHI by the estimated BMR (Department of

Table 1 Factors used to calculate energy expenditure from AR

Activity	*PAR*
Lying or sleeping	1.0
Seated or standing activities, such as eating, reading, watching TV, strolling	1.4
Light work, such as washing-up, cooking, shopping, light gardening	2.0
Walking	2.9
Heavy work, such as cleaning, cleaning windows, beating mats, heavy gardening	3.5
Light exercise, such as bowling, golf, sailing, walking fast	3.2
Moderate exercise, such as dancing, tennis, swimming, biking	5.3
Heavy exercise, such as football, jogging, rowing, skiing, aerobics	7.4

PAR = physical activity ratio.

Health, 1991). The individual Goldberg cut off for the FIL was used to identify under- and over-reporters (Black, 2000).

Biological markers for the intake of protein, sodium and potassium. One 24-h urine collection per person ($n = 33$), performed during week 12, was used to validate the reported dietary intake of protein, sodium and potassium on a group level. The subjects were instructed to record the start and the finish of the collection in a questionnaire, as well as any lost specimens and if there were any other problems regarding the collection. The same day the 24-h urine collection was completed, the urine was weighed, to estimate the volume. Samples were collected and stored at −20°C until analyses of PABA, nitrogen, sodium and potassium were made.

To verify the completeness of the urine collections, the PABA method was used (Jakobsen *et al*, 1997). On the day of the urine collection, the subjects took three 80 mg PABA tablets, one in the morning after emptying the urinary bladder, the next within 6 h, and the third within 12 h. The time at which the PABA tablets was taken was recorded by the subjects. The PABA in the urine was determined using the HPLC method, and any urine collection with a PABA recovery level below 78% was classified as incomplete. The content of nitrogen, sodium and potassium of incomplete samples was adjusted using the linear regression equations developed by Johansson *et al* (1999). Since these equations were developed based on the colorimetric method, we replaced the figure in the equations representing the mean PABA recovery level for complete urine collections, that is, 93%, with the mean PABA recovery level reported when using the HPLC method, that is, 88% (Jakobsen *et al*, 1997). Thus, the linear regression equations for nitrogen, sodium and potassium were:

$$\text{Nitrogen (g/day)}: y = 2.3 + 0.088x$$

$$\text{Sodium (mmol/day)}: y = 45 + 0.82x$$

$$\text{Potassium (mmol/day)}: y = 19 + 0.60x$$

where y is the analyte in urine and x is the PABA recovery value (88% minus the measured value).

The sodium and potassium in the urine were analyzed using direct ion-selective electrode (Cobas Integra 700, Roche Diagnostics Scandinavia AB) and the nitrogen by chemiluminescence (Antek instrument nitrogen system 703C, Antek Instruments, Inc., Houston, TX, USA). The nitrogen excretion in the urine was used as a biological marker for protein intake by multiplying the content of nitrogen in the urine by the factor 7.72 (Bingham & Cummings, 1985). The sodium content of the urine was used as a biological marker of sodium intake (Bingham, 1987) and the potassium in the urine was used as a biological marker of potassium intake, by dividing the potassium content of the urine by 0.77 (Johansson *et al*, 1992).

Statistics

The statistical analyses were performed using SPSS for Windows version 11.0.1 and the results were considered statistically significant at a two-tailed P-value of <0.05.

For normally distributed variables, the Student's t-test for independent samples was used to test the differences between the groups, while the Mann–Whitney U-test was performed for variables with skewed distributions. For comparisons between the methods, the Student's t-test for paired samples was used.

Pearson's product moment correlation was used to determine the association between the TEE measured by means of the DLW method and that estimated by the AR. Agreement between the measured and the estimated TEE was examined according to Bland and Altman (1986). Spearman's rank correlation was used to test the trend from low to high values in the Bland–Altman plot.

Results

Subjects

Data on the disease activity, duration of the disease and other disease-related information have been presented in detail elsewhere (Sköldstam *et al*, 2003). At baseline, there were no significant differences between the MD and the CD groups regarding age, sex and anthropometric measurements (Table 2). During the 3-month study period, the median weight loss in the MD group was 2.5 kg, while body weight in the CD group was fairly stable ($P = 0.001$). The nine subjects who participated in the measurement of TEE by means of DLW did not differ from the remaining subjects regarding age, sex, body mass index or weight change during the period of the study. During the 14-day DLW measurement, no significant weight difference was observed in these subjects.

Table 2 Baseline characteristics and weight difference during the study for the MD group and the CD group participating in a 3-month dietary intervention study in Kalmar, Sweden

	MD group (n = *17*)	*CD group* (n = *16*)
Age (y)	58.8 (9.9)	59.5 (8.1)
Sex (men/women)	2/15	2/14
Height (cm)	166 (8)	168 (8)
Weight (kg)	77.8 (14.1)	74.4 (11.7)
Body mass index at baseline (kg/m^2)	28.1 (4.4)	26.4 (3.2)
Weight change during the study (kg)*,†	−2.5 (−3.9 to −1.2)	−0.1 (−1.0 to 0.3)

*Data are presented as medians (25th–75th percentiles) because of skewed distributions.
†Statistically significant difference between groups, $P = 0.001$. Differences between groups were analyzed using the Student's t-test for independent samples for normally distributed variables and using the Mann–Whitney U-test for variables with skewed distributions.
Data are presented as the mean (s.d.) unless otherwise stated.

There were no differences between the MD and the CD groups regarding the reported and the measured TEE or dietary intake in relation to biological markers. Therefore, most results will be presented for all subjects.

Dilution space ratios

The mean dilution space ratio was 1.032 (s.d. = 0.004) in the total sample of subjects included in the DLW measurements.

Validity of the reported energy expenditure and EI

There was a strong correlation ($r = 0.98$, $P < 0.01$) between the reported energy expenditure estimated by the 3-day AR method and the energy expenditure measured by the DLW method. However, the median difference between the reported and the measured TEE was −0.7 MJ/day (mean difference = −0.94 MJ; $P = 0.026$ for the difference between methods) and the mean ratio between the reported and the measured TEE was 0.92. In general, there was a good agreement between the AR and the DLW method at low TEE and there was a trend towards a larger underestimation of the AR at higher TEE (Figure 1).

The ratio between the EI, based on the DHI, and the TEE, based on the AR (TEE_{AR}), was 0.97 when all the subjects were included (Table 3), and the correlation coefficient between the EI and the TEE_{AR} was 0.62 ($P < 0.01$). There was no significant difference between the MD and CD group regarding the EI/TEE_{AR} ratio.

For the subjects whose TEE was both measured by the DLW (TEE_{DLW}) method and estimated by the AR, it was possible to calculate the EI/TEE ratio using both methods. In these subjects, the EI/TEE ratio was significantly lower using the DLW method (mean EI/TEE ratio = 0.99) compared to the AR method (mean EI/TEE = 1.07, $P = 0.014$ for the difference between methods). Also, the EI, FIL and EI/TEE_{AR} ratio were significantly higher among the subjects who participated in the DLW measurements compared to the remaining subjects ($P = 0.006$, 0.013 and 0.036, respectively).

According to the Goldberg cut off for FIL values (Black, 2000), three subjects were identified as under-reporters (one MD subject and two CD subjects). No differences were found between the MD and the CD groups regarding under- or over-reporting. For the subjects included in the DLW measurements, the cut off for FIL was calculated based on both PAL according to the AR and PAL according to the DLW. All of these subjects were identified as valid reporters according to both methods.

For the nine subjects whose TEE was measured by the DLW method, the calculated FQ based on the DHI was 0.88 (s.d. = 0.02) compared to the RQ of 0.85 used for the calculation of the TEE from the DLW measurements.

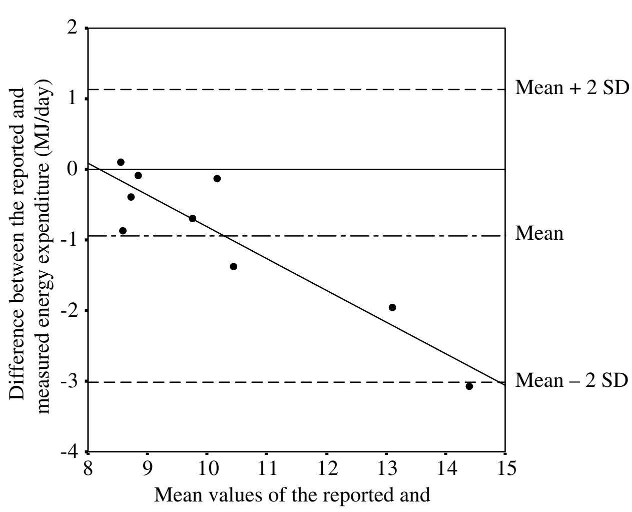

Figure 1 Difference between the total energy expenditure reported by means of a 3-day AR method and measured by the DLW method, plotted against the mean value of the reported and measured energy expenditure according to Bland and Altman (1986) ($r_s = -0.75$, $P < 0.05$). Mean difference = −0.94 MJ/day and 2 s.d. = 2.08 MJ/day.

Table 3 Validation of the reported energy expenditure with the DLW method, and the reported EI with the 3-day AR and the DLW method

Variables	*All subjects** n = 32	*AR subjects†* n = 23	*DLW subjects‡* n = 9
TEE_{AR} (MJ/day)	9.29 (1.27)	9.08 (1.06)	9.82 (1.65)
TEE_{DLW} (MJ/day)	—	—	10.76 (2.59)
PAL_{AR}	1.53 (0.09)	1.52 (0.11)	1.55 (0.06)
PAL_{DLW}	—	—	1.68 (0.15)
EI (MJ/day)	9.01 (1.99)	8.43 (1.68)	10.50 (2.04)
FIL	1.48 (0.26)	1.42 (0.25)	1.66 (0.20)
EI/TEE_{AR} ratio	0.97 (0.17)	0.93 (0.18)	1.07 (0.11)
EI/TEE_{DLW} ratio	—	—	0.99 (0.14)

DLW = doubly labelled water, AR = activity registration, TEE = total energy expenditure, PAL = physical activity level, EI = energy intake, FIL = food intake level.
*All subjects who completed the AR and the DHI.
†Subjects whose TEE was *not* measured by means of the DLW method.
‡Subjects whose TEE was both measured by means of the DLW method and estimated by the AR.
The results are presented as mean (s.d.).

Validity of the reported intake of protein, sodium and potassium

There were no significant differences in the number of incomplete collections between the MD and the CD groups (four incomplete collections in the MD group and three in the CD group), even though the PABA recovery was significantly lower in the MD group (80 *vs* 86% in the CD group, $P = 0.01$).

There were no significant differences between the reported intake of protein, sodium and potassium and their respective biological markers (Table 4). Furthermore, the reported intake of these nutrients and the relationship between

Table 4 Comparison of the reported intake of energy, protein, sodium and potassium with the corresponding biological markers (BM)

	*DHI**	*BM*†	*DHI/BM*	P-*value*‡
Energy (MJ/day)§	9.01 (1.96)	9.29 (1.27)	0.97 (0.17)	0.336
Protein (g/day)‖	89.6 (22.9)	87.4 (25.3)	1.08 (0.28)	0.520
Sodium (g/day)§	3.1 (0.8)	3.5 (1.3)	0.93 (0.68–1.16)	0.176
Potassium (g/day)§	4.0 (1.0)	3.8 (1.2)	1.13 (0.46)	0.540

*Reported intakes of energy, protein, sodium and potassium assessed by DHI.
†Reported energy expenditure assessed by the 3-day AR, nitrogen in 24-h urine multiplied by 7.72 (Bingham & Cummings, 1985), sodium in urine and potassium in urine divided by 0.77 (Johansson *et al*, 1992).
‡*P*-values refer to comparison of the reported intakes of energy, protein, sodium and potassium with the respective biological markers. The differences between the reported intakes and the biological markers were analyzed using the Student's *t*-test for paired samples.
§$n = 32$.
‖$n = 33$.
Data are presented as mean (s.d.), except for the ratio between sodium intake and urine sodium, which is presented as median (25–75th percentiles) because of skewed distribution.

reported intake and the biological markers did not differ between the MD and the CD groups.

Discussion

To our knowledge, this is the first study where the reported dietary intake of patients with RA has been validated by means of quantitative biological markers.

Validity of the reported energy expenditure

The DLW method is today considered as the ideal method for the estimation of TEE in free-living subjects. However, since this is an economically and technically demanding method, there is a need for simpler field techniques for assessing physical activity. For this reason, a 3-day AR was validated using the DLW method on nine subjects. Although the TEE_{AR} was highly correlated to the TEE_{DLW} ($r = 0.98$), the AR generally underestimated the TEE (the median difference was −0.7 MJ/day) and the underestimation was greater in subjects with high TEE, indicating a systematic bias. Then again, this result is based on only two subjects. Thus, there is a possibility that this may be a random result. One reason for the marked underestimation in the subjects with high TEE may be that these subjects chose registration days that were not representative of their habitual level of physical activity. All the subjects were instructed to perform the AR on three representative days. The AR is, however, a labor-intensive and tedious method, which requires that the type of activity is registered by the subject at 15-min intervals. This is presumably easier to do on a sedentary day at home rather than on more active days. Since the DLW measurement is a noninvasive technique covering around 14 days, this method is more likely to give an accurate estimation of the habitual activity level. Another possible reason for the underestimation of the AR at high activity levels is the PAR factors that were selected. If, for instance, the PAR factors are too low at high intensity levels this could have a fairly large impact on the calculated PAL. Also, the PAR factors used for activities of lower intensity, such as washing-up and light gardening work, may have been too low (Ainsworth *et al*, 2000). Furthermore, when estimating the TEE by means of the AR, the PAL-value obtained was multiplied by the BMR estimated using the equations by the Department of Health (1991), which are standard equations not specifically developed for individuals with RA. In a study by Roubenoff *et al* (1994), the resting energy expenditure (REE), after adjustment for body cell mass, was found to be higher in RA patients compared to healthy controls. Furthermore, in the group of RA patients the REE increased with the cytokine production. If this is also true for the subjects participating in the present study, the BMR may have been underestimated, which would lead to an underestimation of TEE according to the AR. However, in a more recent study Roubenoff *et al* (2002) found that in another group of RA subjects the REE was not elevated, and the authors suggested that this was a result of good disease control. Since the subjects participating in the present study had a disease activity comparable to the subjects in the latter study by Roubenoff *et al*, it is likely that the BMR was similar to that of healthy individuals.

Validity of the EI

In this study, the EI was assessed by a DHI method designed to provide information on the habitual dietary intake during the preceding month. Compared to other dietary assessment methods, the DHI has generally been shown to provide the most plausible EI in relation to BMR (Black *et al*, 1991). In the present study, there was no statistical difference between the EI and the TEE_{AR}. However, since the TEE_{AR} was significantly lower than TEE_{DLW} there was probably an underestimation of the EI. For the subjects whose TEE was measured by the DLW method, the EI was almost equal to TEE_{DLW}. Then again, these subjects had a higher EI, FIL and EI/TEE_{AR} ratio compared to the remaining subjects, which indicates that the EI of the DLW subjects was more accurate. The reason for this is unknown, but there is a possibility that these subjects became more aware of the validation of the DHI, and therefore made a greater effort to provide as truthful data as possible regarding their dietary intake.

Since many of the subjects in the MD group did not have a stable weight at the time of the dietary assessment, the under-reporting noted in this group may not be true under-reporting, since the EI is expected to be lower than the TEE when weight loss occurs. There was, however, no significant difference between the MD and the CD groups regarding EI in relation to TEE, or in the number of under-reporters, as classified by the Goldberg cut off (Black, 2000).

Validity of the reported intake of protein, sodium and potassium

Since only one urine collection per subject was available, the intake of protein, sodium and potassium was validated on a group level. The reported intake of protein, sodium and potassium showed good agreement with their respective biological markers, indicating that it was possible to obtain valid dietary data regarding these nutrients by the DHI. As described above, the EI may have been somewhat underestimated. Since the reported protein intake corresponded well to the biological marker, this may be an indication of a selective misreporting of macronutrients.

In dietary intervention studies, there is a risk that the experimental group report their prescribed diet instead of the actual intake. In the present study, the lack of differences between the experimental and the control groups regarding the reported intake in relation to the biological markers indicate that the dietary assessment was not biased by the intervention.

In conclusion, the reported EI was close to the TEE assessed by the AR. Since the AR underestimated the TEE compared to the DLW method, this indicates that the DHI had a bias towards underestimation of EI. However, as this study is based on only nine DLW measurements more validation studies regarding the AR method are needed before firm conclusions can be drawn. Concerning the reported intake of protein, sodium and potassium, there was good agreement with their respective biological markers. The validity of the reported dietary intake did not differ between the MD and the CD groups. This indicates that the DHI could assess the dietary intake fairly well and that the dietary assessment was not biased by the dietary intervention.

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