Published in final edited form as:

J Am Diet Assoc. 2009 May ; 109(5): 899–904. doi:10.1016/j.jada.2009.02.008.

Comparison between Dietary Assessment Methods for Determining Associations between Nutrient Intakes and Bone Mineral Density in Postmenopausal

Vanessa A. Farrell, MS, RD, CSCS [Research Specialist, Sr],

University of Arizona, Department of Nutritional Sciences, P.O. Box 210038, Shantz 118, Tucson, AZ 85721, Tel: 520-626-4920, Fax: 520-621-9446, stanford@u.arizona.edu

Margaret Harris, PhD [Assistant Professor-Health Specialist],

University of Arkansas Division of Agriculture, Cooperative Extension Service-FCS, P.O. Box 391, Little Rock, AR 72203, Tel: 501-671-2295, mharris@uaex.edu

Timothy G. Lohman, PhD [Professor],

University of Arizona, Department of Physiology, P.O. Box 210093, Tucson, Arizona 85721, Tel: 520-621-2004, Fax: lohman@email.arizona.edu

Scott B. Going [Professor],

University of Arizona, Department of Nutritional Sciences, P.O. Box 210038, Tucson, Arizona 85721, Tel: 520-621-4705, E-mail: 520-621-9446, Fax: going@u.arizona.edu

Cynthia Thomson, PhD, RD [Associate Professor],

University of Arizona, Department of Nutritional Sciences, P.O. Box 210038, Tucson, Arizona 85721, Tel: 520-626-1565, Fax: 621-9446, cthomson@u.arizona.edu

Judith L Weber, PhD, RD [Associate Professor], and

University of Arkansas for Medical Sciences, Department of Pediatrics, College of Medicine, 800 Marshall Street, Slot 512-26, Little Rock, AR 72211, Tel: 501-364-3382, Fax: 501-364-1552, weberjudithl@uams.edu

Linda B. Houtkooper, PhD, RD [Associate Director, Programs]

University of Arizona, Cooperative Extension, P.O. Box 210036, Tel: 520-621-5308, Fax: 520-621-1314, houtkoop@cals.arizona.edu

Abstract

It is important to identify the role of nutrition in the treatment and prevention of osteoporosis. The goal of this study is to compare the equivalency of nutrient intakes assessed by diet records (DR) and the Arizona Food Frequency Questionnaire (AFFQ) and the associations of these nutrients with bone mineral density (BMD). This is a secondary analysis of cross-sectional data that was

© 2009 The American Dietetic Association. Published by Elsevier Inc. All rights reserved.

Correspondence to: Vanessa A. Farrell.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

analyzed from 6 cohorts (Fall 1995–Fall 1997) of postmenopausal women (n=244; 55.7±4.6 years) participating in a 12 month, block-randomized, clinical trial. One-year dietary intakes were assessed using eight days of DR and the AFFQ. Participant's BMD was measured at the lumbar spine (L2–L4), femur trochanter, femur neck, Ward's triangle and total body using dual energy X-ray absorptiometry. Linear regression analyses (p 0.05) were adjusted for the effects of exercise, hormone therapy use, body weight at one year, years post menopause and total energy intake. Significant correlations (r=0.30–0.70, p 0.05) between dietary assessment methods were found with all dietary intake variables. Iron and magnesium were consistently and significantly positively associated with BMD at all bone sites regardless of the dietary assessment method. Zinc, dietary calcium, phosphorous, potassium, total calcium, and fiber intakes were positively associated with BMD at three or more of the same bone sites regardless of the dietary assessment method. Protein, alcohol, caffeine, sodium, and vitamin E did not have any similar BMD associations. The DR and AFFQ are acceptable dietary tools used to determine the associations of particular nutrients and BMD sites in healthy postmenopausal women.

Keywords

osteoporosis; bone mineral density; postmenopausal; diet

INTRODUCTION

Determining the relationship between dietary intake and bone mineral density (BMD) is important for identifying nutritional strategies for minimizing age-related bone loss (1). The relationship between dietary intake and BMD has been studied by several investigators in pre and postmenopausal women (1–13) with conflicting results due, in part, to differences in the age of participants and the dietary assessment methods used. Identifying significant associations between dietary intake and BMD requires accurate dietary assessment methods, and these associations may vary by menopausal status.

Diet records (DR) and Food Frequency Questionnaires (FFQ) are common instruments used to assess dietary intakes. Multiple day DR can be burdensome to the participant, are costly to administer and analyze, and may cause changes in eating behavior. They are, however, the most accurate and feasible method to measure food intake in adults (14). The FFQ, on the other hand, have a limited cost, low burden on the participant, and are easier to administer and analyze (15). The validity of the FFQ has been questioned in recent research, particularly related to disease endpoints such as osteoporosis and cancer (16). Accurate, reliable, time efficient, low-cost dietary intake assessment methods are needed to determine associations between dietary intake and disease (17).

This study examined both DR and the Arizona Food Frequency Questionnaire (AFFQ) in postmenopausal women, an age group that is at high risk for osteoporosis. No other study has simultaneously compared these two dietary assessment methods and their estimated dietary nutrient intake associations with BMD in postmenopausal women. It is hypothesized that DR and AFFQ, assessing the same year of dietary intake, provide equivalent estimates

of nutrient intakes when determining the associations of dietary nutrient intakes with BMD in healthy, post-menopausal women.

METHODS

Study design and anthropometry

This is a secondary analysis of cross-sectional data that was collected from the first year of the Bone Estrogen Strength Training (BEST), a blocked- randomized, clinical trial. The BEST study investigated the effect of exercise on BMD in healthy postmenopausal women (18,19). Participants were stratified by use of hormone therapy (HT) and then randomized to exercise or control conditions. They were provided with and requested to consume 800 mg of calcium in supplemental form each day during the trial to minimize variability in calcium intake. Subject inclusion criteria, 12-month measurements of BMD at the 5 sites of interest (lumbar spine L2–L4 ($1.130.16 \text{ g/cm}^3$), femur trochanter ($0.75 \pm 0.11 \text{ g/cm}^3$), femur neck ($0.88 \pm 1.12 \text{ g/cm}^3$), Ward's triangle ($0.76 \pm 1.14 \text{ g/cm}^3$), and total body ($1.11 \pm 0.08 \text{ g/cm}^3$)) along with anthropometric and body composition measurements were described previously (18). The University of Arizona Internal Review Board approved the study and the subjects provided written and informed consent.

Dietary intake

Dietary intake was assessed from diet records collected from eight randomly assigned days throughout the year. Three days of DR were collected and analyzed at baseline, two days at six months and three days at 12 month. Eight days of DR has been shown to be a sufficient number of days to measure most of the nutrients and dietary components of interest (protein, fat, carbohydrate, calcium, iron, phosphorus, potassium, sodium, vitamin C, and fiber) based on the sample size for the group mean intakes (20). Alcohol, caffeine, magnesium, zinc, vitamin E, and vitamin D were included in the analyses because of their possible impact on BMD. Participants completed an intensive 90 minute DR training prior to each DR recording period. Training consisted of participatory portion size and dimension estimation, directions on recording food descriptions, and evaluation of portion size estimation accuracy (21). Examples of individual food and recipe items, including combination dishes, were prepared and portioned out for use in all training sessions to increase the accuracy of portion size estimation. Participants did not receive dietary advice and were instructed to refrain from changing their diets during the study. Each 2–3 week recording period included one weekend day and 1–2 nonconsecutive weekdays. Seasonal eating, consecutive day food leftovers, and weekend eating were taken into account by assessing intake at three time points throughout the year and recording 1 day per week over a 2–3 week period at each collection time point.

Completeness and accuracy of the DR were fostered by personal interviews given by trained technicians. Recipes, labels, and restaurant information were collected to enhance food item entry. The DR were analyzed for dietary intakes using the Minnesota Nutrient Data System (NDS) 93 (versions 2.8–2.92, 1995–1999, Nutrition Coordinating Center, Minneapolis, MN). Foods not in the database were substituted with a similar food item that had 10% disagreement for energy, carbohydrate, protein, fat and sodium of the original food. A

master control sheet for each cohort, by test period, tracked each DR through the data entry process. This process included: initial entry of the data, checking the NDS analysis with the original DR, correcting any errors to the data, checking the corrections, final corrections, and the filing of completed DR.

Quality assurance of the DR was completed after each diet recording session for each cohort. Individual DR dietary intakes were calculated for energy, cholesterol and the nutrients of interest (protein, fat, carbohydrate, alcohol, caffeine, calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, vitamin E, vitamin D, vitamin C, and fiber). Individual dietary intakes were compared to the group dietary intakes ± 3 standard deviations (SD). If an individual dietary intake was above or below 3 SD of the group dietary intake, the original record was rechecked with the original NDS analysis. Corrections were made as necessary and all dietary intakes were again compared to the group dietary intakes. If no corrections were needed, documentation of the inflated or deflated dietary intake was made and the DR would be considered completed.

Dietary intake was assessed at the end of the first year using the previously validated AFFQ (22). Participants were asked to complete the questionnaire in relation to their overall pattern of food intake during the previous 12 months. The AFFQ is based on the Block Model and is a 153 item, semi quantitative, scannable questionnaire on the frequency of food consumption, using age and gender specific estimates of portions. The AFFQ was modified to include southwestern foods (23). They were distributed with verbal and written instructions at the one-year DR training, completed at home, and collected during the 12-month anthropometry and BMD testing. Completeness and accuracy of the AFFQ were fostered by personal or phone interviews. The AFFQ were checked a second time for completeness before they were sent to the Arizona Diet and Behavioral Assessment Center for analysis. Questionnaires missing more than 10 items were excluded from the analysis. Nutrient analysis for the AFFQ was completed using a proprietary software program called Metabolize (version 2.7, 2003, Arizona Diet and Behavioral Assessment Center, Tucson, AZ), which was updated to include version 17 of the USDA food composition database in 2005.

The subjects were instructed to take two tablets of calcium citrate (200 mg elemental calcium/tablet) (Citracal®, Mission Pharmacal, San Antonio, TX), twice a day (800 mg/day), without food, with a minimum of four hours between doses. Calcium supplement compliance was monitored through tablet counts. Participants were considered compliant if they consumed 80% or more of their expected calcium tablet intake.

STATISTICAL METHODS

All data analyses were performed using the Statistical Package for the Social Sciences (version 11.5, 2002, SPSS Inc., Chicago, IL). Year-one average nutrient intake values were calculated from estimates of dietary intake alone except for total calcium. Average total calcium intake was calculated as the sum of the mean calcium intakes obtained from the DR or AFFQ plus mean intakes from the calcium supplements calculated through tablet count compliance.

Dietary intake distributions were examined and log-transformed, when appropriate, to meet the assumption of the statistical tests. Paired t-tests were used to detect statistically significant differences in dietary intakes between the two dietary intake assessment methods. Pearson's correlations between energy-adjusted mean nutrient intake estimates from DR and AFFQ were computed using the residual method (24). The average energy intake for each dietary assessment method was used to make the energy adjustments. Standardized residuals were used in calculations to allow comparability across the two diet assessment methods. Linear regression was used to test the associations between nutrients of interest and BMD, adjusting for the effects of exercise, HRT use, body weight at 1 year, years post menopause and total energy intake. Significance was evaluated at the $p = 0.05$ level. With a sample size of 244, correlations as low as $r=0.15$ could be detected at a power of 99% and regression models were able to detect an adjusted R-squared of 0.10 at a power of 98%.

RESULTS AND DISCUSSION

Three hundred twenty-one women were enrolled in the primary study. The current investigation excluded participants who had less than five days of DR ($n=28$), and missing or incomplete AFFQ ($n=20$). Five participants were excluded for having AFFQ mean energy intake twice that of the DR. Twenty-four were excluded because they did not have valid dual-energy X-ray absorptiometry measurements. Two hundred and forty-four women were included in these analyses.

Mean age of the subjects was 55.7 ± 4.6 years. Participants were on average nearly six years past menopause (5.7 ± 3.0 years) and had a 1-year mean body mass index that classified them as being slightly overweight (68 ± 11.5 kg, 163 ± 6.6 cm, 25.6 ± 3.9 kg/m²). No significant change in weight or body mass index over the year indicated the women maintained their weight as instructed.

Diet records and AFFQ dietary intakes, % difference, and Pearson's correlations at one year are reported in Table 1. Nutrients are arranged by highest Pearson's correlation to lowest. Paired sample t-test between the dietary intakes from eight random days of DR and the AFFQ at 12 months showed no significant differences between mean values for any nutrients. This suggests both methods capture similar dietary intakes in this sample.

Pearson's correlations from the two dietary assessment methods ($r=0.33-0.71$, $p<0.05$) are also reported in Table 1. Estimates of fat, carbohydrate, alcohol, caffeine, potassium, vitamin C, and fiber from the two dietary assessment methods had the highest correlations ($r = 0.6$). The lowest correlations ($r = 0.41$) were for energy, protein, sodium, and total calcium.

Compared with results from other studies that compared nutrient intakes with DR and FFQ, this study showed stronger positive correlations for carbohydrate, fat, magnesium (25), vitamin D (26) vitamin E (26, 27, 28), and zinc (25). In contrast, results from this study showed weaker positive correlations with protein (26, 27), calcium, magnesium (26), phosphorous (26), and vitamin D (29). There were comparable positive associations with alcohol (25, 28), fiber, iron (26, 27), phosphorus (25), and vitamin C (28, 29). Differences in findings can be attributed to dietary assessment methods, sample sizes, gender, age,

ethnicity, nutrients assessed, nutrient databases, methodology, and quality assurance of the collection of dietary information.

Multiple linear regression analyses were conducted to test the robustness of the correlations between dietary intakes, using the two dietary assessment methods, and BMD collected at 12 months. Linear regressions were adjusted for the effects of exercise, HT, body weight at one year, years post menopause, and total energy intake. Table 2 summarizes the significant associations of dietary intakes from DR and AFFQ at five BMD sites. Significant associations ($p < 0.05$) are reported using the standardized β coefficient.

Iron and magnesium were significantly associated with all BMD sites regardless of the dietary assessment method used. Iron, magnesium, zinc, fiber, calcium, total calcium, phosphorous, and potassium, were each associated with three or more of the same BMD sites. Protein and caffeine only had significant association with BMD using the DR. Alcohol, vitamin E, and sodium were not associated with any BMD site using either dietary assessment method. Except for dietary fat and caffeine, all dietary intakes had positive associations with the BMD sites regardless of the dietary assessment method used. Better agreement with similar significant BMD associations was found with the micronutrients than with the macronutrients. The magnitude of associations among the BMD sites and the dietary intakes from both diet assessment methods tended to be similar.

A study by Ilich (2003), showed dietary intake associations with different BMD sites using a 3 day DR in 136 healthy Caucasian, postmenopausal women. Using stepwise regression, Ilich *et. al.* found dietary intakes associated with three or more skeletal BMD sites for calcium (total body, Wards, hand), magnesium (neck, Ward's, trochanter), protein (total body, Ward's, hand), vitamin C (Ward's, trochanter, femur, shaft) and zinc (trochanter, femur, shaft). In comparison, the current study showed, using DR and AFFQ, magnesium, calcium, and zinc having three or more of the same significant associations with the same BMD sites.

Using a FFQ, New (1997), found that higher intakes of potassium (spine, neck, trochanter, Ward's), magnesium (spine), vitamin C (spine), alcohol (spine), and fiber (spine) were associated with higher bone mass in 994 healthy premenopausal women. Compared to New (1997), this study found potassium (neck, Ward's, total body), magnesium (neck, Ward's, trochanter, spine, total body), and fiber (neck, Ward's, trochanter, total body) had nutrient associations with three or more BMD sites, using both DR and AFFQ. Even though the results were similar between the two studies, hormonal status may have an effect on nutrient associations with BMD and; therefore, pre and postmenopausal women may have different dietary intake associations with BMD (10).

The participants were asked to keep their DR with them throughout the day and to measure their food and record it in their DR as they ate. It is unknown whether many participants actually recorded their food choices as they ate or recorded what they ate at the end of the day or before the diet record interview, thus turning the DR into a dietary recall. The AFFQ is limited in food choices and vague in serving size options, which make the portion size reference different for each individual thus, decreasing the accuracy of the diet assessment

method. Actual nutrient estimates used within and between dietary assessment methods used different versions of the USDA databases. This can lead to incomplete estimated nutrient intake information and missing nutrient values. Although these dietary assessment methods have their limitations, databases are updated and, FFQ continue to be revised to gather more accurate information.

CONCLUSION

This study suggests that both DR and AFFQ, assessing the same year of dietary intake, provided equivalent estimates of particular nutrient intakes when determining the associations of dietary nutrient intakes with BMD in healthy, postmenopausal women. This analysis showed iron and magnesium were consistently and significantly associated with BMD at all bone sites and zinc, fiber, phosphorous, potassium, calcium, and total calcium were significantly associated with BMD at three or more of the same bone sites regardless of the dietary assessment methods. Protein, alcohol, caffeine, sodium, and vitamin E, assessed by DR and AFFQ, did not have any similar BMD associations in this analyses; therefore, caution should be used if either tool is used to investigate these nutrient associations with BMD. This type of research can be used to examine the associations of nutrients in bone health, which can lead to valuable information in the prevention and treatment of osteoporosis.

Acknowledgments

Financial Support: Supported by National Institutes of Health grant AR39559 and Mission Pharmacal®.

REFERENCES

1. Ilich J, Brownbill R, Tamborini L. Bone and nutrition in elderly women: protein, energy, and calcium as main determinants of bone mineral density. *Eur J Clin Nutr.* 2003; 57:554–565. [PubMed: 12700617]
2. New S, Bolton-Smith C, Grubb D, Reid D. Nutritional influences on bone mineral density: a cross-sectional study in premenopausal women. *Am J Clin Nutr.* 1997; 65:1831–1839. [PubMed: 9174480]
3. Teegarden D, Lyle R, McCabe G, McCabe L, Proulx W, Michon K, Knight A, Johnston C, Weaver C. Dietary calcium, protein, and phosphorous are related to bone mineral density and content in young women. *Am J Clin Nutr.* 1998; 68:749–754. [PubMed: 9734757]
4. Tucker K, Hannan M, Chen Honglei, Cupples L, Wilson P, Keil D. Potassium, magnesium, and fruit and vegetable intakes are associated with greater bone mineral density in elderly men and women. *Am J Clin Nutr.* 1999; 69:727–736. [PubMed: 10197575]
5. Whiting S, Boyle J, Thompson A, Mirwald R, Faulkner R. Dietary protein, phosphorous and potassium are beneficial to bone mineral density in adult men consuming adequate dietary calcium. *J Am Coll Nutr.* 2002; 21:402–409. [PubMed: 12356781]
6. New S, Robins S, Campbell M, Martin J, Garton M, Bolton-Smith C, Grubb D, Lee S, Reid D. Dietary influences on bone mass and bone metabolism: further evidence of a positive link between fruit and vegetable consumption and bone health? *Am J Clin Nutr.* 2000; 71:142–151. [PubMed: 10617959]
7. Sasaki S, Yanagibori R. Associations between current nutrient intakes and bone mineral density at calcaneus in pre- and postmenopausal Japanese women. *J Nutr Sci Vitaminol.* 2001; 47:289–294. [PubMed: 11767209]

8. Harris M, Houtkooper L, Stanford V, Parkhill C, Weber J, Flint-Wagner H, Weiss L, Going S, Lohman T. Iron is associated with bone mineral density in healthy postmenopausal women. *J Nutr*. 2003; 133:3598–3602. [PubMed: 14608080]
9. Macdonald H, New S, Golden M, Campbell M, Reid D. Nutritional associations with bone loss during the menopausal transition: evidence of a beneficial effect of calcium, alcohol, and fruit and vegetable nutrients and of a detrimental effect of fatty acids. *Am J Clin Nutr*. 2004; 79:155–165. [PubMed: 14684412]
10. Maurer J, Harris M, Stanford V, Lohman T, Cussler E, Going S, Houtkooper L. Dietary iron positively influences bone mineral density in postmenopausal women on hormone replacement therapy. *J Nutr*. 2005; 135:863–869. [PubMed: 15795448]
11. Okubo H, Sasaki S, Horiguchi H, Oguma E, Miyamoto K, Hosoi Y, Kim M, Kayama F. Dietary patterns associated with bone mineral density in premenopausal Japanese farmwomen. *Am J Clin Nutr*. 2006; 83:1185–1192. [PubMed: 16685064]
12. Ožeraitien V, B t nait V. The evaluation of bone mineral density based on nutritional status, age, and anthropometric parameters in elderly women. *Medicina (Kaunas)*. 2006; 14(10):836–841. [PubMed: 17090984]
13. Salminen H, Sääf M, Johansson S, Ringertz H, Strender L. Nutritional status, as determined by the mini-nutritional assessment, and osteoporosis: a cross-sectional study of an elderly female population. *Eur J Clin Nutr*. 2006; 60:486–493. [PubMed: 16391579]
14. McKeown N, Day N, Welch A, Runnswick S, Luben R, Mulligan A, McTaggart, Bingham S. Use of biological markers to validate self-reported dietary intake in a random sample of the European prospective investigation into cancer United Kingdom Norfolk cohort. *Am J Clin Nutr*. 2001; 74:188–196. [PubMed: 11470719]
15. Thomson C, Giuliano A, Rock C, Ritenbaugh C, Flatt S, Faerber S, Newman V, Caan B, Graver E, Hartz V, Witacre R, Parker F, Pierce J, Marshall J. Measuring dietary change in a diet intervention trial: comparing food frequency questionnaire and dietary recalls. *Am J Epidemiol*. 2003; 157:754–762. [PubMed: 12697580]
16. Bingham S, Luben R, Welch A, Wareham N, Khaw K, Day N. Are imprecise methods obscuring a relation between fat and breast cancer? *Lancet*. 2003; 362(9379):212–214. [PubMed: 12885485]
17. Hartman, A.; Block, G. Macronutrients, investigating their role in cancer. In: Moon, TE.; Micozzi, MS., editors. *Dietary assessment methods for macronutrients*. New York: Marcel Dekker; 1992. p. 87-124.
18. Going S, Lohman T, Houtkooper L, Metcalfe L, Flint-Wagner H, Blew R, Stanford V, Cussler E, Martin J, Teixeira P, Harris M, Milliken L, Figueroa-Galvez A, Weber J. Effects of exercise on bone mineral density in calcium-replete postmenopausal women with and without hormone replacement therapy. *Osteoporos Int*. 2003; 14:637–644. [PubMed: 12844212]
19. Metcalfe L, Lohman T, Going S, Houtkooper L, Ferriera D, Flint-Wagner H, Guido T, Martin J, Wright J, Cussler E. Postmenopausal women and exercise for prevention of osteoporosis: The Bone, Estrogen, and Strength Training (BEST) Study. *ACSM's Health and Fitness Journal*®. 2001; 5:6–14.
20. Basiotis P, Welsh S, Cronin F, Kelsay J, Mertz W. Number of days of food intake records required to estimate individual and group nutrient intakes with defined confidence. *J Nutr*. 1987; 117:1638–1641. [PubMed: 3655942]
21. Weber J, Tinsley A, Houtkooper L, Lohman T. Multimethod training increases portion-size estimation accuracy. *J Am Diet Assoc*. 1997; 97:176–179. [PubMed: 9020247]
22. Martínez M, Marshall J, Graver E, Whitacre R, Woolf K, Ritenbaugh C, Alberts D. Reliability and validity of a self-administered food frequency questionnaire in a chemoprevention trial of adenoma recurrence. *Cancer Epidemiol Biomarkers Prev*. 1999; 8:941–946. [PubMed: 10548325]
23. Taren D, de Tobar M, Ritenbaugh C, Graver E, Whitacre R, Aickin M. Evaluation of the southwest food frequency questionnaire. *Ecology of Food and Nutrition*. 1999; 38:515–547.
24. Willett, W. *Nutritional epidemiology*. 2nd edition. New York: Oxford University Press; 1998.
25. Ambrosini G, Mackerras D, de Klerk N, Musk A. Comparison of an Australian food-frequency questionnaire with diet records: implications for nutrition surveillance. *Public Health Nutr*. 2003; 6(4):415–422. [PubMed: 12795831]

26. Tokudome S, Imaeda N, Tokudome Y, Fujiwara N, Nagaya T, Sato J, Kuriki K, Ikeda M, Maki S. Relative validity of a semi-quantitative food frequency questionnaire versus 28 day weighed diet records in Japanese female dietitians. *Eur J Clin Nutr.* 2001; 55:735–742. [PubMed: 11528486]
27. Rimm E, Giovannucci E, Stampfer M, Colditz G, Litin L, Willett W. Reproducibility and validity of an expanded self administered semi-quantitative food frequency questionnaire among male health professionals. *Am J Epidemiol.* 1992; 135:1114–1126. [PubMed: 1632423]
28. Roddam A, Spencer E, Banks E, Beral V, Reeves G, Appleby P, Barnes I, Whiteman D, Key T. Reproducibility of a short semi-quantitative food group questionnaire and its performance in estimating nutrient intake compared with a 7-day diet diary in the million women study. *Public Health Nutr.* 2005; 8(2):201–213. [PubMed: 15877913]
29. Jain M, Howe G, Rohan T. Dietary assessment in epidemiology: comparison of a food frequency and a diet history questionnaire with a 7-day food record. *Am J Epidemiol.* 1996; 143:953–960. [PubMed: 8610709]

Table 1

Diet Record (DR) and Arizona Food Frequency Questionnaire (AFFQ) nutrient intake estimates, Percent Differences, and Pearson's Correlations in postmenopausal women (n=244).

Nutrient	Diet Records Mean $\pm$ SD ^a	AFFQ Mean $\pm$ SD	% Difference ^b	Pearson's Correlation ^c
Alcohol (g)	5 $\pm$ 8	3 $\pm$ 5	40	0.71
Caffeine (mg)	189 $\pm$ 163	224 $\pm$ 210	-19	0.69
Fat (g)	58 $\pm$ 20	50 $\pm$ 23	14	0.63
Carbohydrate (g)	228 $\pm$ 53	238 $\pm$ 102	-4	0.62
Fiber (g)	20 $\pm$ 6	21 $\pm$ 11	-5	0.62
Potassium (mg)	2823 $\pm$ 695	3228 $\pm$ 1290	-14	0.60
Vitamin C (mg)	133 $\pm$ 65	156 $\pm$ 102	-17	0.60
Vitamin E (mg)	9 $\pm$ 4	8 $\pm$ 5	11	0.59
Magnesium (mg)	302 $\pm$ 74	324 $\pm$ 126	-7	0.59
Calcium (mg)	776 $\pm$ 261	942 $\pm$ 468	-21	0.56
Iron (mg)	15 $\pm$ 5	14 $\pm$ 6	7	0.55
Zinc (mg)	10 $\pm$ 3	10 $\pm$ 5	0	0.54
Phosphorus (mg)	1136 $\pm$ 277	1247 $\pm$ 533	-10	0.48
Vitamin D (mcg)	5 $\pm$ 3	3 $\pm$ 3	40	0.47
Protein (g)	70 $\pm$ 18	64 $\pm$ 26	9	0.41
Sodium (mg)	2698 $\pm$ 810	2693 $\pm$ 1076	0	0.33
Energy (kcal)	1707 $\pm$ 365	1631 $\pm$ 637	5	0.31 ^d
Total Calcium ^e (mg)	1483 $\pm$ 316	1598 $\pm$ 539	-8	0.31

^aSD = standard deviation

^b% difference estimated mean nutrient intakes from DR-AFFQ/DR. Percent differences are not statistically different between methods for any nutrient, p > 0.05.

^cPearson's correlations between DR and AFFQ estimated mean nutrient intakes are log transformed and energy-adjusted (standardized residual method) p > 0.05.

^dPearson's correlation between DR and AFFQ for Energy. Energy is Log transformed p > 0.05.

^eDietary calcium plus calcium supplement (mg).

Table 2

Significant associations between bone mineral density and nutrients intakes estimated by 8 days of diet records and the Arizona Food Frequency Questionnaire (AFFQ) at one year (n=244).

Nutrient	# of Bone Site Agreements ^b	Standardized Coefficient β^a									
		DIET RECORDS					AFFQ				
		Neck ^c	Wards ^c	Troc ^c	Spine ^c	Total ^c	Neck ^c	Wards ^c	Troc ^c	Spine ^c	Total ^c
Iron (mg)	5	0.289	0.380	0.252	0.214	0.240	0.334	0.426	0.232	0.265	0.358
Magnesium (mg)	5	0.310	0.315	0.140	0.175	0.257	0.564	0.514	0.276	0.291	0.384
Zinc (mg)	4	0.267	0.307	0.227	0.146	0.204	0.335	0.374	0.196	--	0.219
Fiber (g)	4	0.257	0.267	0.122	--	0.171	0.294	0.272	0.192	0.225	0.230
Phosphorus (mg)	3	0.393	0.413	0.258	0.196	0.327	0.413	0.433	--	--	0.291
Potassium (mg)	3	0.238	0.231	--	--	0.184	0.442	0.388	--	--	0.246
Calcium (mg)	3	0.204	0.222	--	--	0.165	0.330	0.324	0.172	--	0.249
Total Calcium ^d (mg)	3	0.209	0.154	--	--	0.130	0.290	0.279	0.177	--	0.147
Fat (g)	2	-0.188	-0.259	--	-0.299	-0.293	--	--	--	-0.241	-0.293
Vitamin D (IU)	2	0.151	0.175	--	--	--	0.155	0.158	--	--	--
Vitamin C (mg)	1	0.151	0.155	--	0.155	0.177	--	--	--	0.170	--
Carbohydrate (g)	1	--	--	--	0.227	--	--	--	--	0.388	0.376
Protein (g)	0	0.305	0.312	0.236	--	0.245	--	--	--	--	--
Caffeine (mg)	0	--	--	--	--	-0.118	--	--	--	--	--
Alcohol (g)	0	--	--	--	--	--	--	--	--	--	--
Sodium (mg)	0	--	--	--	--	--	--	--	--	--	--
Vitamin E (mg)	0	--	--	--	--	--	--	--	--	--	--

^a p 0.05

^b The number of the same nutrient and bone site agreements between 8 days of diet records and the AFFQ, both representing one year.

^c Participant's bone mineral density was measured at the femur neck (Neck), Ward's triangle (Wards), femur trochanter (Troc), lumbar spine L2-L4 (Spine), and total body (Total).

^d Dietary calcium plus supplemental calcium (mg)