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Bicycle Riding, Walking, and Weight Gain in Premenopausal Women

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Abstract

Context—No research has been conducted on bicycle riding and weight control in comparison to walking.

Objective—To assess the association between bicycle riding and weight control in premenopausal women.

Design, Setting, and Participants—This was a 16-year follow-up of 18, 414 women in the Nurses' Health Study II.

Main Outcome Measures—Weight change between 1989 and 2005 was the primary outcome and odds of gaining >5% of baseline body weight (BBW) by 2005 the secondary outcome.

Results—At baseline, only 39% walked briskly while only 1.2% bicycled for ≥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,−1.56), bicycling (−1.59 kg; 95%CI= −2.09, −1.08), and other activities (−1.45 kg; 95%CI= −1.66, −1.24) but not for slow walking (+0.06 kg; 95%CI= −0.22, 0.35). Women who reported no bicycling in 1989 and increased to as little as 5 minutes/day in 2005 gained less weight (−0.74 kg; 95%CI= −1.41, −0.07, P-*trend*<0.01) than those who remained non-bikers. Normal weight women who bicycled ≥ 4 hours/week in 2005 had lower odds of gaining >5% of their BBW (Odds Ratio (OR) =0.74, 95%CI=0.56–0.98) compared with those who reported no bicycling; overweight/obese women had lower odds at 2–3 hours/week (OR=0.54, 95%CI=0.34–86).

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

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[*]The authors contributed equally to the manuscript.

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INTRODUCTION

In 1995, the Centers for Disease Control and Prevention and the American College of Sports Medicine recommended that every US adult accumulate 30 minutes or more of moderate-intensity activity on most, preferably all, days of the week to address rising obesity and improve health;[1] similar recommendations were issued in 2008.[2] Nevertheless, 66% of adults are overweight or obese, 16% of children and adolescents are overweight, and 34% of children and adolescents are at risk of overweight in the U.S.[3]

Extensive research has been conducted on walking in relation to weight control,[4–6] but less has examined bicycling.[7] Of the studies conducted on bicycling, many have included primarily men,[8–11] combined walking and bicycling,[12–15] and been conducted in countries with different bicycle environments. In the U.S., roads, lanes, and shared-use paths are the recommended facilities,[16–18] while in the Netherlands, facilities include barrier-protected and bicycle-exclusive cycle tracks.[19] In the Netherlands, where bicycle riding is actively supported by an extensive network of bicycle exclusive cycle tracks, 27% of the population bicycles. Of this population of bicyclists, 55% are females.[20] In contrast, in the U.S., only 0.5% of the commuting population 16 years of age and older bicycles, of which only 23% are females.[21] In 2007, only 48% of the U.S. population engaged in the recommended levels of physical activity[22] in comparison to 64% in The Netherlands.[23] While based on different measures and not demonstrating causality, the obesity prevalence of men and women is 23.9% in the U.S. and 8.1% in the Netherlands.[24]

In previous papers, we reported that brisk walking was beneficial for prevention of weight gain among women with normal weight [25] and for maintenance after weight loss,[26] whereas nonbrisk walking (i.e. slow walking) was of little benefit except for women with excessive weight. We are extending this research to examine bicycle riding in association with weight gain in premenopausal women using data from the Nurses' Health Study II.

METHODS

Subjects

The Nurses' Health Study II (NHS II) is an ongoing prospective study of 116,608 U.S. female nurses aged 25–42 years in1989, 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 NHS II 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=2,820); reported extreme weight values <37 Kg or >182 Kg (n=1,291); reported extreme weight changes of >40 kg lost or >60 kg gained (n=15); had extreme baseline body mass index (BMI<15 or >45 kg/m^2) (n=670); had physical chronic conditions impairing exercise (n=3,380); were unable to walk in 1989 or 2005 (n=106); or reported >240 minutes/day of total PA (n=2285). Further exclusions included reporting myocardial infarction, stroke, angina, diabetes (n=8,759), or cancer (n=3,248) through 2005. After these exclusions, 18,414 healthy premenopausal women remained in the analysis.

Assessment of Physical Activity 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 (slower than 10 minutes/mile), running (10 minutes/mile or faster), bicycling (including stationary machine), calisthenics/aerobics/aerobic dance/rowing machine, tennis/squash/racquetball, lap swimming, or other aerobic activity (e.g. lawn mowing). For each activity, women chose one of 10 duration categories which ranged from zero to ≥11 hours per week. For walking, women reported their usual pace in 1989 and 2005: easy (<2 miles per hour - mph), average (2–2.9 mph), brisk (3–3.9 mph), very brisk (≥4 mph), or unable to walk. For simplicity in our analysis, slow and average walking paces were collapsed under "slow walking"; brisk and very brisk walking paces were collapsed under "brisk walking." Women were also asked in 1989 and 2005 to report the average number of flights of stairs climbed daily. Stair climbing (min/d) was then estimated. Total discretionary activity (min/d) was the sum of the duration reported in each of the nine activities reported at baseline and in 2005. The questionnaire has been validated in a random representative sample of NHSII participants (n=147).[27] Using past-week activity recalls and 7-day activity diaries as the referent methods, the correlation between activity reported on questionnaires and that of recalls was 0.79, and that reported on diaries was 0.62.

Duration of sitting at home was used as a measure of sedentary behavior (i.e., inactivity). In 1989, total sitting at home was collected with one general question ('How many hours per week do you spend sitting at home?'), which was later expanded to two specific questions in 2005 ('How many hours per week do you spend: 1-Sitting at home while watching TV/VCR? 2-Other sitting at home (e.g., reading, meal times and at desk)?'). Because inactivity and in particular, TV watching, has been associated with obesity [28] and this might confound the associations with PA, total sitting at home was included in our models.

Outcome definitions

Our primary outcome was defined as 16-year weight change between 1989 and 2005. The secondary outcome was defined as gaining more than 5% of weight from baseline in 1989 to the 16-year follow-up. Weight and height were assessed at baseline (1989), and weight was assessed on each follow-up questionnaire. Self-reported weight was strongly correlated in adults with measured weight (r=0.97).[29] Baseline body mass index (BMI; kg/m^2) was calculated from self-reported baseline height and weight.

Covariates

Diet components that have previously been observed to be predictive of weight gain[30–33] were included in the analysis. Using a validated FFQ, 1991 and 2003 intakes of sugar-sweetened beverages, energy-adjusted *trans*-fats, and energy-adjusted dietary fiber were included in the model to account for changes in these covariates. Alcohol consumption at baseline (1989) and 2003 was also included. The other risk factors for weight change in the multivariate models were smoking status (never, past, current), oral contraceptive use (never, past, current), parity (nulliparous, 1, 2, ≥3 births), and anti-depressant intake (never, past, current) at baseline and in 2005.

Statistical Methods

In the first set of analyses, multiple linear regression was used to assess the relation between change in total activity and change in weight over 16 years. Weight change was modeled as weight in 2005 as the outcome and 1989 baseline weight as a predictor. Both 1989 and 2005 activity were predictors in the model, therefore the beta for 2005 activity represented 16-year change. In a second model, total activity was partitioned among slow walking, brisk walking, bicycling, and other activities (the other seven assessed activities). Total activity and specific activities were modeled per an increase of 30 minutes a day, while holding the levels of other activities and covariates constant. We also conducted a stratified analysis by baseline weight status [underweight and normal weight (BMI<25 kg.m^{-2}) vs. overweight or obese (BMI≥25 kg.m^{-2})] to assess effect modification. There were no important differences across the age strata; thus, the results are not presented stratified by age.

Additionally, bicycling in 1989 and 2005 was categorized into 4 groups (0; ≤5; >5–15; and >15 min/d). The top and bottom categories in 1989 were cross-classified with the 4 categories in 2005 and were assessed in 2 other linear regression models.

To assess a dose response relationship between bicycling and weight gain, logistic regression was used to estimate the odds ratio (OR) of gaining >5% of baseline body weight at 16-year follow-up for categories of time spent bicycling at the end of this follow-up period (2005). Bicycling in 2005 was categorized into 5 groups using the collapsed categories from the questionnaire (0; 1–59 min/week; 1–1.5 hours/week; 2–3 hours/week; and ≥4 hours/week). Mean weight changes and their standard errors (SE) were calculated for each of the bicycling categories.

RESULTS

The 1989 baseline characteristics of the study population by levels of slow walking, brisk walking, and bicycling are displayed (Table 1). Fifty percent of the women reported they spent time walking slowly, 39% reported they spent time walking briskly, and 48% reported they spent time bicycling. For our sample, the average 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 average time spent sitting at home was five 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 to 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.

Physical activity types and 16-year weight change

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

In linear regression models using change in PA as a continuous variable 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 (−1.31 kg, 95%CI= −1.44, −1.18) while a 30 min/d increase in total time sitting at home was associated with greater weight gain (+0.21 kg, 95%CI= +0.18, +0.25) (Table 2). When we partitioned the change in total discretionary activity, the estimated weight gain for a 30 min/d increase in all women was significantly less for brisk walking (−1.81 kg; 95%CI = −2.05,−1.56), bicycling (−1.59 kg; 95%CI= −2.09, −1.08), and for other activities (−1.45 kg; 95%CI = −1.66, −1.24), whereas an increase in slow walking was not associated with less weight gain (+0.06 kg;

95%CI = −0.22, +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 $kg.m^{-2}$) compared to lean women (BMI <25 $kg.m^{-2}$) (P-interaction<0.01 for all), whereas slow walking continued to show no benefit even among overweight and obese women (−0.6 kg, 95%CI= −1.35, +0.16) (P-interaction=0.74).

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 increase in bicycling (−0.74 kg; 95%CI= −1.41, −0.07), and even lower weight gain was seen with greater duration of bicycling (P-trend<0.01) (Figure 1A). In comparison, women who initially bicycled for >15 min/d at baseline and who decreased their bicycling time in 2005 to >5–15 min/d gained more weight (+2.13 kg; 95%CI=0.35, 3.92), which accrued with more reduction in bicycling (P-trend<0.01) (Figure 1B).

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 to women who did not bicycle in 2005, those who engaged in bicycling ≥4 hours/week were less likely to gain weight (OR= 0.71, 95%CI=0.55–0.93) after controlling for other covariates (Table 3). There was a significant inverse dose response relationship between increased time spent bicycling in 2005 and odds of weight gain (P-trend<0.01). The results appeared to be stronger in women with excess baseline weight as compared to lean women. The mean weight gain was the smallest [5.5 (SE 0.4) kg] in women who engaged in ≥4 hours/week of bicycling as compared to women who bicycled for less time.

COMMENT

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 in 2005. Conversely, women who bicycled for ≥15 min/d 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 they walked briskly at baseline, while 50% reported they walked slowly. Walking briskly can be difficult, especially for women who are overweight/obese or those with arthritis or other disabilities.[34] Overweight women spent half the time walking briskly (5.4 min/d) compared to lean women (10 min/d) while overweight and lean women spent comparable times bicycling (2 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 U.S. 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 non-obese men between the ages of 53 and 57 was associated with weight attenuation. Though the age range was similar to the women in our study, this population only included lean males. In France and Northern Ireland, Wagner et al[38] studied 8865 men aged 50–59 and found that men who walked or bicycled to work for ≥30 min/d had a lower body mass index (BMI) of 0.3 kg/m^2, a smaller waist circumference of 1 cm, and body mass change of 0.06 kg/m^2 compared to 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 males and walking was not differentiated between slow and brisk even though the walking was ≥30 min/d.

In an Australian study which included men (n=3810) and women (n=3022), Wen and Rissel[39] determined that men who bicycled to work (n=93) were significantly less likely to be overweight and obese (39.8%) compared to those who drove to work (60.8%) but these inverse relationships were not evident in the women studied (n=10), which could be due to the lack of power. In both men (n=195) and women (n=216), walking to work was not associated with overweight or obesity and the authors suggested 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 the men in that study was associated with less weight gain.

Hemmingsson et al[36] conducted a randomized trial in abdominally obese women (30–60 years of age) with success defined as bicycling ≥ 2 km/d (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 and −2.6cm, 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/obese women bicycled for approximately the same amount of time as lean women but did not walk briskly the same amount of time as lean women. The study conducted in Sweden supports our finding that overweight/obese women will bicycle and can then achieve weight control.

While our research found significant associations between bicycling and less weight gain, dose response associations, and greater benefits for overweight/obese women, as previously shown in other studies,[25, 26, 40] our research also revealed how few women bicycled for a substantial period of time. Though 48% indicated they bicycled and, they 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 minutes/day 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 U.S. on walking. Compared to bicycling,[7] multiple studies have been conducted on walking, described as the "near perfect form of exercise."[5] Perhaps walking has been identified as beneficial because it has been compared, in the U.S. car-centric nation, to not walking.[41, 42] The research that has been conducted on bicycling in the U.S. has included bicycle environments based on the American Association of State Highway and Transportation Officials (AASHTO) bicycle guidelines[18] and the Federal Highway Administration (FHWA) teachings[43] which favor roads, lanes, and shared-use paths. The guidelines have been based primarily on the perceptions of male bicyclists perhaps because more males bicycle[21] and the studies have thus included a higher percentage of male respondents.[8–10] Research conducted in Minnesota, Canada, and Australia, suggested females have a greater preference for separation from vehicle traffic.[44–47]

Compared to the U.S., the Dutch use 50- to 60-year old male and female bicyclists as the design models in their bicycle facility guidelines[48] and these guidelines detail bicycle-exclusive cycle tracks and cycle track intersection and curb cut treatments.[19, 49] On Dutch roads with car speeds of 80 km/h (49.71 miles per hour), 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 miles per hour).[19] Though the Netherlands might be acculturated as a bicycle country, Canada's Quebec bicycle design handbook features cycle tracks and other European bicycle facilities.[50]

As a result of being car-centric or being overly cautious about trying different bicycle facilities, in the U.S., 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. [51–54]

Strengths and Limitations

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 Caucasian. 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, 55] 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 physical activity was assessed and not total physical activity, (i.e., not time spent in activity doing housework or nursing work). Finally, although the different activities were analyzed in terms of min/d, 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/week 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 post-partum 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.

CONCLUSION

Bicycling, like brisk walking, is associated with reduced weight gain in premenopausal women, especially among overweight/obese women. The U.S. should not only encourage brisk walking, but also conduct additional research 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 females' requests, the outcome might lead to bicycle facilities in the U.S. comfortable to more people and facilitate greater weight control.

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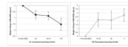

Figure 1.
Figure 1A includes only women who did not initially bicycle (0 min/d) at baseline (1989), (n=9,556). The figure reflects the slope of weight change if women remained in the non-bicycling category in 2005 (reference), or if they increased their bicycling in 2005.
Figure 1B includes only women who initially bicycled for >15 min/d at baseline (1989), (n=1,506). 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.
The T bars in both figures 1A and 1B represent the standard error for weight change (kg).
a) Adjusted for 1989 baseline age, weight, plus the covariates listed in Table 2 footnote c.

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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.

	WALKING					Biking		
	Zero	**Slow walking**		**Brisk walking**				
Minutes/day (min/d)	0	>0–9	10+	>0–9	10+	0	>0–9	10+
No of women	1,921	5,789	3,438	3,025	4,241	9,556	6,405	2,453
Age, years, mean	32.0	31.7	31.3	31.4	31.6	31.8	31.4	31.1
Total discretionary physical activity, min/d, mean	20.0	19.8	62.1	25.0	65.5	31.0	36.3	77.8
Total walking, min/d, mean	0	4.8	33.6	5.5	33.2	15.2	15.2	23.7
Slow walking, min/d, mean	0	4.8	33.6	0	0	7.6	7.4	9.7
Brisk walking, min/d, mean	0	0	0	5.5	33.2	7.7	7.8	14.0
Bicycle riding, min/d, mean	3.6	2.9	6.1	3.5	7.1	0	4.0	24.1
Other activities, min/d, mean	16.3	12.1	22.5	16.0	25.2	15.8	17.1	30.1
Body mass index at 1989, kg/m^2, mean	23.0	23.5	23.1	22.5	22.5	23.0	23.0	22.9
Weight change, 1989 to 2005, kg, mean	9.4	9.5	9.4	9.1	9.0	9.1	9.4	9.8
Sitting at home, min/d, mean	115	118	118	117	112	121	113	109
Energy intake, kcals/day, mean	1,710	1,784	1,835	1,780	1,788	1,778	1,797	1,794
Alcohol intake, grams/day, mean	3.2	2.9	3.2	3.4	3.4	3.0	3.2	3.7
Sugar-sweetened beverage intake[†], servings/day, mean	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.4
Trans-fat[‡], grams/day, mean	3.4	3.4	3.3	3.2	3.0	3.3	3.3	2.9
Fiber[‡], grams/day, mean	17.5	17.4	18.2	18.3	19.6	17.8	18.3	19.9
Current smoking, %	12.0	10.8	9.7	10.2	7.6	11.1	9.2	6.8

	WALKING					Biking		
	Zero	Slow walking		Brisk walking				
Oral contraceptive use, %	23.7	22.3	20.8	23.0	24.1	22.5	21.8	25.3
Parity, number of births, mean	1.1	1.3	1.2	1.0	0.9	1.2	1.1	0.9
Antidepressant use, %	0.5	0.3	0.3	0.3	0.4	0.4	0.4	0.2

† Sugar-sweetened beverages include sugar-sweetened carbonated beverages, punch, fruit drinks, lemonade, or ice tea.

‡ Energy-adjusted values.

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Table 2

Predictors of 16-year weight change [(a)] by 30 minutes/day increase in physical activity and inactivity between 1989 and 2005 among 18,414 US premenopausal women, for all women and for women stratified by 1989 baseline BMI (kg/m^2).

	All women (n=18,414)	BMI<25 (n=14,518)	BMI≥25 (n=3,896)	
Mean weight change 1989–2005 (SD) (kg)	**9.3 (9.7)**	**8.4 (7.9)**	**12.6 (13.4)**	
Model 1	**βeta (95%CI)**	**βeta (95%CI)**	**βeta (95%CI)**	**P-*interaction***
Total discretionary activity				
Simple model [(b)]	−1.52 (−1.65, −1.38)	−1.14 (−1.26, −1.02)	−3.06 (−3.49, −2.63)	
Multivariate-adjusted model [(c)]	−1.31 (−1.44, −1.18)	−0.94 (−1.06, −0.82)	−2.76 (−3.19, −2.34)	<0.01
Total sitting at home				
Simple model [(b)]	0.25 (0.21, 0.28)	0.22 (0.19, 0.26)	0.29 (0.20, 0.38)	
Multivariate-adjusted model [(c)]	0.21 (0.18, 0.25)	0.19 (0.16, 0.23)	0.23 (0.14, 0.32)	<0.01
Model 2				
Slow walking				
Simple model [(d)]	0.01 (−0.28, 0.30)	0.17 (−0.11, 0.45)	−0.70 (−1.48, 0.08)	
Multivariate-adjusted model [(e)]	0.06 (−0.22, 0.35)	0.16 (−0.12, 0.44)	−0.60 (−1.35, 0.16)	0.74
Brisk walking				
Simple model [(d)]	−2.07 (−2.32, −1.83)	−1.39 (−1.61, −1.17)	−6.10 (−7.01, −5.19)	
Multivariate-adjusted model [(e)]	−1.81 (−2.05, −1.56)	−1.13 (−1.35, −0.92)	−5.28 (−6.18, −4.38)	<0.01
Bicycle riding				
Simple model [(d)]	−1.82 (−2.33, −1.31)	−1.35 (−1.81, −0.89)	−3.30 (−5.07, −1.53)	
Multivariate-adjusted model [(e)]	−1.59 (−2.09, −1.08)	−1.12 (−1.58, −0.67)	−3.23 (−4.96, −1.50)	<0.01
Other activities [(f)]				
Simple model [(d)]	−1.63 (−1.85, −1.42)	−1.29 (−1.49, −1.10)	−2.99 (−3.75, −2.23)	
Multivariate-adjusted model [(e)]	−1.45 (−1.66, −1.24)	−1.11 (−1.30, −0.91)	−2.88 (−3.63, −2.14)	<0.01

Abbreviations: BMI= body mass index; CI= confidence interval;

(a) Based on linear regression coefficients (95% CI) for every 30 min/day increase in 2005 physical activity and inactivity; weight change in kg;

(b) In the simple model, the change in total discretionary activity and total sitting at home were analyzed in the same model and adjusted for 1989 baseline age, weight, total discretionary activity, and total sitting at home

(c) Adjusted for the factors listed in footnote b plus the following covariates: height (1989), total average alcohol intake (1989, 2003), (0; >0–<2.5; 2.5–5; >5–10; >10 g/day), sugar-sweetened beverage intake (1991; 2003) (0; >0–0.5; >0.5–1; >1 servings/day), energy-adjusted *trans*-fat (1991; 2003) (≤2.5; >2.5–3; >3–4; >4 g/day), energy-adjusted fibers (1991–2003) (5–15; >15–20; >20–25; >25 g/day), oral contraceptive use (1989, 2005) (never; current; past), smoking (1989; 2005) (never; past: 0–7 pack years; past: 8+ pack years; current: >0–19 pack years; current: 20+ pack years), parity (1989, 2005) (never given birth; one birth; two births; 3+ births), anti-depressant intake (1989, 2005) (never; current; past).

(d) 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, other activities, and total sitting at home

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

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

Table 3

Odds ratio of gaining≥5% of baseline body weight between 1989 and 2005 by time spent bicycle riding in 2005 while adjusting for baseline bicycling (1989) among premenopausal women, for all women and for women stratified by 1989 BMI

	Bicycle riding in 2005					P-*trend*
	0 min/d	**1–59 min/week**	**1–1.5 hrs/week**	**2–3 hrs/week**	**≥4 hrs/week**	
All women						
N	13,432	2,886	1,259	564	273	
Mean weight change, kg (SE)	9.7 (0.1)	8.6 (0.2)	8.0 (0.2)	6.9 (0.3)	5.6 (0.4)	
Simple OR (95%CI) [(a)]	1.00 (Ref)	0.92 (0.83–1.01)	0.79 (0.69–0.90)	0.68 (0.56–0.81)	0.56 (0.43–0.72)	
Multivariate OR (95%CI) [(b)]	1.00 (Ref)	0.97 (0.88–1.08)	0.94 (0.82–1.08)	0.85 (0.70–1.02)	0.71 (0.55–0.93)	<0.01
BMI<25						
N	10,391	2,382	1,045	469	231	
Mean weight change, kg (SE)	8.7 (0.1)	7.9 (0.2)	7.6 (0.2)	6.8 (0.3)	5.5 (0.4)	
Simple OR (95%CI) [(a)]	1.00 (Ref)	0.95 (0.85–1.05)	0.82 (0.71–0.94)	0.75 (0.61–0.92)	0.58 (0.44–0.76)	
Multivariate OR (95%CI) [(b)]	1.00 (Ref)	1.00 (0.90–1.12)	0.95 (0.82–1.11)	0.95 (0.76–1.17)	0.74 (0.56–0.98)	0.10
BMI≥25						
N	3,041	504	214	95	42	
Mean weight change, kg (SE)	13.1 (0.2)	11.9 (0.6)	10.2 (0.9)	7.4 (1.2)	5.7 (1.9)	
Simple OR (95%CI) [(a)]	1.00 (Ref)	0.78 (0.63–0.97)	0.68 (0.50–0.92)	0.43 (0.28–0.66)	0.47 (0.25–0.89)	
Multivariate OR (95%CI) [(b)]	1.00 (Ref)	0.86 (0.68–1.09)	1.02 (0.72–1.43)	0.54 (0.34–0.86)	0.53 (0.26–1.05)	0.01

[(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.