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Original Communication
Validity of self-reported energy intake in lean and obese young women, using two nutrient databases, compared with total energy expenditure assessed by doubly labeled water

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Objective: To compare self-reported total energy intake (TEI) estimated using two databases with total energy expenditure (TEE) measured by doubly labeled water in physically active lean and sedentary obese young women, and to compare reporting accuracy between the two subject groups.
Design: A cross-sectional study in which dietary intakes of women trained in diet-recording procedures were analyzed using the Minnesota Nutrition Data System (NDS; versions 2.4/6A/21, 2.6/6A/23 and 2.6/8.A/23) and Nutritionist III (N3; version 7.0) software. Reporting accuracy was determined by comparison of average TEI assessed by an 8 day estimated diet record with average TEE for the same period.
Results: Reported TEI differed from TEE for both groups irrespective of nutrient database ($P < 0.01$). Measured TEE was 11.10 ± 2.54 and 11.96 ± 1.21 MJ for lean and obese subjects, respectively. Reported TEI, using either database, did not differ between groups. For lean women, TEI calculated by NDS was 7.66 ± 1.73 MJ and by N3 was 8.44 ± 1.59 MJ. Corresponding TEI for obese women were 7.46 ± 2.17 MJ from NDS and 7.34 ± 2.27 MJ from N3. Lean women under-reported by 23% (N3) and 30% (NDS), and obese women under-reported by 39% (N3) and 38% (NDS). Regardless of database, lean women reported higher carbohydrate intakes, and obese women reported higher total fat and individual fatty acid intakes. Higher energy intakes from mono- and polyunsaturated fatty acids were estimated by NDS than by N3 in both groups of women ($P \leq 0.05$).
Conclusions: Both physically active lean and sedentary obese women under-reported TEI regardless of database, although the magnitude of under-reporting may be influenced by the database for the lean women.
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Contributors: JLW was involved in diet record keeping training, calculation of energy expenditure, statistical analyses and writing the paper. PMR and KAG were involved in the day to day collection of data, and were responsible for overall data management including calculations and statistical analyses, and writing the paper. KAG was also involved in designing the study. JPD was responsible for isotope analyses and provided advice on calculations and the manuscript. VAS was involved in diet record keeping training and manuscript preparation and was responsible for overseeing diet composition analysis. SBG was responsible for overseeing body composition analyses and provided advice on the manuscript. WHH and LBH were the co-principal investigators responsible for designing the study and overseeing all aspects of the work and participated in preparation of the manuscript.
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Introduction

The measurement of total energy expenditure (TEE) by the doubly labeled water method (Lifson *et al*, 1955) has been used frequently in recent years as a biomarker for the validation of self-reported energy intake. Doubly labeled water studies have consistently demonstrated significant under-reporting of total energy intake compared with TEE, especially in female athletes, adolescents and the obese (Schoeller, 1995). In a review of 10 doubly labeled water studies conducted over the past 12 y by the Dunn Nutrition Centre, Black *et al* (1993) concluded that energy intake was self-reported accurately by normal weight, self-selected, motivated volunteer adult subjects using weighed diet records, but under-reported by 18 – 19% by randomly recruited men and women, respectively. Women in the lowest third of energy intake under-reported by 39%. Obese and previously obese women under-reported their energy intake by 27–36%. Mertz *et al* (1991) also reported accurate recording of energy intake by well-motivated and trained volunteer subjects of both sexes, and the trend toward greater under-reporting error by those with the lowest intakes.

Other studies in obese subjects have shown a range of energy intake under-reporting of 33–47% relative to TEE measured by the doubly labeled water method (Prentice *et al*, 1986; Lichtman *et al*, 1992; Buhl *et al*, 1995; Platte *et al*, 1995). Under-reporting of energy intake of 11 and 32% has been shown in lean, athletic women (Schulz *et al*, 1992; Edwards *et al*, 1993) compared to doubly labeled water-determined TEE. Both groups appear to demonstrate under-reporting trends that are greater than for normal-weight subjects.

These studies, using different dietary reporting methods and nutrient databases, have shown that both obese, sedentary women and lean, athletic women consistently under-report their energy intake to a greater extent than women of normal body weight. Thus, what has not been determined is whether the level of under-reporting is due to differences in dietary methodology or nutrient database used to analyze reported intakes. The purpose of this study was to use the same diet record methodology, in both obese, sedentary women and lean, athletic women, to compare self-reported energy intake to TEE measured by doubly labeled water. Further, we addressed the previously unresolved issue of whether the nutrient database used to analyze the dietary intake data resulted in different validation outcomes.

Methods

Subjects

Subjects were 16 college-aged women recruited through advertisements targeting participation in collegiate athletics or weight management counseling through The University of Arizona Campus Health Service. There were eight obese, sedentary women and eight lean, athletic women aged 18–32 y (mean age 23.9 ± 5.0 y). The racial and ethnic composition of the two groups were 62.5% Caucasian, 25.0% black and 12.5% Hispanic for the lean women and 37.5% Caucasian, 12.5% black, and 50.0% Hispanic for the obese women. Other participant characteristics are summarized in Table 1.

Subject candidates were pre-screened by phone, during which the study protocol was described. Interviewer-administered medical, dietary and physical activity histories were obtained, along with written, informed consent. A 5 ml blood sample was collected for a thyroid profile. The analyses were conducted at a local clinical laboratory. Women with serum thyroid hormone concentrations outside the normal ranges, histories of cancer or heart disease, or other medical conditions or medication use which could alter normal energy metabolism, were excluded. The study protocol was approved by the Human Subjects Committee of The University of Arizona.

Dietary intake

During a 45 min session, the women were individually trained in portion size measurement and estimation using

Table 1 Comparison of subject characteristics

	Lean (n = 8)		*Obese* (n = 8)		
	Mean ± s.d.	*Range*	*Mean ± s.d.*	*Range*	P[a]
Age (y)	22.8 ± 3.1	21–30	25.1 ± 6.4	18–35	0.362
Height (cm)	162.8 ± 8.9	154.9–178.3	162.0 ± 5.8	151.1–167.4	0.844
Weight (kg)	56.6 ± 6.8	44.3–66.1	83.9 ± 9.6	72.0–102.9	< 0.001
Body weight change (kg)	− 0.13 ± 0.46	− 0.7–0.7	− 0.49 ± 0.53	− 1.1–0.4	0.160
BMI (kg/m^2)[b]	21.4 ± 2.2	18.4–25.2	32.0 ± 3.5	28.2–37.0	< 0.001
Body fat (%)[c]	16.2 ± 4.1	11.1–23.7	40.8 ± 3.6	33.8–44.6	< 0.001
Fat-free mass (kg)[d]	47.4 ± 6.3	36.9–58.3	49.5 ± 5.4	43.9–57.3	0.472
Maximal VO_2 (ml/kg/min)[e]	49.1 ± 5.1	42.3–54.9	28.3 ± 5.7	19.9–35.7	< 0.001
Total energy intake (MJ/day)[f]					
NDS[g]	7.66 ± 1.73^B	(4.74–10.69)	7.46 ± 2.17^B	(4.01–10.55)	0.836
	(1831 ± 413 kcal/day)	(1133–2555 kcal/day)	(1783 ± 519 kcal/day)	(959–2521 kcal/day)	
N3[h]	8.44 ± 1.59^B	(5.45–10.61)	7.34 ± 2.27^B	(3.71–11.39)	0.283
	(2017 ± 380 kcal/day)	(1302–2535 kcal/day)	(1754 ± 543 kcal/day)	(886–2723 kcal/day)	
Total energy expenditure (MJ/day)[f]	11.10 ± 2.54^A	(6.87–14.76)	11.96 ± 1.21^A	(10.61–14.52)	0.397
	(2653 ± 607 kcal/day)	(1642–3527 kcal/day)	(2859 ± 289 kcal/day)	(2536–3471 kcal/day)	

[a]From one-way analysis of variance.
[b]Body mass index = weight (kg) divided by height (m) squared.
[c]Calculated by the multi-component method of Lohman (1992).
[d]Fat-free mass = body weight − (body weight × (% body fat/100)).
[e]$n = 6$ for lean and obese groups.
[f]Energy intake and energy expenditure means with different letter superscripts are significantly different ($P < 0.001$; two-way analysis of variance).
[g]Minnesota Nutrition Data System, versions 2.4/6A/21 (Nutrition Coordinating Center, University of Minnesota, 1992), 2.4/6A/23 (1994) and 2.6/8A/23 (1994).
[h]Nutritionist III, version 7.0 (N-Squared Computing, 1991).

a modification of the method of Weber *et al* (1997) which included training participants in groups of four to eight. For this method, the women measured two samples each of solid, liquid and amorphous foods, estimated the portion sizes of 12 plastic food models, and learned how to measure and estimate the dimensions of solid foods by length, width and height or diameter. Subjects were also taught how to record their dietary intake in a diet record booklet. The training sessions were conducted by staff trained in the portion size estimation training protocol and in diet record data entry. At the end of the training session, subjects received a page of summary instructions, a sample completed diet record form, and a diet record booklet. Each subject then completed one full day of diet recording as practice. The 1-day practice diet record was reviewed with each subject and follow-up training was provided as necessary prior to the first day of record keeping for the study.

Eight days of estimated dietary records were collected to correspond to the 8 day TEE measurement protocol. Subjects recorded all dietary intake for the period of time initiated by the administration of the doubly labeled water dose on the morning of day 1 and ended by the collection of a urine sample on the morning of day 9. Diet record data were reviewed daily for completeness, and the women were contacted by phone within 24 h to rectify any incomplete, missing or uninterpretable entries. All diet records were entered into two nutrient data programs having different nutrient databases: Nutritionist III (N3), version 7.0 (N-Squared Computing, 1991), and the Minnesota Nutrition Data System (NDS) program versions 2.4 and 2.6, food databases 6A and 8A, and nutrient database versions 21 and 23 (Nutrition Coordinating Center, University of Minnesota, 1992, 1994). More than one version of the NDS software was used because NDS provides regular updates to the nutrient database that do not invalidate or conflict with recent previous versions. NDS program staff recommend updating to the newest program and database versions during the course of a study as these updates become available. Three coders were trained in diet record data entry procedures for the two nutrition programs, and quality control procedures were instituted to maximize inter-coder reliability. Records for all eight days for each participant were entered by two of the three coders in both nutrition programs. Discrepancies greater than 10% in total energy or macronutrients within databases were investigated for data entry error. If differences were not due to data entry error, the entries were not changed.

Total energy expenditure (TEE)

TEE was measured by the doubly labeled water method (Lifson *et al*, 1955). Subjects were scheduled to begin measurements between the fifth and eighth days after the start of their menstrual cycle. A urine sample was collected for determination of background oxygen-18 (^{18}O) and deuterium (^{2}H) isotope abundances on day 1. In order to estimate an adequate isotope dose, total body water (TBW) was determined by single frequency bioelectric impedance analysis (Model 1990B, Valhalla Scientific, San Diego, CA) using the Kushner *et al* (1992) equation. The women then drank a weighed mixture of deuterium oxide ($^{2}H_2O$; 99.8 atom%; Isotec Inc., Miamisburg, OH) and ^{18}O-labeled water ($H_2\,^{18}O$; 10.1 atom%; Isotec Inc., Miamisburg, OH) containing 0.15 g of ^{2}H and 0.3 g of ^{18}O per kg of TBW. The time was recorded when the isotope dose was administered. Urine samples were collected at the laboratory in sterile specimen containers on days 2, 5, 8 and 9, at approximately the same time of day as the administration of the isotopes on day 1 and the time was recorded when each sample was collected. This provided data points for the calculation of carbon dioxide production using the Weir (1949) equation and for the estimation of TBW using ^{18}O dilution. Back-extrapolation of the linear regression of the natural logs of the ^{18}O isotope enrichment of the post-dose urine samples against time to the ^{18}O space at time zero provided the estimate of TBW. Immediately following collection four, 5 ml aliquots of each urine sample were stored frozen at $-80°C$ in airtight cryogenic vials until being packed on dry ice in a sealed, insulated biomailer and shipped overnight to the Stable Isotope Laboratory at the Pennington Biomedical Research Center for analysis. The ^{18}O and ^{2}H abundances were measured in duplicate samples using a gas-inlet isotope ratio mass spectrometer (MAT 252, Finnigan MAT GmbH, Bremen, Germany), and the isotope enrichment of each post-dose sample was calculated relative to the abundance in the pre-dose sample (DeLany *et al*, 1989). The coefficients of variation for these analyses were 0.26 and 0.53% for ^{18}O and ^{2}H, respectively.

The TEE was calculated by the multi-point method (Schoeller, 1983; 1988) using the day 2, 5 and 9 urine samples as the initial, middle and final time point, respectively, with dilution space adjusted as described by Racette *et al* (1994):

$$TEE = ((N/2.078)(1.007k_O \quad 1.041k_H) \quad (0.0246 \times 1.05N \\ (1.007k_O \quad 1.041k_H))) \times 22.4 \times 5.6535$$

where N is the body water pool $((N_O/1.007)+(N_H/1.041))/2$; N_O and N_H are ^{18}O and ^{2}H dilution spaces (moles); k_O and k_H are turnover rates of ^{18}O and ^{2}H (days^{-1}); and $0.0246\times1.05\,N\,(1.007\,k_O - 1.041\,k_H)$ is to correct for water loss that is subject to isotopic fractionation. The energy equivalent of carbon dioxide, 5.6535 (Elia & Livesey, 1992), was based on an assumed RQ of 0.86.

Body composition

Body weights were measured daily to the nearest 0.1 kg using a digital platform scale (Kubota model K-10-300L-A, Chugai Boyeki (America) Corp., Commack, NY), and standing height was measured to the nearest 0.5 cm using a stadiometer (Narragansett Machine Co., Providence, RI) on days 1 and 8. For each parameter the mean of all measurements was used in body mass index (BMI) and body composition calculations.

Relative body fat (percentage body fat) was determined by the multi-component method (Lohman, 1992), which includes body density, TBW and total body mineral content:

$$\%\text{fat} = ((2.747/D_b) \quad 0.714w + 1.146b \quad 2.0503) \times 100$$

where D_b is body density, w is TBW and b is total body mineral content. Body density was determined from hydrodensitometry using procedures described by Going *et al* (1993), TBW from ^{18}O dilution, and total body mineral content from dual energy X-ray absorptiometry (DXA; Lunar DPX-L, version 1.3 y, Madison, WI) using the Going *et al* (1993) protocol. Body fatness can be estimated more accurately using this multi-component approach than by density alone due to the accuracy of ^{18}O dilution and DXA for measurement of TBW and total body mineral, respectively. The TBW measurement was made over the entire 8 day study period. Hydrodensitometry and DXA measurements were made on days 1 and 8 of the study. Fat-free mass (FFM) was estimated using body weight and percentage body fat data.

Fitness testing

A graded exercise treadmill test, which provided a measure of maximal oxygen consumption (VO_2), was used to determine the fitness level of each subject. The maximal treadmill test was performed using a modified Bruce protocol described by the American College of Sports Medicine (1995). The Bruce protocol uses 3 min stages to assess steady state, as well as maximal, heart rate and associated VO_2. A maximal $VO_2 \geq 40\,\text{ml}\,O_2/\text{kg/min}$ was used to determine minimal fitness for inclusion in the lean, athletic subject group. Based on the 1994 data for physical fitness norms from the Institute for Aerobics Research, Dallas, TX (American College of Sports Medicine, 1995), this level of aerobic capacity placed the subjects above the 75th percentile for women aged 20–29 y and above the 80th percentile for those aged 30–39 y.

Data analysis

Differences between the lean and obese subject groups, between methods (nutrient databases or total energy intake (TEI) and TEE), and the interactions of subject group and method were assessed using 2×2 or 2×3 factorial analyses of variance. Differences between means with an observed probability ≤ 0.05 were considered significant. In addition, the method of Bland and Altman (1986) was used to compare TEI calculated by each database with TEE measured by doubly labeled water (DLW). All statistical analyses were carried out using SPSS version 9.0 software (SPSS Inc., Chicago, IL). Adjusting total energy or macronutrient intakes for FFM did not alter any of the results below.

Results

Age and height were not significantly different between groups. However, as expected, weight, BMI and percentage body fat were significantly lower, and maximal VO_2 was significantly higher for the lean compared to the obese women (Table 1). FFM did not differ between groups (Table 1).

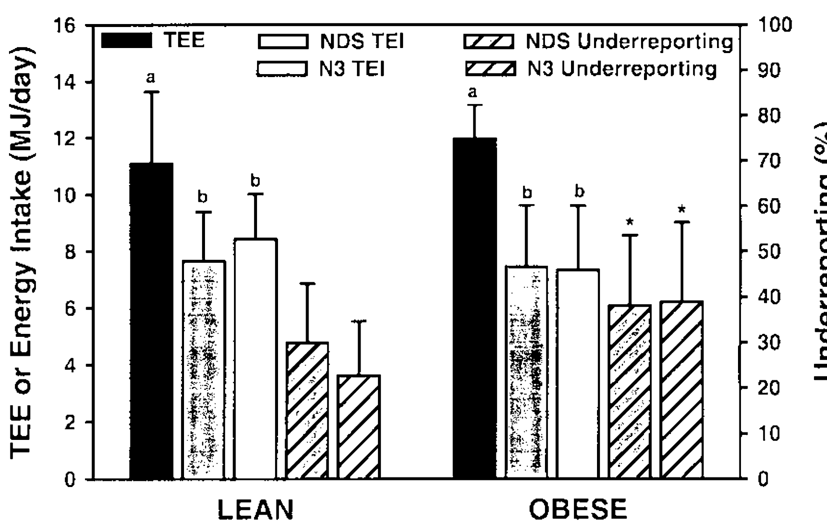

Figure 1 TEE ± s.d., TEI ± s.d. estimated from 8 day diet records by two nutrient databases (NDS and N3), and percentage under-reporting of energy intake in comparison with measured TEE (megajoules of dietary energy under-reported per 100 megajoules of total energy expended) for eight lean, athletic and eight obese, sedentary women. The * label above a bar indicates that the percentage under-reporting is higher for obese women than for lean women ($P \leq 0.05$). Within a subject group, bars with different letter (a or b) labels represent TEE and TEI that differ from each other ($P \leq 0.01$ for lean subjects and $P \leq 0.001$ for obese subjects).

Reported TEI, whether estimated using NDS or N3, was not significantly different between groups (Table 1). Measured TEE also was not significantly different between the lean and obese groups of women (Table 1). Both groups reported energy intakes that were significantly different from TEE measured by doubly labeled water regardless of the nutrient database used (Figure 1). In all cases, energy intake was under-reported. The lean group under-reported by 23%, equivalent to 2.66 MJ (636 kcal), based on N3-estimated intakes and by 30%, equivalent to 3.44 MJ (822 kcal) based on NDS-estimated intakes. The obese group under-reported by 39% or 4.51 MJ (1078 kcal) and 38% or 4.62 MJ (1104 kcal) when calculated by N3 and NDS, respectively. In both nutrient databases, the magnitude of under-reporting by the obese subjects was significantly greater than that of the lean subjects (Figure 1).

Comparison of TEI calculated using either NDS or N3 with DLW-measured TEE using Bland and Altman (1986) plots revealed no obvious relation between the difference and the mean (Figure 2). A bias of 3.97 MJ (949 kcal) was observed for daily energy intakes calculated by NDS with limits of agreement of 0.31 and 7.63 MJ (74 and 1824 kcal; Figure 2A). For daily energy intakes calculated using N3 the bias was 3.64 MJ (870 kcal) with limits of agreement of −0.50 and 7.78 MJ/day (−120 and 1859 kcal; Figure 2B). Regardless of database, the difference of 3.05 MJ (729 kcal) between measured TEE and calculated TEI for the lean women was lower ($P=0.032$) than the 4.57 MJ (1092 kcal) difference obtained for the obese women. However, in all cases the discrepancy between TEE and self-reported TEI was too large for the methods to be considered interchangeable.

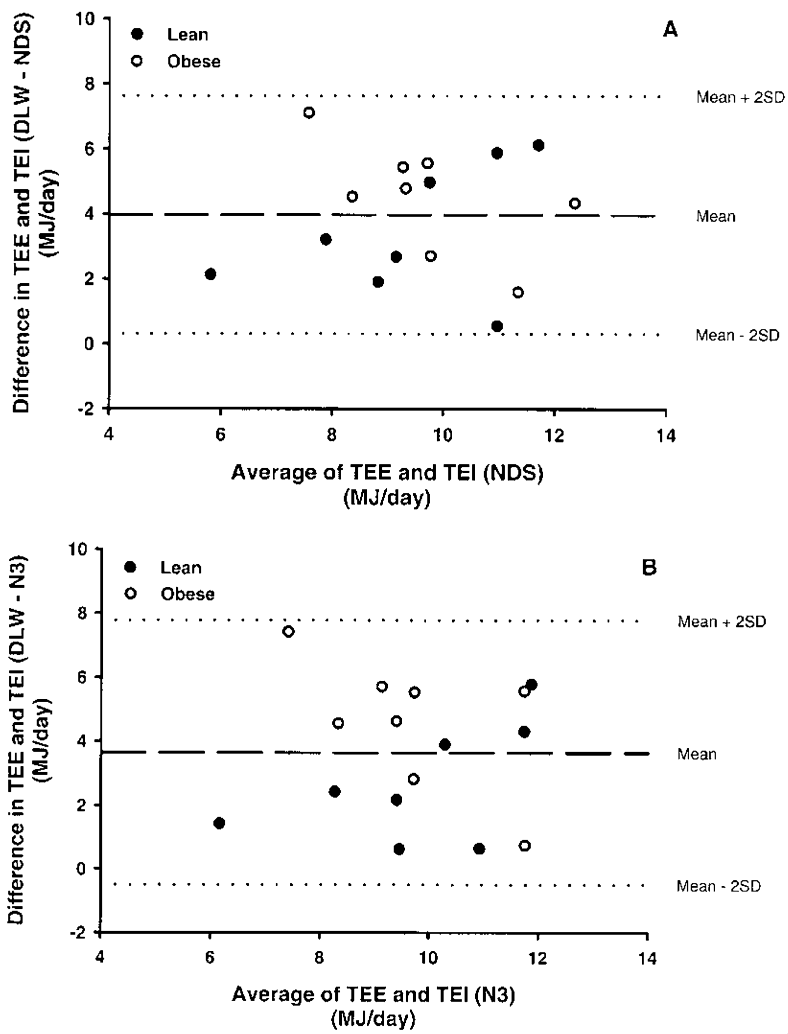

Figure 2 Comparison of the difference between the doubly labeled water (DLW) method and TEI estimated from 8 day diet records for assessing TEE using the Bland and Altman (1986) technique. TEI were calculated by NDS (A) and N3 (B). Dashed lines represent the mean difference; dotted lines represent the limits of agreement (±2 s.d.).

Comparisons of reported macronutrient intakes between groups were significant for carbohydrate and fat intakes expressed either as a percentage of TEI or as grams in both databases, with the lean group reporting higher carbohydrate intake and the obese group reporting higher fat intake (Figure 3). Reported protein intake (g) was significantly higher in the lean group (Figure 3B).

The obese women reported significantly higher intakes of saturated, monounsaturated and polyunsaturated fatty acids as a percentage of TEI regardless of the database used (Figure 4A), as well as higher intakes of saturated and monounsaturated fatty acids expressed in grams of intake in both databases (Figure 4B). With respect to database differences, reported mono- and polyunsaturated fatty acids, expressed as percentage of TEI, were significantly higher in NDS than in N3 in both the lean and obese groups (Figure 4A). This finding was also true for polyunsaturated fatty acids expressed in grams of intake per day for both subject groups (Figure 4B).

Only saturated fatty acid energy intake, expressed as a percentage of total fat energy intake differed between groups in both databases (Figure 5). Other significant differences were all database- rather than subject group-driven. All three fatty acid categories were signficantly higher in NDS than in N3 in both subject groups (Figure 5).

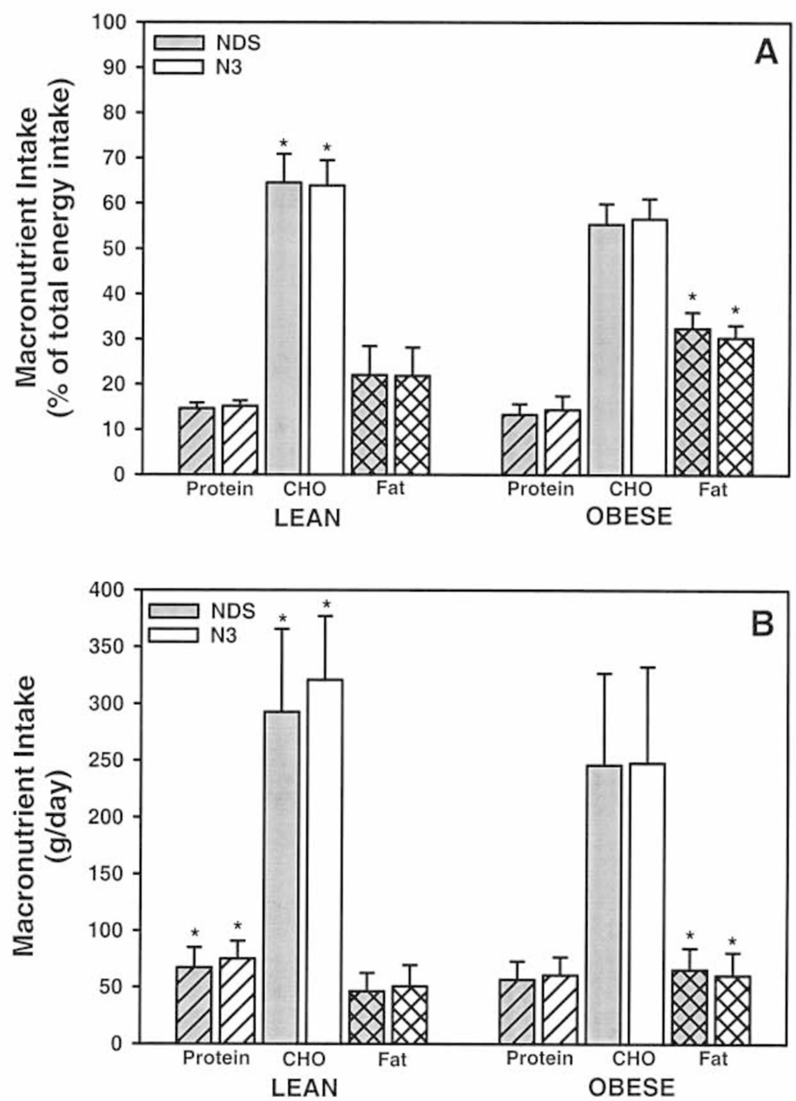

Figure 3 Daily macronutrient intakes ± s.d. of eight lean, athletic and eight obese, sedentary women estimated from 8 day diet records calculated by two nutrient databases (NDS and N3) in megajoules per 100 megajoules of TEI (A) and in grams (B). The * label above a bar indicates that nutrient intake is higher than the corresponding nutrient intake for the other subject group ($P \leq 0.001$ for carbohydrate and fat intakes expressed as percentage of TEI; $P \leq 0.05$ for all nutrient intakes expressed as grams per day).

Discussion

Both the lean and obese subject groups reported TEI that was significantly less than measured TEE, regardless of nutrient database used. Total self-reported energy intake did not differ between the two groups of women in this study; however the obese women reported a significantly higher total fat intake in both nutrient databases. In both subject groups, higher intakes of mono- and polyunsaturated fatty acids were found using the NDS database.

The obese group consistently under-reported their TEI by 38% (NDS) to 39% (N3). This magnitude of under-reporting is similar to the 36% found in previously obese women by Black *et al* (1993). Prentice *et al* (1986) reported underestimates of TEI of 33% by obese women, while non-obese women in the same study reported their energy intake accurately (−2% of TEE). However, weight loss in their obese group may have accounted for approximately half of the discrepancy between energy intake and expenditure, indicating that this group of women were most likely both under-reporting and under-eating compared to usual intake. In two obese groups studied by Lichtman *et al* (1992), the group in which the subjects perceived themselves as diet-resistant under-reported their energy intake by a mean

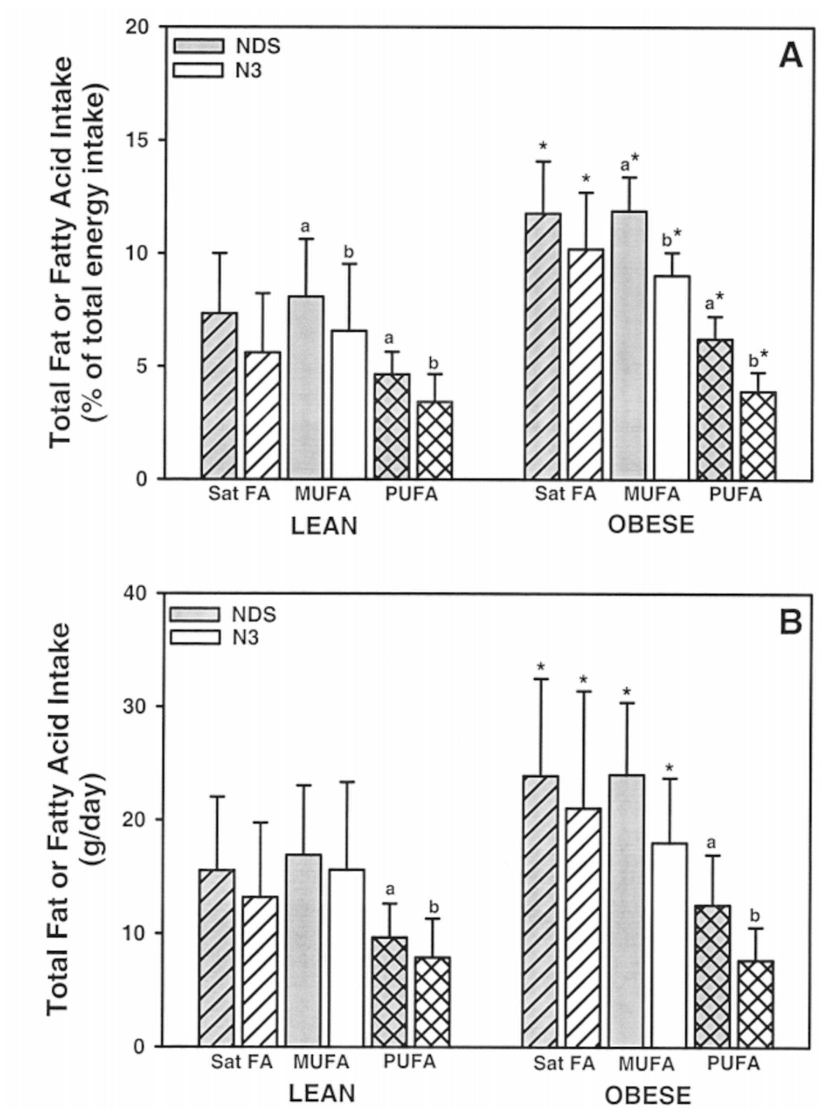

Figure 4 Daily fatty acid (FA) intakes ± s.d. of eight lean, athletic and eight obese, sedentary women estimated from 8 day diet records calculated by two nutrient databases (NDS and N3) in megajoules per 100 megajoules of TEI (A) and in grams (B). The * label above a bar indicates that fatty acid intake is higher for obese women than for lean women ($P \leq 0.001$ for saturated and monounsaturated fatty acid intakes expressed as percentage of TEI; $P \leq 0.01$ for polyunsaturated fatty acid intake expressed as percentage of TEI and for saturated fatty acid intake expressed as grams per day; $P \leq 0.05$ for mono- and polyunsaturated fatty acid intakes expressed as grams per day). Within a subject group, bars with different letter (a or b) labels represent fatty acid intakes that differ between the nutrient databases ($P \leq 0.05$).

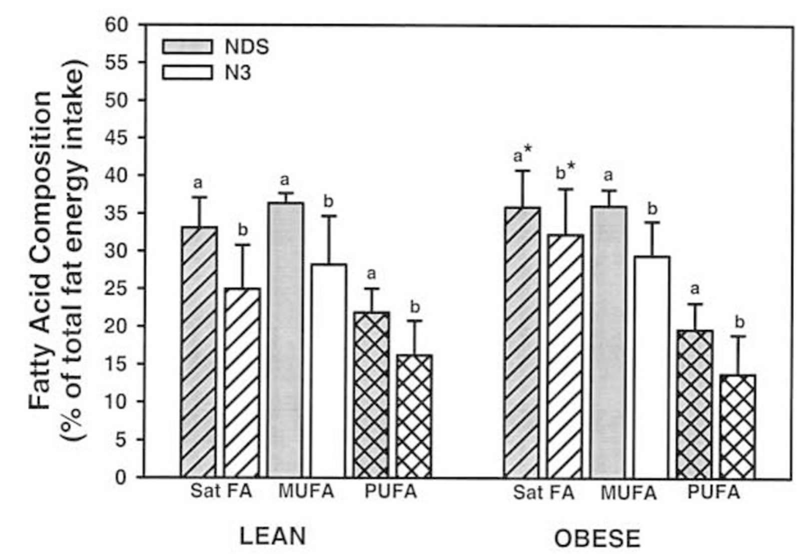

Figure 5 Dietary fatty acid (FA) composition ± s.d. for eight lean, athletic and eight obese, sedentary women estimated from 8 day diet records calculated by two nutrient databases (NDS and N3) in megajoules per 100 megajoules of total fat intake. The * label above a bar indicates that saturated fatty acid intake is higher for obese women than for lean women ($P \leq 0.01$). Within a subject group, bars with different letter (a or b) labels represent fatty acid intakes that differ between the nutrient databases ($P \leq 0.05$ for lean subjects and $P \leq 0.01$ for obese subjects).

of 47% (after adjustment for weight loss during the measurement period); however, the non-diet-resistant group under-reported by 19%. Mean under-reporting by the non-diet-resistant group in the Lichtman *et al* (1992) study was much less than in the present study. However, most studies showed similar (36%, Black *et al* (1993); 33%, Prentice *et al* (1986)) or greater under-reporting (46–59%; Platte *et al* (1995); Buhl *et al* (1995); Lichtman *et al* (1992)) than in the present study. Although it does appear clear that obese and previously obese women routinely under-report their energy intake, the magnitude of under-reporting, and the corresponding contributing factors, are not clear.

In the present study, reported energy intake of the lean, athletic women differed by 9% ($P = 0.005$) between the two nutrient database programs (N3 and NDS). Under-reporting ranged from 23% for the estimates from N3 to 30% for those from NDS. The NDS results compare similarly with the 32% under-reporting found in the Edwards *et al* (1993) study of female endurance runners. As in the Edwards study, there was no change in body weight over the 8 day measurement period in the present study. In contrast, Schulz *et al* (1992) reported an under-estimation of 22% by female endurance runners, which is similar to the 23% under-reporting observed when the diet records were analyzed using N3 in the present study. However, the women in the Schulz study lost weight over the course of the measurement period, and when their reported energy intake was adjusted for body weight change, under-reporting was reduced to just 11%.

The potential significant change in body weight over the course of the measurement period was investigated in both subject groups to explore the issue of under-reporting *vs* under-eating; however, no significant changes in body weight occurred. Therefore, it was assumed that, in both groups, differences between reported energy intake and measured energy expenditure were due to under-reporting of energy intake.

The difficulties in evaluating the accuracy of self-reported energy intake by obese and lean women are due in part to the variability in dietary reporting protocols and nutrient databases used in previous studies to analyze the reported data and, to a much smaller extent, the energy expenditure measurement protocols used in each study. The doubly labeled water technique has been shown to be accurate to 1%, with a coefficient of variation of 2–8%, depending on the isotope dose and the length of the measurement (isotope elimination) period (Schoeller, 1995). When validated against known food intake (provided entirely by the study investigators), two studies have shown an agreement between energy intake and expenditure within 5.5%, with a coefficient of variation of 9% (Bandini *et al*, 1989; Riumallo *et al*, 1989). The method has also been shown to be valid in obese subjects, however with potentially slightly underestimated values in subjects with the highest levels of body weight and fat (Ravussin, *et al*, 1991).

All of the studies cited in this paper used the diet record method of reporting energy intake. However, the studies conducted at the Dunn Nutrition Centre, including the study by Prentice *et al* (1986), used weighed diet record protocols; all of the other studies used estimated diet record protocols. In addition, the food tables and/or nutrient databases used varied considerably. Studies conducted at the Dunn Nutrition Centre and two other studies used nutrient databases representing foods in their respective countries (Paul & Southgate, 1978; Wiles *et al*, 1980; Tan *et al*, 1985; Souci *et al*, 1986). Other studies used the McCance and Widdowson food composition tables, Nutri-Calc Plus (version 1.10), Nutritionist III, and the Minnesota Nutrition Data System (Paul & Southgate, 1978; Dwyer, 1988; N-Squared Computing, 1991; Nutrition Coordinating Center, University of Minnesota, 1992, 1994). Most of the nutrient databases used in these studies are either outdated now, or do not apply to the US population. Therefore, only two studies used nutrient databases similar to the ones compared in this study: an earlier version of NDS was used in the Schulz *et al* (1992) study, and a comparable version of N3 was used in the Edwards *et al* (1993) study.

In a comparison of six microcomputer dietary analysis systems conducted by Nieman *et al* (1992), 3 day diet records with 73 food items were entered into each program and nutrient averages were compared with the United States Department of Agriculture Nutrient Database for Standard Reference (USDA NDB; full version, release 9). The six programs varied widely in the number of foods and nutrients in the database, use of non-USDA data and input of data for missing values, and several operational characteristics. All six programs yielded results within 7% of the USDA NDB for energy, protein, total fat and total carbohydrates. Lee *et al* (1995) compared eight dietary analysis systems using the same methodology, and found all but one of the programs to be within 15% of the USDA NDB for energy, protein, total fat and total carbohydrate. These differences occurred due to variations in the number of foods and nutrients included in the different databases. In the first comparison (Nieman *et al* 1992, NDS version 2.2 (1990) and N3 version 7.0 (1991) were used. Total energy was within 4 and 1% of the USDA NDB (1990) for NDS and N3, respectively. Protein, total fat and carbohydrate all were within 3% of the USDA NDB for both programs. In the second comparison (Lee *et al*, 1995), the Counseling NDS version 2.6 and Nutritionist IV version 3.5 were used. Total energy, protein, total fat and carbohydrate were all within 4% of the USDA NDB for both programs. In comparing total energy between the lean and obese groups in the present study, no significant differences were found between the program versions of NDS and N3. Total energy differed by 9.6% between programs within the lean group, and by 1.6% between programs within the obese group. Similarly, differences under 10% between the programs for protein, total fat and total carbohydrate, whether expressed as percentages of total energy or as grams of intake, were not significant within either subject group.

In the present study, nutrient database differences included significantly higher intakes of mono- and polyunsaturated fatty acids, when expressed as a percentage of TEI, in both subject groups in NDS than in N3. Polyunsaturated fatty acid intake, expressed in grams of intake, was also higher in both subject groups using NDS. When expressed as a percentage of total fat energy intake, NDS yielded significantly higher values for all fatty acids in both subject groups. The higher fatty acid intakes calculated using NDS may be attributable to the higher level of specificity available for data entry. The NDS system prompts the user for food source and processing method, fat used in preparation, and recipe or product ingredients that contribute fat. The N3 program does not include a system of fat-related or other prompts. Mechanisms are provided for adding foods to both databases, either by entering food label information directly into the N3 database, or in the case of NDS, submitting a 'missing food' request which is researched by the program staff. Additionally, NDS contains approximately 16 000 foods in its database; the N3 database includes about 5000 foods. However, for reporting TEI, it does not appear to make a difference which nutrient database is used as long as the same data collection and data entry protocols are followed. If specificity with respect to fat intake is desired, then the NDS database versions used in this study provided greater accuracy than the version of N3 used.

This study confirms results from previous studies that both obese women and lean, athletic women consistently under-report their TEI; however the obese women under-reported to a greater extent than the lean women. The total fat content of the diets reported by the obese group was higher than for the lean group. Additionally, the fatty acid content of the diets reported by the two groups differed by nutrient database used. All fatty acid intakes were higher in NDS than in N3. The lean women reported diets significantly higher in carbohydrate; the obese women reported diets significantly higher in fat. Perhaps the most important findings from this study were the significant difference in total fat intake between groups in both databases, and the higher fatty acid intakes in NDS found for both subject groups. Although the magnitude of under-reporting did not reach significance between databases in this study, the 9.6% difference in calculated TEI between databases for the physically active lean women clearly warrants attention. Because the lean women in this study consumed a relatively low fat diet, the greater accuracy of the NDS database is likely to be responsible for this difference. Based on these results, recommendations with respect to choice of nutrient database for a specific study or clinical application may depend in part on the population involved and the level of dietary fat intake. For example, for use in a weight loss program for obese women, the greater specificity of the NDS program with respect to dietary fat might be advantageous, especially considering the higher total fat intake reported by the obese women compared with the lean women. However, since both groups of women significantly under-reported their TEI, it would appear that the estimated diet record may not be appropriate for use in either group. It is tempting to think about the possibility of using an underestimation correction factor for study populations for which there are independent criterion data (such as doubly labeled water) available in a sub-sample of the population, but our data show a wide range of individual reporting accuracy which reduces our support for this solution. The nutrient database used may not be the issue so much as the dietary data collection method. Comparison of nutrient databases used to analyze data collected using other dietary data collection methods (eg recalls, food frequency questionnaires), and including a 'normal' weight study group may be necessary to address these issues.

In evaluating the implications of this study, certain limitations must be acknowledged. The sample size is small, thereby reducing statistical power. Since there were three dietary coders who entered the data, it is possible that a 'coder effect' may be present; however, the coders were trained and certified using a standard protocol prior to being allowed to enter any data. Additionally, rigorous quality control procedures, during both training and data collection, were instituted and monitored by the study investigators. Another possible limitation relates to the amount of nutrient specific information we were able to gather on foods missing from the program databases.

A potential next step may be to investigate the relationship between body image and under-reporting, because the reporting accuracy of these two groups of women are both different from that of women of normal weight and activity. In one study of female athletes, the women completed a Food Attitude Scale to assess their attitudes toward food in general, and toward their body image, specifically (Edwards *et al*, 1993). In those women, perceived body image was inversely related to body weight, and a greater discrepancy was found between energy intake and energy expenditure in the heavier athletes. Similarly, it has been hypothesized that obese individuals, who may also experience a poor body image or depression, subconsciously under-report a diet that supports the desired low body weight (Mertz *et al*, 1991; Kretsch *et al*, 1999).

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