Prospective study of nut consumption, long-term weight change, and obesity risk in women1–4

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ABSTRACT

Background: Data concerning the long-term association between nut consumption and weight change in a free-living population are sparse.

Objective: The objective was to determine the relation between nut consumption and long-term weight change.

Design: The participants were 51,188 women in the Nurses’ Health Study II aged 20–45 y, who had no cardiovascular disease, diabetes, or cancer. We prospectively evaluated the dietary intake of nuts and subsequent weight changes from 1991 to 1999.

Results: Women who reported eating nuts ≥2 times/wk had a slightly less mean (± SE) weight gain (5.04 ± 0.12 kg) than did women who rarely ate nuts (5.55 ± 0.04 kg) (P for trend < 0.001). For the same comparison, when total nut consumption was subdivided into peanuts and tree nuts, the results were similar (ie, less weight gain in women eating either peanuts or tree nuts ≥2 times/wk). The results were similar in normal-weight, overweight, and obese participants. In multivariate analyses in which lifestyle and other dietary factors were controlled for, we found that greater nut consumption (≥2 times/wk compared with never/almost never) was associated with a slightly lower risk of obesity (hazard ratio: 0.77; 95% CI: 0.57, 1.02; P for trend = 0.003).

Conclusions: Higher nut consumption was not associated with greater body weight gain during 8 y of follow-up in healthy middle-aged women. Instead, it was associated with a slightly lower risk of weight gain and obesity. The results of this study suggest that incorporating nuts into diets does not lead to greater weight gain and may help weight control. Am J Clin Nutr 2009;89:1–7.

INTRODUCTION

Considerable evidence from epidemiologic studies and clinical trials has shown that nut consumption has beneficial effects on cardiovascular health (1–3), type 2 diabetes (4), and inflammation (5). In fact, nuts, including peanuts, were the first food group to be shown to have a heart health claim by the US Food and Drug Administration (6).

Peanuts are technically a legume; however, they are typically included in the nut group because they are used in a comparable manner and have a similar nutrient profile. Moreover, according to data from the US Department of Agriculture, peanuts (both whole peanuts and peanut butter) account for ~68% of total nut consumption, which makes them the most widely consumed nut in the United States (7). The European Investigation into Cancer and Nutrition (EPIC) Study, which includes more than half a million participants from 10 Western European countries, found a trend toward higher nut consumption in southern compared with northern countries. Overall, participants consumed more tree nuts than peanuts, with the most popular choice being walnuts (41% of total tree nut consumption) (8).

Each type of nut varies somewhat in its particular nutritional value, but, in general, nuts are energy dense and provide between 23.4 and 26.8 kJ/g (9). The total fat content ranges from 45% to 75% of weight, but this fat is mostly unsaturated (10). Nuts also contain protein, dietary fiber, and an array of vitamins and minerals, including folic acid, niacin, vitamins E and B-6, calcium, magnesium, copper, zinc, selenium, phosphorus, arginine, potassium, and low sodium (unless added) (11). Nuts also contain bioactive substances, such as antioxidants and phytosterols (11, 12). Consequently, nuts offer a nutritious contribution to the habitual diet (13).

Rapidly increasing obesity prevalence rates necessitate weight management to be a priority for the prevention and treatment of chronic diseases, especially cardiovascular disease and type 2 diabetes. At the same time, nuts have been proposed as a protective food group for these illnesses (14, 15). In this context, because nuts are a fat-rich and energy-dense food, the potential detrimental effect of increasing body weight has generated some concern and criticism; therefore, compromising initiatives have

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aimed to promote nut consumption in place of less healthful food choices.

Nevertheless, data are still lacking and, in most cases, are based on small numbers of subjects in well-controlled trials not primarily designed to evaluate body weight changes. In addition, the duration of the nut exposure period in intervention trials has been relatively short; thus, extrapolations have to be made to generalize the effects of nut consumption on energy balance over a longer period of time among a free-living population. Therefore, the objective of this study was to assess the long-term relation between nut or peanut butter consumption and weight change in a large prospective cohort of young and middle-aged women.

SUBJECTS AND METHODS

Study population

The Nurses’ Health Study II is a prospective cohort study of 116,671 female US nurses aged 24–44 y at study initiation in 1989. This cohort was followed by using biennial mailed questionnaires in 1991, left analysis, women were excluded if they did not complete dietary records, evaluated previously in the original Nurses’ Health Study (16). Previously reported validity and reliability of the FFQs are comparable with those used in the Nurses’ Health Study II. The computation of the intake of nutrients such as fats and fiber are described elsewhere (17, 18).

Assessment of nondietary exposures

Information about age, cigarette smoking status, oral contraceptive use (none or current), hormone replacement therapy (never, current, or past), and pregnancies was collected. Physical activity was assessed in the 1991 and 1997 questionnaires; participants were asked about the average times per week they engaged in various forms of exercise, which was multiplied by the metabolic equivalent task (MET) value specific to each activity. The MET-hours for all activities were combined to obtain a total weekly MET-hours score, which was correlated with energy expenditure measured in diaries or by recalls: \( r = 0.62 \) and \( r = 0.79 \), respectively (19).

Assessment of the outcome

Participants provided information on their body weight and height for each of the biennial questionnaires. Self-reported weight was highly correlated with 2 technician measurements (\( r = 0.97 \)) in the original Nurses’ Health Study (20). Body mass index (BMI) was calculated as weight (kg) divided by height squared (m). Weight change was determined by subtracting the participant’s weight at baseline from weight at the follow-up assessment. Obesity was defined as a BMI \( \geq 30 \), consistent with World Health Organization’s criterion.

Statistical analysis

To assess the relation between nut or peanut butter consumption and body weight change during follow-up, we divided women into 4 categories according to their reported baseline frequency of peanut butter, peanuts, and other nut consumption: never/almost never, 1–3 times/mo, 1 time/wk, and \( \geq 2 \) times/wk. Given the frequency distribution of total nut consumption for this cohort (ie, only 7% of women reported eating nuts \( \geq 2 \) times/wk with less than half of them consuming \( \geq 1 \) serving/d), the highest category of consumption includes women consuming nuts ranging from 2 to 4 servings/wk to 4–5 servings/d. We also performed a secondary analysis with the highest category (\( \geq 2 \) times/wk) divided into the category 2–4 servings/wk and \( \geq 5 \) servings/wk; however, the numbers became small because \(<1\%\) of the women in this cohort reported consuming nuts \( \geq 5 \) times/wk. The percentage of women for each FFQ category of response for nut consumption was as follows: never/almost never, 58.8%; 1–3 times/mo, 19.5%; 1 time/wk, 14.8%; 2–4 times/wk, 6.0%; 5–6 times/wk, 0.5%; 1 time/d, 0.3%; 2–3 times/d, 0.09%; 4–5 times/d, 0.006%; and \( \geq 6 \) times/d, 0%.

Least-squares means for change in body weight in kilograms were calculated from 1991 to 1999 across categories of baseline nut consumption. The multivariate models were adjusted for age, BMI, alcohol intake (0, 0.1–4.9, 5.0–9.9, or \( \geq 10 \) g/d), physical activity (quintiles of MET score), smoking (never, past, or current), postmenopausal hormone use (no, current or past, or missing), oral contraceptive use (no, current, or missing) and potential dietary confounders such as glycemic load and intakes of total fiber, trans fat, alcohol, fruit, vegetables, red meat,
processed meat, refined grain, whole grain, snacks, sugar-
sweetened beverages, diet beverages, low-fat dairy products, and
high-fat dairy products (continuous) at baseline. We also ad-
justed for changes in covariates and changes in soft drink con-
sumption during follow-up, which had previously been reported
to be associated with weight gain in this cohort (21) and other
cohorts (22). To take into account the effects of overall dietary
patterns, we conducted additional analyses to adjust for changes
in prudent and Western dietary patterns based on the results
from principal component analysis of the 39 predefined food
groups by using the PROC FACTOR procedure in SAS (version
9; SAS Institute, Cary, NC) (23, 24).

Tests for linear trend across increasing categories of peanut
butter, peanut, and other nut consumption were performed by
assigning the median value of nut consumption to the respective
categories of exposure and entering this continuous variable into
models. To assess potential effect modification by baseline BMI,
we analyzed associations between total nut consumption and
weight gain after stratifying by baseline BMI. Categories were
defined on the basis of World Health Organization’s cutoffs (14):
BMI < 25 (normal weight), BMI of 25 to 29.99 (overweight),
and BMI ≥ 30 (obese).

After excluding obese participants at baseline, we assessed the
hazard ratio (HR) of incident obesity (BMI ≥ 30) for each
category of consumption compared with the lowest category
using Cox proportional hazards analysis stratified by 5-y age
categories and 2-y intervals. Duration of follow-up was calcu-
lated as the interval between the return of the 1991 questionnaire
and incidence of obesity, death, or 1 June 2001. To reduce within-
participant variation and to best represent long-term diet, we used
cumulative nut consumption during follow-up. However, we
stopped updating consumption data (ie, we used the 1991, but not
the 1995, consumption information) if participants reported (ie,
in 1993 or 1995 questionnaires) a diagnosis of cardiovascular
disease, cancer (except nonmelanoma skin cancer), diabetes, or
gestational diabetes because changes in diet after development of
these diagnoses may confound the association between nut
consumption and obesity. Statistical significance was defined at
an α level of 0.05, including the assessment of significant in-
teraction terms. SAS software version 9.1 was used for all
analyses (SAS Institute).

RESULTS

The mean (±SD) 8-y weight change was a weight gain from
baseline of 5 ± 7 kg among this cohort of 51,188 women
(mean ± SD age: 37 ± 5 y). In 1991, ~15% of women reported
eating 1 serving/wk [equivalent to 1 oz, or 28.35 g, nuts
(peanuts + tree nuts)], and 7% reported eating ≥2 servings/wk of
peanuts plus tree nuts. Peanut butter was more frequently con-
sumed than plain nuts; 10,968 (21%) and 11,083 (22%) women
consumed peanut butter once per week and at least twice per
week, respectively.

Women with more frequent total nut consumption in 1991
tended to be older, to consume more calories, be more physically
active, and smoke more than women who rarely consumed nuts
(Table 1). Women who frequently ate nuts were also leaner and
more likely to consume alcohol than were women who rarely ate
nuts. Frequent nut consumption was associated with a higher
intake of total fat, mostly monounsaturated and polyunsaturated
fats, and a lower intake of trans fat. On average, women with
a higher consumption of nuts also had a higher intake of dietary
fiber and a lower average glycemic load—a composite measure
of carbohydrate quality multiplying the glycemic index for a
particular food by the quantity ingested. Women who con-
sumed more nuts ate more fish, but also ate more snacks. They
consumed fewer refined grains, poultry, and red and processed
meats. Consumption of high-calorie carbonated soda was similar
in both women who ate nuts and in those who never/almost
never ate nuts.

Although, on average, participants increased their body
weight, women with higher dietary intakes of total nuts (ie, ≥ 2
servings/wk) after a mean 8 y of follow-up experienced 0.51 kg
less weight gain (95% CI: −0.82, −0.20) compared with those
who rarely ate nuts, after adjustment for potential confounders
(P for trend < 0.001) (Table 2). For the same comparison, but
with total nut consumption subdivided into peanuts and tree
nuts, an inverse association with a higher magnitude was shown
for tree nuts (−1.01-kg difference; 95% CI: −1.67, −0.36; P for
trend < 0.001) and a marginally significant inverse association
was shown for peanut consumption (−0.37-kg difference; 95%
CI: −0.98, 0.23; P for trend = 0.011). No association was found
when we assessed peanut butter consumption (P for trend = 0.305; data not shown). Adjustment for dietary pattern scores
did not appreciably alter the results (Table 2). In the analyses in
which we additionally adjusted for total energy intake, in-
terpreted as nut consumption under isocaloric conditions, the
results were similar. Similarly, when BMI was assessed as the
outcome, higher nut consumption was associated with lower
BMIs over an average of 8 y (data not shown).

In a secondary analysis in which we separated the category ≥ 2
servings/wk (n = 3,550) into 2–4 servings/wk (n = 3,061) and
≥5 servings/wk (n = 489), there was an even greater difference
for the highest compared with the lowest category of total nut
consumption (0.68 kg less weight gain; 95% CI: −1.08, −0.28;
P for trend <0.001). For those who reported consuming nuts
2–4 times/wk, there was 0.26 kg less weight gain (95% CI: −0.74, 0.22).

Stratifying by categories of BMI, we found no evidence of a
positive association between total nut consumption and weight
gain during follow-up in any of the subgroup analyses (data not
shown). Among normal-weight women, there was a significant
trend toward less weight gain for women who consumed nuts
more frequently. The P value for the interaction term for BMI
and nut consumption categories was not significant (P = 0.29).

During 408,664 person-years of follow-up, we identified 5924
new cases of obesity. Overall nut consumption was associated
with a slightly lower risk of becoming obese (P for trend = 0.003), although the inverse association was stronger for tree nut
consumption than for peanut consumption, and the CI for the
highest group of total nut consumption included the null value
(Table 3). When we assessed peanut butter consumption, we
found no evidence of an association with obesity. The multivar-
iate-adjusted HR of obesity for those participants who consumed
peanut butter ≥2 times/wk compared with those who rarely
consumed peanut butter was 0.97 (95% CI: 0.87, 1.07; P for
trend = 0.219).

To address potential confounding by smoking, we included
smoking status (never, past, or current) as a covariate in multi-
variate models. In addition, we performed a sensitivity analysis
including only those women who reported never smoking (n = 33,768). The results did not change materially in the analyses in which weight change during follow-up was the outcome. When we assessed the incidence of obesity, HR estimates were similar; however, the CIs for the adjusted HRs were wider, probably because of reduced statistical power. The P value for linear trend remained statistically significant for tree nuts (data not shown).

**DISCUSSION**

In this large prospective study of healthy middle-aged women, frequent nut or peanut butter consumption was not associated with significantly higher body weight gain during 8 y of follow-up. We consistently observed a tendency toward less weight gain with increasing frequency of nut consumption, regardless of whether all nuts, peanuts, or tree nuts were evaluated.

These findings agree with the results from 2 prospective cohort studies. In a 28-mo prospective study (the SUN Study) conducted in Spain in free-living university graduates (n = 8865), a significant inverse association between nut consumption and weight gain was reported. Compared with those who never or almost never ate nuts, participants who ate nuts ≥2 times/wk had a 31% lower risk of gaining ≥5 kg during follow-up (multivariate-adjusted odds ratio: 0.69; 95% CI: 0.53, 0.90). Participants who frequently consumed nuts had an average 0.42 kg less weight gain than did those who rarely consumed nuts after adjustment for potential confounders (25). In the Nurses’ Health Study, a slightly lower risk of obesity was found among 90 participants who ate an average 35 g walnuts/d for 2 times/wk (P for trend = 0.001).

**TABLE 1**

Characteristics according to baseline frequency of total nut (peanuts + tree nuts) consumption in 51,188 women

<table>
<thead>
<tr>
<th>Subjects [n (%)]</th>
<th>Never/almost never</th>
<th>1–3 times/mo</th>
<th>1 time/wk</th>
<th>≥2 times/wk</th>
<th>P for trend(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y) 36.31</td>
<td>30,102 (58.8)</td>
<td>9,961 (19.5)</td>
<td>7,575 (14.8)</td>
<td>3,550 (6.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Weight (kg) 66.14</td>
<td>66.14 ± 14.41</td>
<td>65.51 ± 14.15</td>
<td>66.03 ± 14.38</td>
<td>64.97 ± 14.35</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI (kg/m(^2)) 24.37</td>
<td>24.37 ± 5.02</td>
<td>24.06 ± 4.94</td>
<td>24.24 ± 5.03</td>
<td>23.77 ± 4.94</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Physical activity (METs(^2)-h/wk) 20.33</td>
<td>20.33 ± 26.03</td>
<td>19.38 ± 24.78</td>
<td>21.19 ± 26.63</td>
<td>23.24 ± 31.85</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Currently smoking (%) 10.68</td>
<td>10.68</td>
<td>11.12</td>
<td>12.02</td>
<td>13.19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Currently using oral contraceptives (%) 11.28</td>
<td>11.28</td>
<td>10.48</td>
<td>10.38</td>
<td>9.19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Currently receiving hormone replacements (%)</td>
<td>2.30</td>
<td>2.36</td>
<td>2.40</td>
<td>2.12</td>
<td>0.92</td>
</tr>
<tr>
<td>Total caloric intake (kcal/d) 1673.01</td>
<td>1673.01 ± 499.38</td>
<td>1818.71 ± 503.63</td>
<td>1939.33 ± 523.23</td>
<td>2082.92 ± 544.83</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Alcohol (g/d)</td>
<td>2.86 ± 0.49</td>
<td>3.45 ± 0.41</td>
<td>3.96 ± 0.62</td>
<td>4.29 ± 0.70</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Carbohydrates (% of energy)</td>
<td>49.89 ± 7.61</td>
<td>49.58 ± 7.09</td>
<td>49.47 ± 7.06</td>
<td>49.72 ± 7.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Protein (% of energy)</td>
<td>19.68 ± 3.55</td>
<td>19.05 ± 3.22</td>
<td>18.82 ± 3.16</td>
<td>18.15 ± 3.19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total fat (% of energy)</td>
<td>31.06 ± 5.72</td>
<td>31.94 ± 5.29</td>
<td>32.26 ± 5.21</td>
<td>33.01 ± 5.44</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Saturated fat (% of energy)</td>
<td>11.15 ± 2.46</td>
<td>11.29 ± 2.29</td>
<td>11.27 ± 2.28</td>
<td>11.09 ± 2.40</td>
<td>0.015</td>
</tr>
<tr>
<td>Monounsaturated fat (% of energy)</td>
<td>11.67 ± 2.47</td>
<td>12.16 ± 2.27</td>
<td>12.38 ± 2.24</td>
<td>12.89 ± 2.37</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Polyunsaturated fat (% of energy)</td>
<td>5.50 ± 1.40</td>
<td>5.74 ± 1.29</td>
<td>5.87 ± 1.26</td>
<td>6.32 ± 1.37</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Polyunsaturated:saturated fat ratio</td>
<td>0.51 ± 0.16</td>
<td>0.53 ± 0.15</td>
<td>0.54 ± 0.15</td>
<td>0.60 ± 0.19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>trans Fat (% of energy)</td>
<td>1.63 ± 0.62</td>
<td>1.67 ± 0.59</td>
<td>1.65 ± 0.57</td>
<td>1.56 ± 0.57</td>
<td>0.019</td>
</tr>
<tr>
<td>Total fiber (g/d)</td>
<td>16.97 ± 7.12</td>
<td>18.35 ± 6.93</td>
<td>19.84 ± 7.38</td>
<td>22.61 ± 8.36</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cereal fiber (g/d)</td>
<td>5.80 ± 3.37</td>
<td>5.62 ± 2.76</td>
<td>5.51 ± 2.60</td>
<td>5.66 ± 2.80</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Glycemic load</td>
<td>122.30 ± 21.83</td>
<td>120.77 ± 20.15</td>
<td>119.33 ± 19.89</td>
<td>118.63 ± 20.83</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fruit (servings/d per 1000 kcal)</td>
<td>0.68 ± 0.51</td>
<td>0.66 ± 0.44</td>
<td>0.68 ± 0.46</td>
<td>0.72 ± 0.50</td>
<td>0.16</td>
</tr>
<tr>
<td>Vegetables (servings/d per 1000 kcal)</td>
<td>1.92 ± 1.11</td>
<td>1.86 ± 1.02</td>
<td>1.89 ± 0.99</td>
<td>1.91 ± 1.09</td>
<td>0.53</td>
</tr>
<tr>
<td>Sweets (servings/d per 1000 kcal)</td>
<td>0.55 ± 0.50</td>
<td>0.59 ± 0.47</td>
<td>0.61 ± 0.48</td>
<td>0.60 ± 0.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Poultry meat (servings/d per 1000 kcal)</td>
<td>0.28 ± 0.19</td>
<td>0.25 ± 0.16</td>
<td>0.25 ± 0.16</td>
<td>0.23 ± 0.16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Red meat (servings/d per 1000 kcal)</td>
<td>0.32 ± 0.20</td>
<td>0.32 ± 0.19</td>
<td>0.30 ± 0.18</td>
<td>0.27 ± 0.18</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Processed meat (servings/d per 1000 kcal)</td>
<td>0.44 ± 0.26</td>
<td>0.44 ± 0.25</td>
<td>0.43 ± 0.25</td>
<td>0.38 ± 0.25</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fish (servings/d per 1000 kcal)</td>
<td>0.16 ± 0.14</td>
<td>0.15 ± 0.13</td>
<td>0.15 ± 0.12</td>
<td>0.16 ± 0.12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Whole grains (servings/d per 1000 kcal)</td>
<td>0.78 ± 0.62</td>
<td>0.76 ± 0.58</td>
<td>0.76 ± 0.55</td>
<td>0.83 ± 0.63</td>
<td>0.13</td>
</tr>
<tr>
<td>Refined grains (servings/d per 1000 kcal)</td>
<td>0.83 ± 0.49</td>
<td>0.79 ± 0.44</td>
<td>0.76 ± 0.42</td>
<td>0.71 ± 0.39</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Snacking (servings/d per 1000 kcal)</td>
<td>0.20 ± 0.26</td>
<td>0.23 ± 0.25</td>
<td>0.23 ± 0.22</td>
<td>0.24 ± 0.22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>High-calorie carbonated soda (servings/d per 1000 kcal)</td>
<td>0.23 ± 0.41</td>
<td>0.24 ± 0.38</td>
<td>0.23 ± 0.36</td>
<td>0.23 ± 0.36</td>
<td>0.54</td>
</tr>
<tr>
<td>Low-calorie carbonated soda (servings/d per 1000 kcal)</td>
<td>0.69 ± 1.00</td>
<td>0.57 ± 0.86</td>
<td>0.56 ± 0.85</td>
<td>0.48 ± 0.78</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>High-fat dairy (servings/d per 1000 kcal)</td>
<td>0.50 ± 0.50</td>
<td>0.52 ± 0.46</td>
<td>0.52 ± 0.46</td>
<td>0.53 ± 0.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Low-fat dairy (servings/d per 1000 kcal)</td>
<td>0.81 ± 0.62</td>
<td>0.73 ± 0.56</td>
<td>0.70 ± 0.54</td>
<td>0.63 ± 0.50</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

\(^1\) Calculated by using general linear models for continuous variables and a chi-square test for the linear trend for categorical variables.

\(^2\) Mean ± SD (all such values).

\(^3\) Metabolic equivalents.
6 mo, Sabate et al (27) found minimal weight gain (mean ± SE: 0.20 ± 0.1 kg), which was less than predicted given the reported dietary intake of walnuts. Similarly, another randomized crossover trial (n = 81) that evaluated modest consumption of almonds (ie, 2 oz/d) for 6 mo found no significant or biologically meaningful changes in body weight (< 0.40 kg; P > 0.05) (28).

Alper et al (29) assessed peanut consumption in 15 healthy normal-weight adults and reported a significantly lower body weight (1.0 kg) than the average weight predicted (3.6 kg) after 19 wk of consuming 505 ± 118 calories/d of peanuts. More recently, Hollis et al (30) showed in a randomized crossover trial (n = 20) that daily consumption of 1440 kJ almonds (≈344 calories/d) for 10 wk did not promote weight gain (mean ± SD: 70.1 ± 10.1 kg at baseline and 70.3 ± 9.3 kg at the end of 10 wk; P > 0.05).

Several trials of nut consumption without constraints on energy balance have shown no significant weight change in the group assigned to a higher consumption of nuts (31). Early results from the clinical trial PREDIMED study conducted in Spain to assess the protective effect of a Mediterranean diet supplemented with olive oil or tree nuts on cardiovascular disease showed an improvement in cardiovascular disease risk factors, but no weight gain (0.01 kg; 95% CI: −0.40 kg, 0.43 kg) was observed after 3 mo in the group allocated to nuts (n = 258) compared with those allocated to a low-fat diet (n = 257) (14). Consequently, higher nut consumption does not appear to cause greater weight gain; rather, incorporating nuts into hypocaloric diets may be beneficial for weight control (26, 32), contributing to satiety and improving long-term adherence (33).

Many mechanisms have been proposed to explain the lack of association, and the suggestion of an inverse relation, between nut intake and weight gain. Nuts are rich in protein, which may enhance satiety and suppress subsequent hunger (10, 34). Almonds and peanuts have the highest protein contents, whereas macadamia nuts and pecans have the lowest (10). Nuts are high in dietary fiber, which may also increase satiation (3, 35). Intake of viscous fiber has been speculated to delay gastric emptying and subsequent absorption; thus, consumption of a diet rich in fiber may suppress hunger for longer periods of time (36). Nuts are high in unsaturated fat contents in nuts may lead to an overall possibly lead to less fat accumulation. The high protein, fiber, and unsaturated fat contents in nuts may lead to an overall increase in diet-induced thermogenesis and in resting energy expenditure (29), which potentially contributes to weight maintenance.

Additionally, increased fecal losses of fat due to incomplete mastication of whole nuts leads to the loss of available energy (27). This may be another possible explanation for the observation of a null association for peanut butter consumption.

### Table 2

Body weight changes (kg) over 8 y (1991–1999) according to baseline frequency of nuts consumption in 51,188 women

<table>
<thead>
<tr>
<th>Frequency of consumption</th>
<th>Never/almost never</th>
<th>1–3 times/mo</th>
<th>1 time/wk</th>
<th>≥ 2 times/wk</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total nuts (peanuts + tree nuts)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects [n (%)]</td>
<td>30,102 (58.8)</td>
<td>9961 (19.5)</td>
<td>7575 (14.8)</td>
<td>3550 (6.9)</td>
<td></td>
</tr>
<tr>
<td>Median consumption of total nuts (servings/d)</td>
<td>0</td>
<td>0.07</td>
<td>0.14</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Crude body weight change (kg)</td>
<td>5.50 ± 0.04</td>
<td>5.26 ± 0.07</td>
<td>5.27 ± 0.08</td>
<td>4.91 ± 0.12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.55 ± 0.04</td>
<td>5.31 ± 0.07</td>
<td>5.30 ± 0.08</td>
<td>5.04 ± 0.12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.55 ± 0.04</td>
<td>5.32 ± 0.07</td>
<td>5.33 ± 0.08</td>
<td>5.15 ± 0.12</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Peanuts**

<table>
<thead>
<tr>
<th>Frequency of consumption</th>
<th>Never/almost never</th>
<th>1–3 times/mo</th>
<th>1 time/wk</th>
<th>≥ 2 times/wk</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects [n (%)]</td>
<td>34,089 (66.6)</td>
<td>13,266 (25.9)</td>
<td>3017 (5.9)</td>
<td>816 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Median consumption of peanuts (servings/d)</td>
<td>0</td>
<td>0.07</td>
<td>0.14</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Crude body weight change (kg)</td>
<td>5.50 ± 0.04</td>
<td>5.34 ± 0.06</td>
<td>5.16 ± 0.13</td>
<td>5.08 ± 0.26</td>
<td>0.003</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.48 ± 0.04</td>
<td>5.38 ± 0.06</td>
<td>5.20 ± 0.13</td>
<td>5.04 ± 0.26</td>
<td>0.003</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.49 ± 0.04</td>
<td>5.36 ± 0.06</td>
<td>5.20 ± 0.13</td>
<td>5.12 ± 0.25</td>
<td>0.011</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.47 ± 0.04</td>
<td>5.39 ± 0.06</td>
<td>5.26 ± 0.13</td>
<td>5.28 ± 0.25</td>
<td>0.120</td>
</tr>
</tbody>
</table>

**Tree nuts**

<table>
<thead>
<tr>
<th>Frequency of consumption</th>
<th>Never/almost never</th>
<th>1–3 times/mo</th>
<th>1 time/wk</th>
<th>≥ 2 times/wk</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects [n (%)]</td>
<td>38,297 (74.8)</td>
<td>10,192 (19.9)</td>
<td>2014 (3.9)</td>
<td>685 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Median consumption of other nuts (servings/d)</td>
<td>0</td>
<td>0.07</td>
<td>0.14</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Crude body weight change (kg)</td>
<td>5.56 ± 0.04</td>
<td>5.13 ± 0.07</td>
<td>5.00 ± 0.16</td>
<td>4.17 ± 0.28</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.53 ± 0.04</td>
<td>5.21 ± 0.07</td>
<td>5.12 ± 0.16</td>
<td>4.33 ± 0.28</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.52 ± 0.04</td>
<td>5.21 ± 0.07</td>
<td>5.22 ± 0.16</td>
<td>4.51 ± 0.27</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg)</td>
<td>5.50 ± 0.04</td>
<td>5.25 ± 0.07</td>
<td>5.32 ± 0.16</td>
<td>4.65 ± 0.27</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

1 P values from the models in which nut consumption was modeled as a continuous variable with the use of the median value of each quintile.

2 Mean ± SE (all such values).

3 Multivariate model adjusted for age (continuous), baseline alcohol intake (0, 0.1–4.9, 5.0–9.9, 10+ g/d), physical activity (quintiles metabolic equivalent score), smoking (never, past, current, missing), postmenopausal hormone use (no, current or past, missing), oral contraceptive use (no, current, missing), baseline BMI (continuous), glycemic load, and intake of total fiber, trans fat, fruit, vegetables, red meat, processed meat, refined grain, whole grain, snacks, sugar-sweetened beverages, diet beverages, low-fat dairy products, and high-fat dairy products (continuous) at baseline.

4 Multivariate model adjusted for multivariate model 2 + changes in confounders between time periods (except BMI).

5 Multivariate model adjusted for multivariate model 3 + changes in the adherence of prudent and Western dietary patterns.
Nevertheless, home-made peanut butter could be a good alternative to improve the nutritional status of elderly subjects who may have difficulty chewing whole nuts.

We considered the possibility that confounding may explain the lack of a positive association between nuts and weight gain because women who frequently consumed nuts had a generally healthier lifestyle and dietary habits than did those who rarely ate nuts (Table 1). In multivariate analyses, however, potential confounders were included in the models, and significant trends toward less weight gain with higher nut consumption still persisted. Although we cannot rule out the possibility of residual or unmeasured confounding, it is unlikely to fully explain the inverse association observed in this large prospective cohort. From a public health point of view, it is important to highlight a tendency toward lower risk of obesity, which suggests that nuts as a factor in the context of a healthy diet can help to prevent or at least to regulate weight gain and to avoid the risk of developing obesity among those participants with a higher frequency of nuts consumption.

We should point out the low percentage of women in the cohort with high levels of nut consumption as a potential limitation of this study. However, when we stratified the highest category into 2 groups, the results pointed in the same direction. We did not adjust for total calorie intakes in our main analysis to avoid the mistaken interpretation of consuming nuts in addition to the usual daily calorie intake. Health professionals should recommend that nut consumption replace the consumption of other unhealthy snacks or desserts rich in trans fats and refined carbohydrates. This message may also help to prevent cardiovascular disease, type 2 diabetes, and other chronic conditions. In a nutshell, the results of this study may help to allay fears of avoiding nuts to stave off weight gain, as long as individuals are aware of the total number of calories consumed to ensure dietary compensation and maintain overall energy balance.

The authors’ responsibilities were as follows—MB-R: participated in the conception and design, statistical analyses, data interpretation, manuscript drafting, and critical revision of the manuscript for important intellectual content; NMW: participated in the analysis and data interpretation, manuscript drafting, and critical revision of the manuscript for important intellectual content; 1P. value from the models in which nut consumption was modeled as a continuous variable with the use of the median value of each quintile. 2Multivariate model adjusted for age (continuous), baseline alcohol intake (0, 0.1–4.9, 5.0–9.9, 10+ g/d), physical activity (quintiles metabolic equivalent score), smoking (never, past, current, missing), postmenopausal hormone use (no, current or past, missing), oral contraceptive use (no, current, missing), baseline BMI (continuous), glycemic load, and intakes of total fiber, trans fat, fruit, vegetables, red meat, processed meat, refined grain, whole grain, snacks, sugar-sweetened beverages, diet beverages, low-fat dairy products, and high-fat dairy products (continuous) at baseline. 3Multivariate model adjusted for multivariate model 2 + changes in the adherence of prudent and Western dietary patterns.

<table>
<thead>
<tr>
<th>Total nuts (peanuts + tree nuts)</th>
<th>Person-years</th>
<th>Age-adjusted HR (95% CI)</th>
<th>Multivariate-adjusted HR (95% CI)</th>
<th>Multivariate-adjusted HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>3368</td>
<td>1.00 (0.91, 1.09)</td>
<td>0.88 (0.80, 0.97)</td>
<td>0.81 (0.61, 1.08)</td>
</tr>
<tr>
<td>1–3 times/mo</td>
<td>1470</td>
<td>0.90 (0.84, 0.95)</td>
<td>0.80 (0.75, 0.86)</td>
<td>0.52 (0.43, 0.64)</td>
</tr>
<tr>
<td>1 time/wk</td>
<td>990</td>
<td>1.00 (0.91, 1.10)</td>
<td>0.87 (0.79, 0.96)</td>
<td>0.77 (0.57, 1.02)</td>
</tr>
<tr>
<td>≥2 times/wk</td>
<td>96</td>
<td>1.00 (0.91, 1.09)</td>
<td>0.88 (0.80, 0.97)</td>
<td>0.81 (0.61, 1.08)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peanuts</th>
<th>Person-years</th>
<th>Age-adjusted HR (95% CI)</th>
<th>Multivariate-adjusted HR (95% CI)</th>
<th>Multivariate-adjusted HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>3812</td>
<td>1.00 (0.91, 1.09)</td>
<td>0.90 (0.84, 1.01)</td>
<td>0.98 (0.84, 1.14)</td>
</tr>
<tr>
<td>1–3 times/mo</td>
<td>1728</td>
<td>0.91 (0.86, 0.96)</td>
<td>0.85 (0.76, 0.95)</td>
<td>0.65 (0.49, 0.86)</td>
</tr>
<tr>
<td>1 time/wk</td>
<td>334</td>
<td>0.93 (0.86, 1.01)</td>
<td>0.98 (0.84, 1.15)</td>
<td>0.80 (0.57, 1.11)</td>
</tr>
<tr>
<td>≥2 times/wk</td>
<td>50</td>
<td>0.93 (0.86, 1.01)</td>
<td>0.98 (0.84, 1.14)</td>
<td>0.85 (0.61, 1.18)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tree nuts</th>
<th>Person-years</th>
<th>Age-adjusted HR (95% CI)</th>
<th>Multivariate-adjusted HR (95% CI)</th>
<th>Multivariate-adjusted HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>4341</td>
<td>1.00 (0.91, 1.09)</td>
<td>0.90 (0.84, 1.01)</td>
<td>0.98 (0.84, 1.14)</td>
</tr>
<tr>
<td>1–3 times/mo</td>
<td>1343</td>
<td>0.83 (0.78, 0.89)</td>
<td>0.71 (0.62, 0.81)</td>
<td>0.37 (0.26, 0.54)</td>
</tr>
<tr>
<td>1 time/wk</td>
<td>211</td>
<td>0.84 (0.77, 0.92)</td>
<td>1.05 (0.87, 1.28)</td>
<td>0.62 (0.39, 0.99)</td>
</tr>
<tr>
<td>≥2 times/wk</td>
<td>29</td>
<td>0.84 (0.77, 0.93)</td>
<td>1.09 (0.90, 1.32)</td>
<td>0.67 (0.42, 1.07)</td>
</tr>
</tbody>
</table>

Hazard ratios (HRs) for obesity (BMI ≥ 30 kg/m²) according to frequency of nut consumption in 408,664 person-years.
content; MAM-G: participated in the conception and design and critical revision of the manuscript for important intellectual content; TYL: participated in the statistical analyses; LS: participated in the data collection; and FBH: participated in the data interpretation, critical revision of the manuscript for important intellectual content, and funding, concept, and design of the study. All authors approved the final version of the manuscript. FBH reported receiving research support from the California Walnut Commission. None of the other authors reported a conflict of interest.

REFERENCES