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Validation of a dietary record routine in geriatric patients using doubly labelled water

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Objective: To validate a 7-day estimated dietary record routine with standardized portion sizes and household measuring in a clinical setting with the doubly labelled water (DLW) method as the reference method.
Design: Energy expenditure was measured with deuterium (^{2}H) and oxygen-18 (^{18}O), and water loss was estimated by ^{2}H dilution as part of the DLW measurements. Energy and water intake was measured with a 7 day dietary record.
Setting: Five nursing home wards in Sweden.
Subjects: Thirty-one geriatric patients with a mean age of 86 y. Inclusion criteria were stable body weight, defined as a maximum change of $\pm$ 4% during the last 4 months of $\pm$ 2% during the last 2 months and without any acute illness.
Results: The mean daily energy intake was 7.2 MJ (1727 kcal) and the mean daily energy expenditure was 6.7 MJ (1595 kcal). The mean daily water intake was 1787 ml and mean daily water loss assessed by labelled water was 1774 ml. Using the dietary record routine, the staff overestimated the patients' energy intake by 8% and water intake from food and beverages by < 1% compared to DLW.
Conclusion: The 7 day dietary record routine based on standardized portion sizes and household measuring seems to be a valid method for assessing the intake of energy and fluids by geriatric patients.
Descriptors: malnutrition; aged; validity; diet records; doubly labelled water; body water
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Introduction

Malnutrition in nursing home residents is an important clinical and public health problem. One important factor contributing to its prevalence appears to be the failure of health care professionals to recognize its signs and identify patients with malnutrition or at risk of becoming malnourished (McWhirter & Pennington, 1994; Mowé & Bøhmer, 1991; Roubenoff *et al*, 1987). Several studies have shown that patients with malnutrition are not diagnosed correctly (McWhirter & Pennington, 1994; Mowé & Bøhmer, 1991; Roubenoff *et al*, 1987) and that the documentation in medical and nursing records in insufficient (Abbasi & Rudman 1993; Mowé & Bøhmer, 1991; Ulander *et al*, 1991). A high rate of malnutrition in elderly patients has been noted in various clinical settings by many investigators during the last few decades (Clarke *et al*, 1998; Tierney, 1996) and is accompanied by a high mortality rate (Cederholm, 1994; Elmståhl *et al*, 1997; Larsson *et al*, 1990). In a recent study of a novel dietary record routine for nursing home patients (Elmståhl *et al*, 1997), investigators found that the energy intake was less than the calculated energy expenditure for 84% of the patients and 30% of the patients had an intake below estimated basal metabolic rate.

Different methods of assessing dietary intake are available for use in identifying malnutrition and patients at risk of becoming malnourished (Cameron & Staveren, 1988; Gibson, 1990). Retrospective methods include dietary history, food frequency questionnaire and 24 h recall, whereas prospective methods include the use of dietary records and duplicate meals. The staff-administered dietary record is the method of choice for monitoring nutritional status in geriatric patients (Cameron & Staveren, 1988), because the findings are not influenced by the various kinds of illnesses and levels of cognitive impairment that are common in this population. Food and fluid intake must be recorded for several days before the patients' intakes can be classified, due to intra- and interpersonal variations (Bingham, 1991; Nelson *et al*, 1989). The doubly labelled water (DLW) method can be used to assess energy expenditure and is thereby an independent method to assess the validity of dietary records in assessing energy intake (Prentice, 1990; Speakman, 1997). However, to our knowledge, no study has been performed on elderly hospitalized patients using a 7-day dietary record routine and DLW concurrently. It is important to validate estimated energy intake in this group of patients if the comparison of energy intakes with recommended dietary amounts for hospitalized elderly are to be meaningful.

The dietary record routine, which is based on standardized portion sizes and household measurement, has been adapted for use by the ward staff in a real world clinical

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setting. Such records have been used clinically during the past few years by various public health systems to estimate patients' food intake. So far, to our knowledge, the validity of using such has not been tested.

Methods of identifying fluid imbalance in hospitalized geriatric patients may also be lacking. This population is at risk for dehydration because the elderly have a diminished sensation of thirst and are less able to regulate their fluid balance (Crowe *et al*, 1987; Phillips *et al*, 1991). If left untreated, dehydration can result in death in many cases (Mahowald & Himmelstein, 1981; Warren *et al*, 1994). Dehydration is poorly defined and its clinical signs can be vague, especially in the elderly (Chernoff, 1994; Weinberg & Minaker, 1995). Water balance studies, particularly those that focus on water intake in weight-stable geriatric patients, may provide information that can help us to better identify dehydration in this susceptible population and diminish associated mortality rates.

The purpose of this study was to validate a 7-day estimated dietary record routine with standardized portion sizes and household measuring in a real world clinical setting with the doubly labelled water method as a reference. The dietary record routine has been used in a previous study (Elmståhl *et al*, 1997) and it is intended to be used in further studies as a screening instrument to detect geriatric patients at risk of developing malnutrition.

Methods

Population

The study population was recruited from five Swedish nursing home wards. Inclusion criteria were nursing home residence, ability to ingest food and fluid orally, and stable body weight, defined as a maximum change of $\pm 4\%$ during the last 4 months or $\pm 2\%$ during the last 2 months. Exclusion criteria were parenteral or enteral nutrition, acute illness, inflammatory conditions, anemia, hypo- or hyperthyroidism, terminal conditions, and protein-energy malnutrition (PEM) as defined by biochemical and anthropometric criteria (Table 1). Blood samples were taken to measure albumin, prealbumin, hemoglobin, triiodothyronine, thyroid-stimulating zhormone, prothrombin, orosomucoid and other blood factors.

Dietary intake

Before the study period started, the ward staff attended a 2 h training session on taking dietary records, conducted by the first author and an experienced clinical dietician. The training consisted of oral and written information on the dietary record routine and practical training in assessing portion sizes using both real dishes and photographs of different dishes. During the study period, the ward staffs were provided written information on the recommended portion sizes and photographs of the different portion sizes, but received no direct assistance from the investigators other than having their questions answered. The record-keeping staff, consisting of registered nurses, practical nurses and nurse assistants, was instructed not to alter any routines during the study.

Dietary intake was recorded for 7 consecutive days by the ward staff and individual charts were obtained daily. The record form is a newly developed estimated dietary record form for use in clinical settings and is designed to be as self-explanatory as possible. It is in A4 size and has two pages. The front page is for individual dietary recording over a 24 h period and the back page gives information about the energy content of some 100 food items that are common in a hospital setting.

Table 1 Criteria for protein energy malnutrition and cut-off levels

Variables	*Normal value*	*Low value*
Weight index[a] (%)	> 80	≤ 80
Triceps skinfold (mm)		
women 70–79 y	> 13	≤ 13
women > 79 y	> 10	≤ 10
men 70–79 y	> 6	≤ 6
men > 79 y	> 6	≤ 6
Arm muscle circumference (cm)		
women 70–79 y	> 19	≤ 19
women > 79 y	> 18	≤ 18
men 70–79 y	> 22	≤ 22
men > 79 y	> 21	≤ 21
Serum albumin (g/l)	> 36	≤ 36
Serum prealbumin (g/l)		
women	> 0.18	≤ 0.18
men	> 0.20	≤ 0.20

Cut-off points according to Swedish norms (Björkelund *et al*, 1997; Symreng, 1983).
A low value for three or more variables is an indicator of protein energy malnutrition (PEM).
[a]Weight index according to Swedish height and weight tables.

Standardized portion sizes using the quartile method (0, 1/4, 2/4, 3/4, 1/1) were used for lunch and dinner; breakfast, snacks and beverages were assessed separately using household measuring devices. Energy and water intake was calculated using a nutrient computer software program (AIVO Kostplan 1.25, Sweden 1997 and Food Composition Table from Swedish PC-kost, December 1997). Fluid intake was calculated from all consumed beverages. Water intake was calculated, using food composition tables, from the combined intake from fluids and from food items. The food was prepared by the hospital kitchen staff and was served by the ward staff. The recipes from the hospital kitchen were used to calculate the energy content of each meal. Swedish norms for the mean weight and/or volume of different food items and portion sizes were used for consumed snacks and beverages consumed (Gilback *et al*, 1988; Statens Livsmedelsverk, 1992). The utensils used on the wards were calibrated by volume. Metabolic water was calculated using the equation 1.07 g water/g fat, 0.60 g water/g carbohydrate, and 0.41 g water/g protein (Fjeld *et al*, 1988). The dietary records were coded by the first author and then checked independently by an experienced clinical dietician in order to avoid coding errors.

Energy expenditure

The energy expenditure of each patient was measured using doubly labelled water (DLW) with the stable isotopes deuterium (^2H) and oxygen-18 (^{18}O) (Prentice, 1990; Speakman, 1997). The amount of isotope was calculated for each individual according to total body water, which was measured by bioimpedance (BIA-109, RJL, Michigan, USA). The isotopes were administered as a mixture of ^2H_2O and $H_2{}^{18}O$ with a calculated initial excess body water enrichment of 150 ppm for ^2H and 300 ppm for ^{18}O. Individual doses were stored in an airtight screw-cap glass container and at $+4°C$. The isotopes were given orally in water. The patients drank approximately 75–100 ml, then the sample bottle was rinsed with approximately 50 ml of tap water, which was also consumed.

Table 2 Mean energy intake (EI) *vs* DLW-estimated energy expenditure (EE) (± s.d.)

	Women (n = 18)	*Men (n = 13)*	*All (n = 31)*
Energy intake			
kcal	1607 ± 324	1892 ± 204	1727 ± 311
range	1124–2165	1496–2239	1124–2239
Energy expenditure			
kcal	1453 ± 272	1791 ± 317	1595 ± 333
range	1009–2079	1255–2290	1090–2290
EI overestimation compared with EE (%)	+10.1	+5.6	+8.4
Spearman's rank correlation coefficients between EI and EE	0.78	0.80	0.81
Mean difference between EI and EE			
kcal	+154 ± 213	+101 ± 193	+132 ± 203
range	293– +470	246– +551	293– +551

The isotopes were given in the evening, just before the patients were going to bed. Before each dose was administered, investigators collected a background blood sample from the subject. The first blood sample was collected before breakfast after an overnight fast without any food or fluid intake. The mean equilibration interval, the time between isotope dosing and collection of the first blood sample, was 10.4 h (s.d.: ± 0.8 h; range: 8.5–13.4 h). The samples were taken by venipuncture using a vacuum system (Becton Dickinson Sterile Vacutainer® systems). Within half an hour after the sample was taken, the serum was separated by centrifuge for 10 min, then transferred to an airtight screw-capped glass container and immediately frozen to 20°C. A total of nine samples were taken from each patient: one sample before the dose, and one sample in the morning and one in the evening of days 1, 8, 15 and 22 of the study.

Sampling from the participants in DLW studies is often done by urine, however has saliva and blood serum or plasma has also been used (Prentice, 1990; Speakman, 1997). Saliva has mostly been used in studies with small children. In a population of geriatric patients the prevalence of urine incontinence is usually high, in Swedish nursing homes about 60% of the patients suffer from incontinence (Hedvall *et al*, 1994). Thereby it is a great practical problem to get urine samples at specific time intervals as the study protocol states. In that context we chose to perform this study with blood samples, even though the invasive method of venipuncture could annoy the patients.

The samples were analysed by isotope ratio mass spectrometry (Aqua Sira, VG, UK). Administration and analyses of the samples followed the Maastricht protocol (Westerterp *et al*, 1995). In the calculation of energy expenditure and water loss, the individual changes in body weight during study has been taken into account.

Water loss

Water loss was estimated by ^{2}H dilution as part of the DLW measurements (Marken Lichtenbelt *et al*, 1994; Westerterp *et al*, 1995). The calculation of water loss has in detail been described before (Westerterp, 1999).

Ethics

Each patient and/or a close relative gave an oral informed consent to the patient's participation in the study. The study was approved by the Local Ethical Committee at Lund University, Sweden.

Statistics

Statistical analyses was performed using *SPSS for Windows* (8th edn Chicago, SPSS Inc. 1997). Values are expressed as means and standard deviations (s.d.). In the sub-group analysis (Tables 3 and 5) the item weight index was set at 80%, in accordance with the criteria for PEM (Table 1). Non-parametric methods were used when analysing data as the samples were small and were not normally distributed (Altman, 1996). The relationship between energy intake and energy expenditure, as well as between water intake and water loss, was examined using the two-tailed Spearman's rank correlation coefficient. The cross-classification by tertiles was examined using the chi square test. The sub-group analysis (Table 3 and 5) was examined using the

Table 3 Energy intake (EI) and DLW-estimated energy expenditure (EE) and influence of body weight (BW) ($n = 31$). Difference between EI and EE (ΔE) and relative difference (ΔE%)

		EI (kcal)	*EI/kg BW (kcal)*	*EE (kcal)*	*EE/kg BW (kcal)*	*ΔE (kcal)*	*ΔE (%)*
Gender	Women ($n = 18$)	1607**	29	1453**	26	154	11
	Men ($n = 13$)	1892	27	1791	26	101	7
Age	< 86 y ($n = 11$)	1834	30	1659	27	175	13
	≥ 86 y ($n = 20$)	1667	27	1559	26	108	8
BMI	< 25 ($n = 21$)	1643*	29	1448**	26	195*	14*
	≥ 25 ($n = 10$)	1903	26	1903	26	0	1
Katz ADL-index	A–E ($n = 13$)	1710	29	1630	27	80	6
	F–G ($n = 18$)	1739	28	1570	25	169	12
Eating	Independent ($n = 26$)	1722	28	1622	26	99	7
	Total help ($n = 5$)	1754	31	1452	25	302	22
Weight index	≤ 80% ($n = 10$)	1627	32**	1418	28	209	14
	> 80% ($n = 21$)	1774	27	1679	25	95	7
Diagnoses	Dementia ($n = 11$)	1881	29*	1804	28*	77	16
	Stroke ($n = 7$)	1534	27	1304	23	230	18
	Other ($n = 13$)	1700	28	1574	26	126	8

* = $P < 0.05$; ** = $P < 0.01$.

Table 4 Cross-classification of energy intake (mean kcal/day) and DLW-estimated energy expenditure by tertiles ($n = 31$)

	Energy expenditure estimated by DLW (kcal)		
Energy intake (kcal)	*1009–1436*	*1437–1695*	*1696–2290*
1124–1631	8	2	0
1632–1907	2	6	3
1908–2239	0	3	7

Mann–Whitney test. The Kruskal–Wallis test was used for the item diagnosis. Results were considered statistically significant if *P*-values were less than 0.05.

Results

Of 102 patients, 37 matched the study criteria and agreed to participate. Data are not available for six of the 37: three patients terminated their participation in the study; in two patients it was impossible to get the required blood samples; and in one patient there was no enrichment of the DLW probably due to the dose not being properly consumed. Thus, the study group consisted of 31 patients (18 women and 13 men) with a mean age of 86 y (s.d.: ± 6 y; range: 65–96 y). The mean length of time spent on the wards was 709 days (s.d: ± 531 days; range: 73–2346 days). The most common diagnoses were dementia ($n = 11$), stroke ($n = 7$), neurological disorders ($n = 3$), and orthopedic disorders ($n = 3$). According to Katz ADL-index (Brorsson & Hulter Åsberg, 1984; Katz *et al*, 1963), the participants were highly dependent on others in activities of daily life (ADL), as indicated by a score of F or G for 18 of the 31 patients, and five patients were dependent in all activities. Only four patients were highly independent, as indicated by scores of A or B. The remaining patients had Katz ADL-index scores of C or E. The mean body weight was 55.8 kg (s.d.: ± 9.1 kg; range: 45.0–74.8 kg) for women and 69.8 kg (s.d.: ± 8.1 kg; range: 56.0–85.5 kg) for men. Mean body mass index (BMI) was 22.6 (s.d.: ± 3.6; range: 16.3–28.2) for women and 24.2 (s.d.: ± 3.4; range; 18.9–29.6) for men. Twenty-six of the 31 patients had a BMI between 20 and 30, and none had a BMI > 30. The mean change in body weight during the study was 0.5 kg (s.d.: ± 1.9 kg; s.e.m: 0.4 kg; $n = 29$). Body weights for two patients were missing at the end of the study, as one patient died and another was relocated after the DLW sampling was finished but before a new body weight value could be measured.

The mean ^{2}H and ^{18}O dilution space ratio was 1.029 (s.d.: ± 0.007: range: 1.007–1.039), which indicates a relatively low variance in the method. We found no significant age or gender differences.

Energy

The mean energy intake was 7.2 MJ/day (s.d. ± 1.3): 6.7 MJ/day (s.d. ± 1.4) for women and 7.9 MJ/day (s.d. ± 0.9) for men. The mean energy expenditure was 6.7 MJ/day (s.d. ± 1.4): 6.1 MJ/day (s.d. ± 1.1) for women and 7.5 MJ/day (s.d. ± 1.3) for men. Using the 7-day dietary record routine, the staff overestimated the mean energy intake by 8.4% when compared to energy expenditure (Table 2). The Spearman's rank correlation coefficients between energy intake and energy expenditure was 0.81 ($P < 0.001$): 0.78 ($P < 0.001$) for women and 0.80 ($P = 0.001$) for men.

The difference between energy intake and energy intake and energy expenditure ($\Delta E = EI \quad EE$) and the relative difference ($\Delta E\%$) were examined in relation to gender, age, body weight, ADL independence, eating ability and diagnoses. No statistically significant differences between ΔE and $\Delta E\%$ were noted for age, ADL independence *vs* dependence, or independence *vs* total dependence during

Table 5 Mean water intake (ml/day) *vs* labeled water estimated water loss (ml/day) (± s.d.)

	Women (n = 18)	*Men (n = 13)*	*All (n = 31)*
Water intake[a] (ml)	1697 ± 211	1911 ± 285	1787 ± 263
range	1123–2052	1532–2464	1123–2464
by body weight (ml/kg)	31 ± 5	28 ± 4	29 ± 5
range	24–40	22–36	22–40
Fluid intake (ml)	1161 ± 242	1206 ± 266	1180 ± 249
range	682–1599	869–1848	682–1848
by body weight (ml/kg)	21 ± 5	17 ± 3	20 ± 5
range	14–31	12–23	12–31
Food water[b] (ml)	536 ± 161	705 ± 91	607 ± 159
range	138–785	543–889	138–889
Total water intake[c] (ml)	1908 ± 236	2159 ± 302	2014 ± 290
range	1269–2283	1756–2729	1269–2729
by body weight (ml/kg)	35 ± 6	31 ± 4	33 ± 5
range	27–45	25–40	25–45
Metabolic water (ml)	212 ± 45	248 ± 25	227 ± 41
range	146–282	199–289	146–289
Water loss estimated by DLW (ml)	1673 ± 286	1914 ± 432	1774 ± 368
range	1070–2150	1260–2580	1070–2580
by bodyweight (ml/kg)	30 ± 5	27 ± 5	29 ± 5
range	20–38	20–34	20–38
Mean difference between total water intake and water loss (ml)	235 ± 166	246 ± 293	240 ± 224
range	104– +524	214– +689	214– +689

[a]Water intake includes water from food and beverages, but not metabolic water.
[b]Food water is here defined as water intake minus fluid intake.
[c]Total water intake includes water from food and beverages and metabolic water.

mealtime corresponding to a score of G on the Katz ADL index (Brorsson & Hulter Åsberg, 1984; Katz *et al*, 1963). Statistically significant differences were found between gender groups, body-weight groups, and diagnoses (Table 3). Cross-classification of energy intake compared to energy expenditure by tertiles showed that 68% of the patients were classified correctly and none was grossly misclassified by more than one tertile (Table 4), and Kendall's tau-value was 0.69.

Water

Mean water intake was 1787 ml/day (s.d. ± 263): 1697 ml/day (s.d. ± 211) for women and 1911 ml/day (s.d. ± 285) for men. Labelled water estimated mean water loss was 1774 ml/day (s.d. ± 368): 1673 ml/day (s.d. ± 286) for women and 1914 ml/day (s.d. ± 285) for men. Using the 7 day dietary record routine, the staff overestimated mean water intake from food and beverages by 0.7% when compared to water loss (Table 5). The Spearman's rank correlation coefficients for the difference between water intake and water loss was 0.82 ($P < 0.001$): 0.77 ($P < 0.001$) for women and 0.79 ($P < 0.01$) for men.

The difference between water intake and water loss ($\Delta W = WI \quad WL$) and the relative difference ($\Delta W\%$) were examined in relation to gender, age, body weight, ADL independence, eating ability and diagnoses. No statistically significant differences in ΔW and ΔW% were noted between gender groups, high and low age, different diagnoses, and independence *vs* total dependence during mealtime corresponding to level G in Katz ADL index (Brorsson & Hulter Åsberg, 1984; Katz *et al*, 1963). Statistically significant differences were found between body-weight groups and ADL-independence/dependence groups (Table 6). Cross-classification of water intake compared to water loss by tertiles showed that 61% of the patients were classified correctly and none was grossly misclassified by more than one tertile (Table 7) and Kendall's tau-value was 0.63. No differences in the cross-classification were found when metabolic water oxidation was taken into account. No evidence of dehydration, defined by hemoglobin of 113−153 g/l for women and 122−166 g/l for men, was found.

Discussion

Although studies have been published on the validity of healthy elderly people's energy intake (Rothenberg, 1997), to our knowledge, this is the first study to use DLW as a means of validating energy and fluid intake information recorded in a dietary record routine among institutionalized geriatric patients. To ensure the reliability of this comparison, we had to overcome the fact that various types of medical conditions can change metabolism and absorption or cause excessive nutritional losses. We also had to consider the fact that dietary intake can be impaired by psychiatric disorders and functional incapacity caused by movement disorders or swallowing problems (Elmståhl *et al*, 1987; Morely, 1997). Hospitalization, the patient's mealtime situation, the numbers of persons from the ward staff present during mealtimes, eating facilities and ambience can affect food intake (Elmståhl *et al*, 1987). Sidenvall (1995) showed that the skills and values of staff highly affected mealtimes and the quality of individual patient care.

For these reasons, we selected geriatric patients who had no diseases or conditions that could affect their energy metabolism, patients who had a stable body weight, normal body temperature, and no evidence of acute illness. Thus, our study population was generally healthier than many geriatric nursing home patients and thereby probably had a higher mean energy intake at a group level compared with all nursing home patients.

In a number of studies, higher energy intake values have been reported by investigators using dietary history method compared to 7 day dietary record (Block, 1982). Most of these diet history studies demonstrated reliability but not validity due to the lack of an existing 'gold standard'. Furthermore, the energy intake indicated by dietary records tends to be lower than the energy expenditure determined in studies based on DLW or calculated energy expenditure (Black *et al*, 1995). However, in a study by Prentice *et al* (1989), the energy intake measured with a 7 day weighted dietary records overestimated the energy expenditure measured with DLW in 14 geriatric patients. Similar findings were noted for children when their intake was reported by their parents (Livingstone *et al*, 1992). We also noted an overestimation of energy intake using the dietary record

Table 6 Total water intake[a] (WI) and labeled water estimated water loss (WI) and influence of body weight (BW) ($n = 31$). Difference between WI and WI (ΔW) and relative difference (ΔW%)

		WI (ml)	*WI/kg BW (ml)*	*WL (ml)*	*WL/kg BW (ml)*	*ΔW (ml)*	*ΔW (%)*
Gender	Women ($n = 18$)	1908*	35	1673	30	115	15
	Men ($n = 13$)	2159	31	1914	27	116	16
Age	< 86 y ($n = 11$)	2035	33	1786	29	117	16
	≥ 86 y ($n = 20$)	2002	33	1768	29	115	15
BMI	< 25($n = 21$)	1917*	35*	1611***	29	120**	20**
	≥ 25 ($n = 10$)	2216	30	2117	29	107	7
Katz ADL-index	A−E ($n = 13$)	2016	34	1876	32*	109*	9*
	F−G ($n = 18$)	2012	32	1701	27	121	21
Eating	Independent ($n = 26$)	2003	33	1789	29	114	14
	Total help ($n = 5$)	2072	36	1698	30	123	23
Weight index	≤ 80 ($n = 10$)	1926	38*	1626	32	119	19
	> 80 ($n = 21$)	2055	31	1845	28	114	14
Diagnoses	Dementia ($n = 11$)	2147	33	1938	30	113	13
	Stroke ($n = 7$)	1872	28	1601	28	118	17
	Other ($n = 13$)	1977	33	1728	29	117	17

* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$.
[a]Total water intake includes water from food, beverages and metabolic water oxidation.

Table 7 Cross-classification of water intake and labeled water estimated water loss by tertiles ($n = 31$)

	Labelled water estimated water loss (ml)		
Water intake (ml)	*1070–1607*	*1608–1887*	*1888–2580*
1123–1639	6	4	0
1640–1893	4	5	2
1894–2464	0	2	8

routine. One possible explanation for this consistent finding may lie in a systematic overreporting by the ward staff; it is also possible that standardized portion sizes overestimate consumed amounts. In this study, the high correlation ($r = 0.81$) between estimated energy intake and DLW could in part be explained by fewer errors in the food intake being made by the ward staff, who also functioned as independent observers and, thus, minimized the risk of patients altering self-reported dietary habits.

It has been previously suggested that a 7 day period is long enough to gain enough information about a food intake to be able to rank and categorize 80% of individuals correctly according to the distribution of energy-producing nutrients (fats, carbohydrates and protein) in their diets and overcome intra- and interpersonal variations in that distribution (Bingham, 1991). In our study, 80% of the patients were correctly classified in the lowest tertiles, and no subject was grossly misclassified by more than one tertile. Since the dietary record routine is intended to be used as an screening instrument to detect patients with malnutrition or at risk of becoming malnourished, it is vital to detect the patients with the lowest intake of energy.

Variations in the dilution space ratio in DLW measurements also seem to be statistically insignificant. The mean dilution space ratio coefficient in this study, 1.029, indicates that there is no systematic bias due to the DLW method. The preferable mean value remains questionable, although a value of 1.034–1.040 has been suggested as a suitable cut-off point (Speakman, 1997).

The difference between food-record reported energy intake and DLW-measured energy expenditure seems to be statistically insignificant with respect to age, ADL-independence/dependence, and independence *vs* totally dependent during mealtime. There was a slight difference by gender, with a greater overestimate made for women; this difference may indicate that the staff believes that women patients eat more than they actually do. However, this difference disappeared when energy intake was related to body weight or energy expenditure. The difference was quite striking for patients with stroke compared with patients who had not had a stroke. The differences in energy intake and energy expenditure may be due to differences in body weight as well as diagnosis: six out of the seven patients with stroke had lower body weights, as indicated by BMI and weight index. Patients with a history of stroke were also more dependent for ADL functions: six out of the seven stroke patients had a score of F or G on the Katz ADL index. The differences for patients with a history of stroke may also be explained by communication problems and/or lack of sufficient attention from the staff.

The study did not indicate whether the energy intake was appropriate for each patient. Thus, the findings cannot be used to determine whether the patients had adapted their physical activity to a lower energy intake or the energy intake is sufficient to support optimal physical activity. It is possible that institutionalized patients can adapt and maintain their energy balance at a suboptimal level. Compared with other studies involving free-living elderly given DLW, this is a low level of energy expenditure. Rothenberg (1997) found a mean energy expenditure of 9.9 MJ (9.6 MJ for women and 10.8 MJ for men) for 12 healthy elderly patients with a mean age of approximately 73 y. Similar values was noted by Pannemans and Westerterp (1995), who found a mean energy expenditure of 9.6 MJ in a group of free-living elderly. A higher mean energy expenditure (8.0 MJ) was reported for non-institutionalized patients with Alzheimer's disease (mean age: 73 y) and healthy elderly study participants (9.3 MJ; mean age: 69 y) (Poehlman *et al*, 1997) compared to this study.

Values for water intake estimated by the dietary record routine and labelled water estimated water loss was much closer. The mean water intake from food and beverages was 1787 ml; the mean water loss was 1774 ml. Using the DLW method, investigators were able to correctly classify 60% of the patients in the lowest tertiles and no patient was grossly misclassified by more than one tertile. There was no difference in the cross-classification when metabolic water was taken into account. We found no statistically significant difference between water intake and water loss in terms of gender, age, diagnoses, or independence *vs* total dependence at meals. A difference was determined in terms of body weight and ADL function, which might be explained by the fact that patients who are not mobile but can eat by themselves seem to get less fluid to drink. Patients who are mobile are able to get fluid by themselves and the totally dependent patients also seem to get enough fluid. Patients who are immobile but can eat without help seem not to get enough attention from the staff; this includes patients who have had a history of stroke. This finding is supported by Blower (1997), who showed that patients who where thirsty and unable to drink independently often waited to ask for help because they did not want to disturb the ward staff.

The group of geriatric patients in our study apparently had a sufficient intake of fluid. The mean water intake from food and beverages (including metabolic water oxidation) was 33 ml/kg body weight per day; the recommended daily fluid intake for elderly adults is 30 ml/kg body weight per day (Chernoff, 1995; Massler, 1985). Studies have shown that a large number of free-living and institutionalized elderly individuals do not get enough fluid, and this is associated with an increased mortality (Adams, 1988; Gaspar, 1988; Haveman-Nies *et al*, 1997). Risk factors for elderly patients developing dehydration include insufficient food and water intake, poor mobility, infection, fever, diarrhoea, vomiting, hospitalization, multiple diseases, and medications (Lavizzo-Mourey *et al*, 1988; Naitoh & Burrell, 1998; Weinberg *et al*, 1994a, b). Interestingly, these factors would contribute to a lack of body weight stability and keep the patient out of this study. Also, patients with cerebrovascular diseases, dementia and delirium have a higher incidence of dehydration (Albert *et al*, 1989; Holstein *et al*, 1994; Inouye *et al*, 1999). Total body water declines with age (Pfeil *et al*, 1995; Steen, 1997), and this decline could also be considered as a risk factor for dehydration.

The results of this study tells us something about how the energy intake matches the energy expenditure in a group of body weight stable geriatric patients. The novel 7 day dietary record routine, based on standardized portion sizes and household measuring, is adopted to be used by ward staff in a real world clinical setting. The dietary record routine seems to be a valid instrument for assessing energy and water intake in geriatric patients and we believe that it could be applied in future studies.

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