Bicycle Riding, Walking, and Weight Gain in Premenopausal Women

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Background: To our knowledge, research has not been conducted on bicycle riding and weight control in comparison with walking. Our objective was to assess the association between bicycle riding and weight control in premenopausal women.

Methods: This was a 16-year follow-up study of 18,414 women in the Nurses’ Health Study II. Weight change between 1989 and 2005 was the primary outcome, and the odds of gaining more than 5% of baseline body weight by 2005 was the secondary outcome.

Results: At baseline, only 39% of participants walked briskly, while only 1.2% bicycled for more than 30 min/d. For a 30-min/d increase in activity between 1989 and 2005, weight gain was significantly less for brisk walking (−1.81 kg; 95% confidence interval [CI], −2.05 to −1.56 kg), bicycling (−1.59 kg; 95% CI, −2.09 to −1.08 kg), and other activities (−1.45 kg; 95% CI, −1.66 to −1.24 kg) but not for slow walking (+0.06 kg; 95% CI, −0.22 to 0.35 kg). Women who reported no bicycling in 1989 and increased to as little as 5 min/d in 2005 gained less weight (−0.74 kg; 95% CI, −1.41 to −0.07 kg; P value for trend, <.01) than those who remained nonbikers. Normal-weight women who bicycled more than 4 h/wk in 2005 had a lower odds of gaining more than 5% of their baseline body weight (odds ratio, 0.74; 95% CI, 0.56 to 0.98) compared with those who reported no bicycling; overweight and obese women had a lower odds at 2 to 3 h/wk (odds ratio, 0.54; 95% CI, 0.34 to 0.86).

Conclusions: Bicycling, similar to brisk walking, is associated with less weight gain and an inverse dose-response relationship exists, especially among overweight and obese women. Future research should focus on brisk walking and greater time spent bicycling.

Arch Intern Med. 2010;170(12):1050-1056
nurses aged 23 to 42 years in 1989, who responded to a mailed questionnaire about their medical history, lifestyle, and health-related behaviors. Follow-up questionnaires have been mailed biennially. Body weight is assessed on every questionnaire, and physical activity (PA) has been assessed periodically, including in the 1989 and 2005 questionnaires. A food frequency questionnaire has been included every 4 years starting 1991. The overall response rate has been approximately 90% over the years of follow-up.

This investigation included the NHSII women who were premenopausal through 2005 (n=56 716). From these, we excluded women who were pregnant or lactating within 12 months of reporting weight (n=15 728); did not report their PA, walking pace, and weight in 1989 and 2005 (n=2820); reported extreme weight values (<73 kg or >182 kg) (n=1291); reported extreme weight changes (>40 kg lost or >60 kg gained) (n=15); had extreme baseline body mass index (BMI <15 or >45 [calculated as weight in kilograms divided by height in meters squared]) (n=670); had physical chronic conditions impairing exercise (n=3380); were unable to walk in 1989 or 2005 (n=106); or reported more than 240 min/d of total PA (n=12285). Further exclusions included reporting myocardial infarction, stroke, angina, or diabetes (n=8759) or cancer (n=3248) through 2005. After these exclusions, 18 414 healthy premenopausal women remained in the analysis.

ASSESSMENT OF PA AND SEDENTARY BEHAVIOR
Participants were asked in 1989 and 2005 to report the average time spent per week in the previous year in each of the following recreational activities: walking or hiking outdoors, jogging (>10 min/mile), running (≥10 min/mile), bicycling (including stationary machine), calisthenics/aerobics/aerobic dance/rowing machine, tennis/squash/racquetball, lap swimming, or other aero-bic activity (eg, lawn mowing). For each activity, women chose 1 of 10 duration categories, which ranged from 0 to 11 h/wk or more. For walking, women reported their usual pace in 1989 and 2005: easy (<2.0 mph), average (2.0-2.9 mph), brisk (3.0-3.9 mph), very brisk (≥4.0 mph), or unable to walk. For simplicity slow and average walking paces were collapsed under “slow walking” and brisk and very brisk walking paces, under “brisk walking.”

RESULTS
The 1989 baseline characteristics of the study population by levels of slow walking, brisk walking, and bicycling are displayed (Table 1). Of the women, 50% reported they spent time walking slowly, 39% reported they spent time walking briskly, and 48% reported they spent time bicycling. For our sample, the mean time spent on slow walking was 7.8 min/d, brisk walking 8.5 min/d, and bicycling 4.6 min/d.

In 2005, on average, participants reported spending more time walking briskly (9.0 min/d), some time walking slowly (5.9 min/d), and the least amount of time bicycling (2.5 min/d). The mean time spent sitting at home was 5 times (153 min/d) as much as total time spent in total activity (30.5 min/d), especially if they were overweight (175 min/d). Compared with lean women, overweight women spent
more time walking slowly (7.6 vs 5.5 min/d) and less time walking briskly (5.4 vs 10 min/d). Even though most women did not spend considerable time bicycling, on average, overweight women (2 min/d) and lean women (2.7 min/d) bicycled comparable amounts of time.

**PA TYPES AND 16-YEAR WEIGHT CHANGE**

Between 1989 and 2005, all women gained a mean (SD) 9.3 (9.7) kg. For a BMI less than 25, women gained a mean (SD) 8.4 (7.9) kg; for a BMI of 25 or greater, women gained a mean (SD) 12.6 (13.4) kg. In parallel, women decreased their mean (SD) time spent on brisk walking slightly increased by 0.5 (21.8) min/d and bicycling by 2.1 (12.2) min/d. Only the mean (SD) time spent on their total discretionary activity by 8.6 (43.3) min/d, and more specifically, decreased the mean (SD) times spent on slow walking by 1.9 (21.8) and bicycling by 2.1 (12.2) min/d. Only the mean (SD) time spent on brisk walking slightly increased by 0.5 (23.1) min/d.

In linear regression models using change in PA as a continuous variable and controlling for baseline activity and other risk factors, a 30-min/d increase in total discretionary activity between 1989 and 2005 was associated with less weight gain (−0.60 kg; 95% CI, −0.85 to −0.35). In our cohort, only a few women (1.2%) actually attained this increase of 30 min/d in bicycling. The benefits of brisk walking, bicycling, and other activities were significantly stronger among overweight and obese women (BMI ≥25) compared with lean women (BMI <25) (P value for interaction, <.01 for all), whereas slow walking continued to show no benefit even among overweight and obese women (−0.60 kg, 95% CI, −1.35 to +0.16) (P value for interaction, .74).

**BICYCLING AND WEIGHT GAIN PREVENTION**

In women who did not bicycle in 1989 and increased their bicycling in 2005, less weight gain was seen even for 5-min/d or less increase in bicycling (−0.74 kg; 95% CI, −1.41 to −0.07), and even lower weight gain was seen with greater duration of bicycling (P value for trend, <.001) (Figure, A). In comparison, women who initially bicycled for more than 15 min/d at baseline and who decreased their bicycling time in 2005 to more than 5 to 15 min/d gained more weight (+2.13 kg; 95% CI, +0.35 to +3.92), which accrued with more reduction in bicycling (P value for trend, .005) (Figure, B).

To assess if a dose-response relationship was evident, we re-examined change in activity as a categorical variable, with 2005 activity as the predictor controlled for 1989 baseline activity. Compared with women who did not bicycle in 2005, those who engaged in bicycling 4 h/wk or more were less likely to gain weight (OR, 0.71; 95% CI, 0.55 to 0.93) after controlling for other covariates (Table 3). There was a significant inverse dose-response relationship between increased time spent bicycling in 2005 and

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**Table 1. Baseline (1989) Age-Standardized Characteristics According to Levels of Slow Walking, Brisk Walking, and Biking for 18,414 US Premenopausal Women in the Nurses’ Health Study II**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Zero</th>
<th>Slow Walking</th>
<th>Brisk Walking</th>
<th>Biking, min/d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>&gt;0-9</td>
<td>≥10</td>
<td>0</td>
</tr>
<tr>
<td>No. of women</td>
<td>1921</td>
<td>5789</td>
<td>3438</td>
<td>3025</td>
</tr>
<tr>
<td>Age, y</td>
<td>32.0</td>
<td>31.7</td>
<td>31.3</td>
<td>31.4</td>
</tr>
<tr>
<td>Total discretionary physical activity, min/d</td>
<td>20.0</td>
<td>19.8</td>
<td>62.1</td>
<td>25.0</td>
</tr>
<tr>
<td>Total walking, min/d</td>
<td>0</td>
<td>4.8</td>
<td>33.6</td>
<td>0</td>
</tr>
<tr>
<td>Slow walking, min/d</td>
<td>0</td>
<td>4.8</td>
<td>33.6</td>
<td>0</td>
</tr>
<tr>
<td>Brisk walking, min/d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5.5</td>
</tr>
<tr>
<td>Bicycle riding, min/d</td>
<td>3.6</td>
<td>2.9</td>
<td>6.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Other activities, min/d</td>
<td>16.3</td>
<td>12.1</td>
<td>22.5</td>
<td>16.0</td>
</tr>
<tr>
<td>BMI at 1989</td>
<td>23.0</td>
<td>23.5</td>
<td>23.1</td>
<td>22.5</td>
</tr>
<tr>
<td>Weight change, 1989 to 2005, kg</td>
<td>9.4</td>
<td>9.5</td>
<td>9.4</td>
<td>9.1</td>
</tr>
<tr>
<td>Sitting at home, min/d</td>
<td>115</td>
<td>118</td>
<td>118</td>
<td>117</td>
</tr>
<tr>
<td>Energy intake, kcal/d</td>
<td>1710</td>
<td>1784</td>
<td>1835</td>
<td>1780</td>
</tr>
<tr>
<td>Alcohol intake, g/d</td>
<td>3.2</td>
<td>2.9</td>
<td>3.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Sugar-sweetened beverage intake, servings/d b</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Trans fat intake, g/d c</td>
<td>3.4</td>
<td>3.4</td>
<td>3.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Fiber intake, g/d c</td>
<td>17.5</td>
<td>17.4</td>
<td>18.2</td>
<td>18.3</td>
</tr>
<tr>
<td>Current smoking, %</td>
<td>12.0</td>
<td>10.8</td>
<td>9.7</td>
<td>10.2</td>
</tr>
<tr>
<td>Oral contraceptive use, %</td>
<td>23.7</td>
<td>22.3</td>
<td>20.8</td>
<td>23.0</td>
</tr>
<tr>
<td>Parity, No. of births</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Antidepressant use, %</td>
<td>0.5</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

*Data are reported as means unless otherwise indicated.

b Sugar-sweetened beverages include sugar-sweetened carbonated beverages, punch, fruit drinks, lemonade, or iced tea.

c Energy-adjusted values.
Table 2. Predictors of 16-Year Weight Change* by a 30-min/d Increase in Physical Activity and Inactivity Between 1989 and 2005 Among 18,414 US Premenopausal Women, for All Women and Women Stratified by 1989 Baseline BMI

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Women (n=18,414)</th>
<th>BMI ≤25 (n=14,518)</th>
<th>BMI &gt;25 (n=3,896)</th>
<th>P Value for Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight change 1989-2005, mean (SD), kg</td>
<td>9.3 (9.7)</td>
<td>8.4 (7.9)</td>
<td>12.6 (13.4)</td>
<td></td>
</tr>
</tbody>
</table>

**Model 1**

- Total discretionary activity
  - Simple modela: -1.52 (-1.65 to -1.38)
  - Multivariate-adjusted modelc: -1.31 (-1.44 to -1.18)
- Total sitting at home
  - Simple modelb: 0.25 (0.21 to 0.28)
  - Multivariate-adjusted modelc: 0.21 (0.18 to 0.25)

**Model 2**

- Slow walking
  - Simple modela: 0.01 (-0.28 to 0.30)
  - Multivariate-adjusted modela: 0.06 (-0.22 to 0.35)
- Brisk walking
  - Simple modela: -2.07 (-2.32 to -1.83)
  - Multivariate-adjusted modela: -1.81 (-2.05 to -1.56)
- Bicycle riding
  - Simple modela: -1.82 (-2.33 to -1.31)
  - Multivariate-adjusted modela: -1.59 (-2.09 to -1.08)
- Other activitiesf
  - Simple modela: -1.63 (-1.85 to -1.42)
  - Multivariate-adjusted modela: -1.45 (-1.66 to -1.24)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CI, confidence interval.

* Based on linear regression coefficients (95% CI) for every 30-min/d increase in 2005 physical activity and inactivity.

a Adjusted for 1989 baseline age, weight, total discretionary activity, and total time sitting at home.

b Multivariate-adjusted model, which tested 1989 baseline age, weight, total discretionary activity, and total time sitting at home, as well as the following covariates: height (1989), total mean alcohol intake (1989-2003) (0, >0-0.5, >0.5-1, or >1 servings/d), energy-adjusted trans fat (1991-2003) (<2.5, >2.5-3, >3.5-4, or >4 g/d), energy-adjusted fiber intake (1991-2003) (<5-15, >15-20, >20-25, or >25 g/d), oral contraceptive use (1989-2005) (never, current, or past), smoking (1989-2005) (never, past [<7 pack years], past [<8 pack years], current [<8-19 pack years], or current [≥20 pack years]), parity (1989-2005) (never, current, or past).

c Change in slow walking, brisk walking, bicycle riding, and other activities were analyzed in the same model and are adjusted for 1989 baseline age, weight, slow walking, brisk walking, bicycle riding, and other activities, and total time sitting at home.

d Same model as described in footnote d plus adjustment for the additional covariates listed in footnote c.

e Other activities included jogging, running, swimming, other aerobic activities (eg, lawn mowing), aerobics, tennis, and stair climbing.

Figure. Increased and decreased bicycling and weight change. A, Increased bicycling: includes only women who did not initially bicycle (0 min/d) at baseline (1989) (n=9,556). The figure reflects the slope of weight change if women remained in the nonbicycling category in 2005 (reference) or if they increased their bicycling in 2005. B, Decreased bicycling: includes only women who initially bicycled for more than 15 min/d at baseline (1989) (n=15,056). The figure reflects the slope of weight change if women remained in the high bicycling activity category in 2005 (reference) or if they decreased their bicycling in 2005. Error bars represent the standard error for weight change. *Adjusted for 1989 baseline age, weight, plus the covariates listed in Table 2 footnote c.

odds of weight gain (P value for trend, <.001). The results appeared to be stronger in women with excess baseline weight compared with lean women. The mean [SE] weight gain was the smallest (5.5 [0.4] kg) in women who engaged in ≥4 h/wk or more of bicycling compared with women who bicycled for less time.
In this large 16-year prospective cohort study of premenopausal women, an increase in time spent bicycling was associated with a significantly lower change in weight, and this relationship was stronger among women with excess weight. For women who did not bicycle in 1989, less weight gain was evident for even a small increase to 5 min/d or less in 2005. Conversely, women who bicycled for 15 min/d or more in 1989 were at a higher risk of weight gain if they decreased or stopped bicycling in 2005.

Although brisk walking, unlike slow walking, has been suggested as a beneficial PA, only 39% of the women reported that they walked briskly at baseline, while 50% reported they walked slowly. Walking briskly can be difficult, especially for women who are overweight or obese or those with arthritis or other disabilities. 34 Overweight women spent half the time walking briskly (5.4 min/d) compared with lean women (10 min/d), while overweight and lean women spent comparable times bicycling (2.0 and 2.7 min/d, respectively).

Unlike discretionary gym time, bicycling could replace time spent in a car for necessary travel of some distance to work, shops, or school as activities of daily living. Bicycling could then be an unconscious form of exercise because the trip's destination, and not the exercise, could be the goal. 35 Research on bicycling in addition to walking is relatively new. 36 Although bicycling was found to be inversely associated with weight gain, fewer studies have included women, many studies have combined walking and bicycling, and several studies have been conducted in countries with bicycle environments different from the United States. Our findings agree with Littman et al, 37 who conducted a study in western Washington State and found that fast bicycling, and not slow walking, in nonobese men between the ages of 53 and 57 years was associated with weight attenuation. Though the age range was similar to the women in our study, this finding was only for lean men.

In France and Northern Ireland, Wagner et al 38 studied 8865 men aged 50 to 59 years and found that men who walked or bicycled to work for more than 30 min/d had a lower BMI of 0.3, a smaller waist circumference of 1 cm, and BMI change of 0.06 compared with men who did not walk or bicycle to work. While this study agreed with our positive association between brisk walking, bicycling, and obesity reduction, the study only included men and walking was not differentiated between slow and brisk, even though the walking time was more than 30 min/d.

In an Australian study that included men (n=3810) and women (n=3022), Wen and Rissel 39 found that men who bicycled to work (n=93) were significantly less likely to be overweight and obese (39.8%) compared with those who drove to work (60.8%), but these inverse relationships were not evident in the women studied (n=10), which could be owing to the lack of power. In men (n=195) and women (n=216), walking to work was not inversely associated with overweight or obesity, and the authors suggested that this may be because walking was not sufficiently vigorous or the distance was not great enough to affect weight. Their findings concur with ours. Bicycling by men in that study was associated with less weight gain.

Hemmingsson et al 40 conducted a randomized trial in abdominally obese women (age 30-60 years) with success defined as bicycling 2 km/d or more (primary) or walking 10 000 steps per day (secondary) for an 18-month duration. The intervention group members were given bicycles and followed a PA prescription of walking or bicycling, while the control group members were given program support and pedometers. The intervention group was more likely to bicycle than the control group (38.7% vs 8.9%), while both groups had the same compliance rates for walking. Both groups achieved similar waist reductions (−2.1 cm and −2.6 cm, respectively; P=0.72). Though none of the participants reported bicycling at baseline, 29% of the women bicycled as part of the intervention group. In our study, overweight and obese women bicycled for approximately the same amount of time as lean women but did not walk briskly for the same amount of time as lean women. The study conducted in Sweden supports our finding that overweight and obese women will bicycle and can then achieve weight control.

### Table 3. Odds Ratio of Gaining 5% or More of Baseline Body Weight Between 1989 and 2005 by Time Spent Bicycle Riding in 2005

<table>
<thead>
<tr>
<th>Time Spent Bicycle Riding in 2005</th>
<th>All women, No.</th>
<th>Mean weight change, kg (SE)</th>
<th>Simple OR (95% CI)</th>
<th>Multivariate OR (95% CI)</th>
<th>P Value for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 min/d</td>
<td>13 432</td>
<td>9.7 (0.1)</td>
<td>1 [Ref]</td>
<td>1 [Ref]</td>
<td></td>
</tr>
<tr>
<td>1-59 min/wk</td>
<td>2886</td>
<td>8.0 (0.2)</td>
<td>1.02 (0.83-1.01)</td>
<td>0.97 (0.88-1.08)</td>
<td></td>
</tr>
<tr>
<td>1-1.5 h/wk</td>
<td>1259</td>
<td>6.9 (0.3)</td>
<td>0.82 (0.56-0.81)</td>
<td>0.85 (0.70-1.02)</td>
<td></td>
</tr>
<tr>
<td>2-3 h/wk</td>
<td>564</td>
<td>5.6 (0.4)</td>
<td>0.56 (0.43-0.72)</td>
<td>0.71 (0.55-0.93)</td>
<td></td>
</tr>
<tr>
<td>≥4 h/wk</td>
<td>273</td>
<td>6.0 (0.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: Ref, reference.

a Adjusted for 1989 baseline age, weight, and bicycling.

b Adjusted for 1989 baseline age, weight, and bicycling; 1989 baseline and 2005 slow walking, brisk walking, other activity, and total sitting at home; plus the covariates listed in Table 2 footnote c.
While our research found significant associations between bicycling and less weight gain, dose-response associations, and greater benefits for overweight and obese women, as previously shown in other studies, our research also revealed how few women bicycled for a substantial period. Though 48% indicated that they bicycled and may have been on a stationary machine, they bicycled on average for only 2.5 min/d. Of these bicyclists, only 13% bicycled for 10 min/d or more at baseline and only 1.2% bicycled for 30 min/d or longer. Perhaps more women did not bicycle for longer periods because of a lack of bicycle environments comfortable to them and an emphasis in the United States on walking. Compared with bicycling, multiple studies have been conducted on walking, described as the near perfect form of exercise. Perhaps walking has been identified as beneficial because it has been compared, in the US car-centric nation, with not walking.41,42 The research that has been conducted on bicycling in the United States has included bicycle environments based on the American Association of State Highway and Transportation Officials (AASHTO) bicycle guidelines18 and the Federal Highway Administration (FHWA) teachings,19 which favor roads, lanes, and shared-use paths. The guidelines have been based primarily on the perceptions of male bicyclists perhaps because more men bicycle,21 and the studies have thus included a higher percentage of male respondents.8-10 Research conducted in Minnesota, Canada, and Australia has suggested that women have a greater preference for separation from vehicle traffic.44-47

Compared with the United States, the Dutch use 50- to 60-year-old male and female bicyclists as the design models in their bicycle facility guidelines,19 pp 39-56 and these guidelines detail bicycle-exclusive cycle tracks and cycle track intersection and curb cut treatments.19,46 On Dutch roads with car speeds of 80 km/h (49.71 mph), a separate cycle track is recommended parallel to the road, and on Dutch roads, which bicyclists share with cars, the recommended car speed is 30 km/h (18.6 mph).19 Though the Netherlands might be acclimated as a bicycle country, Canada’s Technical Handbook of Bikeway Design handbook features cycle tracks and other European bicycle facilities.49

As a result of being car-centric or being overly cautious about trying different bicycle facilities, in the United States, 9% of the population walks for commuting, whereas only 0.5% commutes by bicycle.24 In the Netherlands, 22% of the population walks and 27% commutes by bicycle.20 Individuals who have available comfortable bicycle infrastructure may still require individual determinants, such as self-efficacy and interest in bicycling, but they have, as a start, the infrastructure. Notably, if individuals have comfortable bicycle environments and they then bicycle, they are less likely to have medical risk factors and likely to have lower overall mortality.30,33

There are several limitations to this study. First, the sample was not a random sample from the United States and the women in the study were better educated (all nurses) and primarily white. Second, our PA measurements are inevitably imperfect, which would tend to attenuate the association between PA and weight control. While objective measures of PA may have been desirable, the validity of our self-reported PA questions has been documented.27,34 Third, the intensity of bicycling was not recorded, and the assessment did not discriminate between regular biking and riding a stationary bicycle. Fourth, only recreational PA was assessed and not total PA, (ie, not time spent in activity doing housework or nursing work). Finally, although the different activities were analyzed in terms of minutes per day, information about the frequency of bicycling is lacking from our questionnaires such that we are unable to determine if there is any difference between someone engaging in 70 min/wk all at once vs someone bicycling 10 minutes every day.

These limitations notwithstanding, there are several strengths. First, this research included a large sample size followed with repeated measurements over 16 years. Second, women with conditions affecting weight such as pregnancy-related or postpartum weight gain were excluded. Finally, information on a wide variety of potentially confounding behavioral and demographic variables was collected at every assessment, which allowed us to assess different activity types and weight change associations independent of these potential confounders.

In conclusion, bicycling, like brisk walking, is associated with reduced weight gain in premenopausal women, especially among overweight and obese women. In the United States, brisk walking should not only be encouraged, but additional research should also be conducted to determine which bicycle environments might be preferred by the largest percentage of the population, as in the Netherlands. If facilities were designed based on women’s requests, the outcome might lead to bicycle facilities in the United States that are comfortable to more people and facilitate greater weight control.

Accepted for Publication: December 16, 2009.
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Financial Disclosure: None reported.
Funding/Support: Dr Lusk is supported by Ruth L. Kirschstein National Research Service Award F32 HL083639 from the National Institutes for Health, National Heart, Lung, and Blood Institute. Dr Mekary is supported by grant R25 CA098566 from the National Institutes for Health. The Nurses’ Health Study II: Risk Factors for Breast Cancer in Younger Nurses was supported by grant R01 CA050385 from the National Cancer Institute.
Role of the Sponsors: The funding sources had no role in the study conduct and analysis and are not responsible for the views expressed herein.
Additional Contributions: Stephanie Chiuye, ScD, provided insightful comments on this topic. Lisa Li, MD, MPH, conducted the SAS program review.

REFERENCES


