Prospective study of nut consumption, long-term weight change, and obesity risk in women\textsuperscript{1–4}

Maira Bes-Rastrollo, Nicole M Wedick, Miguel Angel Martinez-Gonzalez, Tricia Y Li, Laura Sampson, and Frank B Hu

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 $\geq 2$ times/wk had slightly less mean ($\pm$ SE) weight gain ($5.04 \pm 0.12$ kg) than did women who rarely ate nuts ($5.55 \pm 0.04$ 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 $\geq 2$ 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 ($\geq 2$ 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.


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 receive 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 $\approx 68\%$ 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 been a focus of public health concern (16).

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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 with a follow-up rate exceeding 90% for each 2-y period. Participants completed self-administered food-frequency questionnaires (FFQs) in 1991, 1995, and 1999. For the present analysis, women were excluded if they did not complete dietary questionnaires in 1991, left >70 items blank, reported extreme caloric intakes (<500 or >3500 kcal/d), had a history of diabetes or cardiovascular disease or reported a diagnosis of cancer (except nonmelanoma skin cancer) before 1999, had no data on physical activity assessed in 1991 or 1997, or were pregnant at the time of the 1991, 1995, or 1999 questionnaire administrations. Participants who did not provide information on weight at any time period were also excluded. After these exclusions, 51,188 women remained available for the analyses. There were no appreciable differences in baseline characteristics between women in the original cohort and those included in the analyses after the above-mentioned exclusions. The Harvard School of Public Health and Brigham and Women’s Hospital Human Subject Committees approved the study protocol.

**Dietary assessment**

The semiquantitative FFQ at baseline (1991) included 133 items to obtain dietary information. Participants were asked to report their average consumption of a commonly used unit or portion size of each food during the previous year. There were 9 possible responses ranging from never to ≥6 times/d. Similar questionnaires were used to update information on the subjects’ diet in 1995 and 1999. In the 1991 and 1995 dietary questionnaires, participants were asked about their average consumption of peanut butter [1 tbsp equivalent to 1 ounce of peanuts (28.35 g)], peanuts [1 oz (28.35 g) of peanuts], and tree nuts [1 oz (28.35 g) of nuts] during the previous year. In the 1999 dietary questionnaire, “tree nuts” was subdivided into 2 separate items: walnuts and other nuts. Thus, consumption of “tree nuts” in 1999 was the sum of these 2 items combined. Total nut consumption was the sum of the intakes for peanuts and other nuts. The corrected correlation coefficient was 0.75 for dietary intake of nuts and peanut butter assessed by questionnaire and 4 1-wk 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 ≥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 ≥2 times/wk. Given the frequency distribution of total nut consumption for this cohort (ie, only 7% of women reported eating nuts ≥2 times/wk with less than half of them consuming ≥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 (≥2 times/wk) divided into the category 2–4 servings/wk and ≥5 servings/wk; however, the numbers became small because <1% of the women in this cohort reported consuming nuts ≥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 ≥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 ≥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,
RESULTS

and BMI, BMI defined on the basis of World Health Organization’s cutoffs (14): weight gain after stratifying by baseline BMI. Categories were we analyzed associations between total nut consumption and models. To assess potential effect modification by baseline BMI, 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 calculated 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 interaction terms. SAS software version 9.1 was used for all analyses (SAS Institute).

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 consumed 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 consumed 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, interpreted 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 = 3550) 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 multivariate-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 multivariate 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 $\geq 2$ times/wk had a $31\%$ lower risk of gaining $\geq 5$ 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 those who consumed nuts regularly during 16 y of follow-up (4).

Two reviews summarize the findings of $>$15 human intervention trials that evaluated the effects of nut consumption on body weight changes (9, 26) and concluded that self-selected diets that included nuts in free-living populations did not have a tendency to increase body weight; we highlight below some more recent intervention studies. In a randomized crossover trial among 90 participants who ate an average 35 g walnuts/d for...
NUT CONSUMPTION AND WEIGHT CHANGE

TABLE 2
Body weight changes (kg) over 8 y (1991–1999) according to baseline frequency of nut consumption in 51,188 women

<table>
<thead>
<tr>
<th>Frequency of consumption</th>
<th>Total nuts (peanuts + tree nuts)</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>Subjects [n (%)]</td>
<td></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>
<td></td>
</tr>
<tr>
<td>Crude body weight change (kg)</td>
<td>5.50 ± 0.04 (^3)</td>
<td>5.26 ± 0.07</td>
<td>5.27 ± 0.08</td>
<td>4.91 ± 0.12</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Multivariate-adjusted body weight change (kg) (^4)</td>
<td>5.55 ± 0.04</td>
<td>5.35 ± 0.07</td>
<td>5.29 ± 0.08</td>
<td>4.98 ± 0.12</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Peanuts</td>
<td>Subjects [n (%)]</td>
<td></td>
<td>34,089 (66.6)</td>
<td>13,266 (25.9)</td>
<td>3017 (5.9)</td>
<td>816 (1.6)</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>
<td></td>
</tr>
<tr>
<td>Crude 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>
<td></td>
</tr>
<tr>
<td>Multivariate-adjusted weight change (kg) (^4)</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>
<td></td>
</tr>
<tr>
<td>Tree nuts</td>
<td>Subjects [n (%)]</td>
<td></td>
<td>38,297 (74.8)</td>
<td>10,192 (19.9)</td>
<td>2014 (3.9)</td>
<td>685 (1.3)</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>
<td></td>
</tr>
<tr>
<td>Crude 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>
<td></td>
</tr>
<tr>
<td>Multivariate-adjusted weight change (kg) (^4)</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>
<td></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 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.

\(^4\) 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.

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 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 kcal 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 satiety (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 energy dense with total fat contents ranging from ~45–75% of weight (10); this fat is predominantly unsaturated. Evidence suggests that monounsaturated and polyunsaturated fatty acids are more readily oxidized than are saturated fats (37), which 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 3
Hazard ratios (HRs) for obesity (BMI in kg/m² ≥ 30) according to frequency of nut consumption in 408,664 person-years

<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[^1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total nuts (peanuts + tree nuts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>3368</td>
<td>1470</td>
<td>990</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Person-years</td>
<td>196,085</td>
<td>122,010</td>
<td>76,752</td>
<td>13,817</td>
<td></td>
</tr>
<tr>
<td>Age-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>0.003</td>
</tr>
<tr>
<td>Multivariate-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>0.008</td>
</tr>
<tr>
<td>Peanuts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>3812</td>
<td>1728</td>
<td>334</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Person-years</td>
<td>237,416</td>
<td>140,334</td>
<td>25,379</td>
<td>5,535</td>
<td></td>
</tr>
<tr>
<td>Age-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>0.094</td>
</tr>
<tr>
<td>Multivariate-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>0.125</td>
</tr>
<tr>
<td>Tree nuts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>4341</td>
<td>1343</td>
<td>211</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Person-years</td>
<td>263,360</td>
<td>118,299</td>
<td>20,947</td>
<td>6058</td>
<td></td>
</tr>
<tr>
<td>Age-adjusted HR (95% CI)</td>
<td>1 (reference)</td>
<td>0.84 (0.78, 0.89)</td>
<td>0.71 (0.62, 0.81)</td>
<td>0.37 (0.26, 0.54)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>0.001</td>
</tr>
<tr>
<td>Multivariate-adjusted HR (95% CI)</td>
<td>1 (reference)</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>
<td>0.012</td>
</tr>
</tbody>
</table>

[^1]: P value from the models in which nut consumption was modeled as a continuous variable with the use of the median value of each quintile.
[^2]: 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 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.
[^3]: Multivariate model adjusted for multivariate model 2 + 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 that can help to prevent weight gain 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 two groups, the results pointed in the same direction. We did not adjust for total calorie intake in our main analysis to avoid the assumption of isocaloric diets. The lack of a positive association (in fact, the observed inverse association) between nut consumption and weight gain, even when we did not adjust for calorie intake, further supports our hypothesis. Because energy intake may also confound this association, sensitivity analyses adjusting for total caloric intake were also conducted and yielded similar results. Another concern is the potential measurement error in the assessment of dietary nut consumption based on semiquantitative FFQs inherent to the nutritional epidemiology field (38, 39). However, nut consumption was reported on dietary questionnaires with reasonable accuracy (16). It is germane to question the importance of a weight loss of 0.5 kg over a period of ≈8 y. Excess calorie intake from nut consumption may produce large effects on weight gain over the long term. Therefore, our results suggest that there may be some mechanisms for energy compensation in agreement with previous literature (27, 28).

In conclusion, frequent nut and peanut butter consumption was not associated with greater body weight gain in this large prospective cohort of women followed up for >8 y. Nevertheless, we should point out the importance of replacement to avoid extra caloric intake. This concept should be stressed in messages addressed to the general population to avoid the mistaken interpretation of consuming nuts in addition to the usual daily caloric 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 testing; PB-B: participated in the analysis and data interpretation, manuscript drafting, and critical revision of the manuscript for important intellectual content.
REFERENCES