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Physical activity and weight gain after smoking cessation in postmenopausal women

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Abstract

Objective—Weight gain frequently occurs following smoking cessation. The objective of this study was to examine whether weight gain after smoking cessation was attenuated by PA in postmenopausal women.

Methods—4717 baseline smokers from the Women's Health Initiative (WHI) were followed for three years. 1282 women quit smoking, and 3435 continued smoking. Weight was measured at baseline and at the year 3 visit. PA was assessed at both times by self-report, summarized as metabolic equivalent task (MET)-hours per week. Multiple linear regression models were used to assess the association between PA and post-cessation weight gain, adjusting for potential confounding factors.

Results—Compared with continuing smokers, quitters gained an average of 3.5 kg (SD=5.6) between the baseline and year 3 visit. Quitters with decreased PA had the highest amount of weight gain (3.88 kg, 95% CI: 3.22-4.54); quitters with increased PA (15 MET-hours/week) had

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the lowest weight gain (2.55 kg, 95% CI: 1.59-3.52). Increased PA had a stronger beneficial association for post-cessation weight gain for obese women compared to normal weight women. Quitters who had low PA at baseline and high PA at year 3 and were also enrolled in a dietary modification intervention had non-significant weight gain (1.88 kg, 95% CI: -0.21-3.96) compared with continuing smokers.

Conclusions—Our data demonstrate that even a modest increase in PA (equivalent to current recommendations) can attenuate weight gain after quitting smoking among postmenopausal women, especially in combination with improved diet.

Keywords

Physical activity; smoking cessation; weight gain

BACKGROUND

Weight gain frequently occurs following smoking cessation.^{1, 2} Results from a meta-analysis showed that an average of 4-5 kg was gained after 12 months of smoking abstinence, the majority of which occurred within three months of quitting.¹ Concerns about post-cessation weight gain often discourage smokers from trying to quit.³ People may have unfounded fears that weight gain associated with quitting could carry its own negative health consequences that outweigh the benefits of quitting.^{4, 5} Thus, it is important to identify strategies to minimize weight gain following smoking cessation. However, a meta-analysis of clinical trial interventions including different pharmacological treatments or non-pharmacological programs (such as weight management education, low calorie diet, or exercise) for preventing weight gain after smoking cessation have shown these programs to be generally unsuccessful or inconclusive.⁶

Physical activity (PA) is a modifiable lifestyle factor relevant to weight control in the general population⁷ and in postmenopausal women.⁸ A meta-analysis⁶ reported no difference in post-cessation weight gain by exercise intervention versus the no exercise control group at the end of treatment (7-12 weeks), but a significant reduction in weight (about 2 kg) at one year post-intervention. To date, only two population-based cohort studies have evaluated the association between physical activity and weight gain among quitters, reporting conflicting results.^{9, 10} A study¹¹ among participants from a randomized control trial of smoking cessation treatment reported that there was no main effect of physical activity; however, quitters who decreased their physical activity had significantly greater weight gain than quitters who increased their physical activity or maintained a high level of activity. To date, no study has evaluated the relationship between PA and post-cessation weight gain in postmenopausal women, and additional studies are needed to understand the interaction between PA and smoking in the setting of weight gain after quitting smoking. Thus, the aim of this study was to examine whether post-cessation weight gain was modified by PA in postmenopausal women who quit smoking. We used the Women's Health Initiative (WHI), a large prospective cohort study in the US, with detailed information on potential confounders and measured weights. We hypothesized that quitters who increased PA or maintained high levels of PA would gain less weight than quitters who were less active.

METHODS

Women's Health Initiative

The WHI was designed to address the major causes of morbidity and mortality in postmenopausal women.¹² Details of the scientific rationale, eligibility requirements and baseline characteristics of the participants in the WHI have been published elsewhere.^{13–17} Briefly, a total of 161,808 women ages 50 to 79 was recruited from 40 clinical centers throughout the United States between September 1, 1993 and December 31, 1998. The WHI includes both clinical trial (CT) and observational study (OS) components. The WHI CT includes four overlapping components: two Hormone Therapy Trials, a Dietary Modification Trial, and a Calcium/Vitamin D Supplementation Trial. Participants in the OS included 93,676 women who were screened for the CT but were ineligible or unwilling to participate, or were recruited through a direct invitation for the OS. The study was approved by institutional review boards at all 40 clinical centers and at the coordinating center. All participants in WHI gave written informed consent.

Study population

All participants who reported that they were current smokers at baseline (N=8,895) in the WHI were considered for inclusion in this study. Current smokers were defined as reporting yes to the question “During your entire life, have you smoked at least 100 cigarettes?” and yes to a subsequent question “do you smoke now?” The following groups of women were excluded from 8,895 current smokers: 707 women who had a history of cancer (except non-melanoma skin cancer) at baseline; 1630 women who had prevalent diabetes or CVD at baseline; 215 women who developed CVD or cancer between baseline and the year 3 visit; 862 women who had missing weight change or physical activity change data between baseline and year 3 visit; 584 women who were older than 70 years old at baseline (because chronic disease often leads to weight loss among individuals aged 70 years and older¹⁸; and 180 women who had missing values on other covariates including number of cigarettes per day, alcohol intake and education. In the final sample, there remained 4717 women.

Measurements

Both exposure and outcome measurements were based on data from the baseline and year 3 follow up visit.

Quitters or continuing smokers—Women were defined as quitters if they reported not smoking at the year 3 follow-up visit; otherwise, they were defined as continuing smokers. Smoking intensity (cigarettes smoked per day) at baseline and the year 3 visit were also collected.

Weight gain—Weight gain was measured by the difference between participant weight in kilograms at year 3 and baseline. Weight was measured at clinic visits by trained personnel with a balance-bean scale using a standardized protocol.

Physical activity—PA was assessed during the baseline and year 3 visit. PA was determined by asking participants how often they were currently participating in different

types of PA (mild, moderate, and strenuous or very hard exercise) and the frequency (from never to 5 days/week) and duration (<20 minutes, 20–39 minutes, 40–59 minutes and one hour) of each exercise session. Examples of mild exercise included slow dancing, bowling, golf; examples of moderate exercises included biking outdoors, exercise machine use, calisthenics, easy swimming, and popular or folk dancing; and examples of strenuous activities included aerobics, jogging, and swimming. Walking outside the home for >10 minutes without stopping was measured separately. Frequency, duration and speed categories for walking were also measured.

Metabolic equivalent (MET) values were calculated by assigning strenuous, moderate, and low-intensity exercise as 7, 4, and 3 METs, respectively¹⁹. MET values were assigned for walking according to the speed (average 3 METs; fast 4 METs; and very fast 4.5 METs). MET-hours/week were computed by multiplying the MET level by the hours exercised per week, and summing the total values for measures of PA (total, walking, low-intensity, moderate-intensity, and strenuous-intensity).

Covariates—In the multivariable models, we considered potential confounders at baseline, including age at enrollment (continuous), race/ethnicity (American Indian or Alaska Native, Asian or Pacific Islander, Black or African-American, Hispanic/Latino, non-Hispanic white, and other), education (high school or less, some college/technical training, college or some post-college, and master or higher), smoking intensity (cigarettes smoked per day), alcohol intake (non-drinker, past drinker, current and <7 drinks/wk, current and ≥7 drinks/wk), history of hormone therapy use (none, estrogen alone, estrogen and progestin, mixed), total energy intake, total healthy eating index (HEI)-2005 score, baseline body mass index (kg/m², continuous), baseline PA (but not for method 3), and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs). Total energy intake was derived from the Food Frequency Questionnaire in the WHI. Total HEI-2005 score was a measure of diet quality that assesses conformance to the 2005 dietary guidelines for Americans.

Statistical Analysis

Baseline and year 3 characteristics of quitters and continuing smokers were described using frequencies and proportions for categorical variables and means (standard deviation [SD]) for continuous variables. Comparisons between the two groups were made using Chi-square tests for categorical variables and t tests for continuous variables. Multiple linear regression models were used to assess the association between PA and post cessation weight gain adjusting for potential confounding factors. Multivariable models were adjusted for potential confounders as described above in Covariates.

The association with PA was analyzed in three ways. First, change of PA was analyzed as a continuous variable. The interaction of change of PA and quitting (yes, no) on weight gain was assessed first. Because the interaction term was not significant, the main effects of quitting (yes, no) and change of PA on weight gain without the interaction term were then assessed (Method 1). Second, change of PA was defined as a categorical variable. The variable was categorized into no change in exercise (change of PA within ±5 MET-hours/

week), decrease in exercise (PA decreased more than 5 MET-hours/week), and increase in exercise (PA increased more than 5 MET-hours/week). This increase in exercise category was further divided by degree of increase in exercise (5-<15 and 15 MET-hours/week). 5 MET-hours/week was chosen because it was the median value in the distribution (Method 2). Third, a change pattern using both PA at baseline and year 3 was defined. Levels of PA at baseline and the year 3 visit were categorized first (e.g. low or high based on a median value of Met-hours/week), and then the pattern of change was defined as: low-low (low at baseline and low at year 3 visit), low-high (low at baseline and high at year 3 visit), high-low (high at baseline and low at year 3 visit), and high-high (high at baseline and high at year 3 visit). 5 MET-hours/week was used as the cut-point for low or high for physical activity (Method 3).

For continuing smokers, whether weight gain differed significantly in terms of change of physical activity level was assessed first. No significant difference in weight gain was observed in terms of change in physical activity level. Therefore, all continuing smokers as a group regardless of changes in physical activity were combined as a reference group.

Since the trajectory of weight gain shifts after age 70, our analysis was restricted to women younger than age 70 at baseline, and then was further stratified by 10-year age groups (50-59, 60-69). We further stratified analysis by baseline BMI and types of PA. Finally, a subset of women who enrolled in the Dietary Modification trial was used to assess whether a combination of increased PA and improved diet (being in the Dietary Modification intervention arm) can avert post smoking cessation weight gain. We performed a sensitivity analysis including women with chronic conditions (including cancer, CVD or diabetes) at baseline or between baseline and the year 3 visit.

RESULTS

Compared with continuing smokers, quitters were more likely to have higher education, a higher HEI-2005 score, higher BMI, greater waist circumference, and to be more physically active and smoke fewer cigarettes per day at baseline. There was no significant difference in age, race/ethnicity, prior hormone use, alcohol intake, total energy intake or waist-hip ratio between continuing smokers and quitters (Table 1). These lifestyle patterns were similar at year 3 between continuing smokers and quitters (Supplementary Table 1). Our results showed that new quitters tended to have better diet quality and increased physical activity than continuing smokers.

Overall, quitters gained on average 3.5 kg between the baseline and year 3 visits (Table 1). A similar amount of weight gain was associated with quitting after adjusting for potential confounders (Table 2 – Method 1). When change in physical activity was analyzed as a continuous variable, increasing physical activity was associated with slightly but significantly less weight gain (Table 2 – Method 1). When change in physical activity was analyzed as a categorical variable (Table 2- Method 2), compared with continuing smokers, quitters with a decrease in physical activity had highest weight gain (3.88 kg, 95% CI: 3.22-4.54); quitters who increased their amount of physical activity by 15 MET-hours/week had the lowest weight gain (2.55 kg, 95% CI: 1.59-3.52) (Table 2 – Method 2). Similarly, women with a high-low pattern of physical activity change (high at baseline and low at year

3 visit) had the highest weight gain (4.94 kg, 95% CI: 4.08-5.79), and women with high-high pattern of physical activity change had the lowest weight gain (2.63 kg, 95% CI: 2.15-3.12) (Table 2 - Method 3).

Although the interaction between quitting and change in physical activity was not significant when change of PA was analyzed as a continuous variable, results from pairwise comparisons when PA was analyzed as a categorical variable (Table 3) showed that post-cessation weight gain was significantly less in those who increased PA (≥ 15 MET-hours/week) compared to those who decreased PA ($p=0.02$). Similarly, post-cessation weight gain was significantly less in women with high-high PA than those with low-low PA ($p=0.0002$), or those with high-low PA ($p<0.0001$). In addition, post-cessation weight gain was also significantly less in women with low-high in PA than those with high-low PA ($p=0.002$). Women who reported low PA at baseline and moved to high PA after quitting had less weight gain compared to women who remained at low PA after quitting, although this finding did not reach statistical significance ($p=.08$). Finally, women who transitioned from low to high PA after quitting did not experience significantly different weight gain compared to women who were high-high in PA ($p=.17$).

The associations between increase in PA and weight gain differed by baseline BMI (Table 4). Increased PA had a stronger beneficial association for post-cessation weight gain for women who were obese compared to normal weight women. Obese women who had the largest increase in PA (≥ 15) experienced non-significant weight gain compared to continuing smokers. We provide basic statistics on the type of physical activity at baseline and year 3 visits in Supplementary Table 2. When analyzing stratified by different types of PA, similar patterns were observed for walking, the predominant form of exercises for postmenopausal women, to that for total PA, even though the cut-point was set at 2.5 MET-hours/week when change in physical activity was analyzed as a categorical variable (Supplementary Table 3). After stratifying the analysis by age (<60 versus ≥ 60 years), relations between PA and post-cessation weight gain appeared slightly stronger in younger than older women (Supplementary Table 4).

Based on a subset of women who enrolled in the Dietary Modification trial, compared with continuing smokers, quitters with increased physical activity ≥ 15 MET-hours/week had non-significant weight gain in both intervention and control arms. Quitters with low-high PA had non-significant weight gain (1.88kg, 95% CI: -0.21 -3.96) in the Dietary Modification intervention arm but had significant weight gain (3.05kg, 95% CI: 1.49-4.61) in the Dietary Modification control arm, although the p value for the interaction was not significant ($p=0.3$) (Table 5).

In a sensitivity analysis, after excluding only the women who were aged 70 or older ($n=1121$), or women with missing values on exposures or other relevant covariates ($n=1220$), 6554 women were left for the sensitivity analysis. We observed very similar results. For example, compared with continuing smokers, quitters with a decrease in physical activity had the highest weight gain (4.26 kg, 95% CI: 3.69-4.83); quitters who increased their amount of physical activity by ≥ 15 MET-hours/week had the lowest weight gain (2.43 kg, 95% CI: 1.60-3.27) (Table 3 – Method 2). Women with a high-low pattern of physical

activity change (high at baseline and low at year 3 visit) had high weight gain (5.06 kg, 95% CI: 4.33-5.77), and women with high-high pattern of physical activity change had low weight gain (2.85 kg, 95% CI: 2.41-3.28) (Table 2 - Method 3).

We also checked the interactions between type of study and exposures of interest and did not detect significant interaction terms (all P values for interaction terms >0.3). The baseline characteristics differences by type of study are provided in Supplementary Table 5.

DISCUSSION

In this large, prospective study of postmenopausal women, we confirmed that quitting smoking was associated with weight gain, despite slightly increased reported physical activity among quitters. However, our data also demonstrated that higher levels of physical activity can attenuate weight gain after quitting, even for moderate increases in physical activity less than current recommendations for physical activity for all adults (150 min/week in moderate intensity activities). For example, 5 MET-hours/week from walking is equivalent to walking for about 90 minutes at 3 miles per hour per week. Furthermore, we observed that women who had low PA but transitioned to high PA after quitting were not significantly different in weight gain from quitters who were high in PA at both times, indicating that being active after quitting is helpful regardless of pre-quit PA.

Our findings are in accord with some^{9, 11} but not all²⁰ previous studies examining the association between physical activity and post-cessation weight gain. In the Nurses' Health Study,⁹ in which women had a mean age of 52 years and weight was self-reported, weight gain was minimized if smoking cessation was accompanied by a moderate increase in physical activity. Excess weight gain was 2.3 kg (1.9-2.6) for women who did not change PA levels, 1.8 kg (1.0-2.5) for women who increased PA of 8-16 MET hours per week, and 1.3 kg (0.7-1.9) for women who increased PA by more than 16 MET-hours per week. Similarly, another study reported that quitters who decreased their physical activity levels had significantly greater weight gain than quitters who increased their physical activity or maintained a high level of activity¹¹. In contrast, in a small intervention trial that included an exercise plan as one of the components of a strategy to prevent post-cessation weight gain, Hall et al. failed to find an effect of the intervention on minimizing weight gain.²⁰ The authors²⁰ suggested the null finding may be due to the overall complexity of their intervention, which included not only the exercise regimen, but also caloric restriction and behavior modification. In another randomized controlled trial of using exercise as an aid for smoking cessation in women,²¹ among quitters, the exercise group participants had gained significantly less weight than controls at the end of treatment (8 weeks), but the effect did not hold for the 2 follow-up periods (20 weeks and 60 weeks).

The proposed mechanisms for weight gain after quitting smoking include decreased resting metabolic rate, increased energy intake, decreased physical activity and increased lipoprotein lipase activity.^{22, 23} However, we further examined whether post-cessation weight gain was associated with worsening diet or physical activity behavior by comparing total energy intake, alcohol intake, quality of diet and physical activity between continuing smokers and new quitters at both baseline and year 3. Our results showed that new quitters

tended to have better diet quality and increased physical activity than continuing smokers. Similarly, another study also reported that post-cessation weight gain was not explained by worsening diet or physical activity.¹⁰ However, we used a subset of women who enrolled in the Dietary Modification Trial in the WHI and observed that the combination of increased PA (low PA at baseline and high at year 3) and being in the dietary modification intervention arm resulted in non-significant weight gain after quitting, although the confidence interval was wide due to small sample size.

Several pharmacotherapies (such as dexfenfluramine, phenylpropanolamine or naltrexone) have been evaluated for preventing post-cessation weight gain. However, it seems that these medications delay, rather than prevent, post-cessation weight gain.^{6, 24} Several intervention studies that evaluated whether weight-related behavioral interventions (focused on managing caloric intake, increasing physical activity, or both) are effective in reducing post-cessation weight gain yielded inconclusive findings. Some studies reported evidence of the short-term benefit (i.e. within 6 months) of weight-control components in smoking cessation interventions for both smoking abstinence and weight control, but did not observe any long-term benefits.²⁵ Other studies reported no evidence that exercise interventions significantly reduced post-cessation weight gain at the end of treatment but found significant reduction at 12 months.⁶ However, studies have shown that physical activity is a key to maintaining weight loss.²⁶ Physical activity also can help to improve well-being and reduce the tension, anxiety, and stress associated with quitting.²⁷ In addition, smoking in our study did not appear to prevent overweight or obesity (BMI=26.5kg/m²).

Strengths of our study include its large sample and longitudinal design, measured weight, and examination of changes in dietary behaviors, alcohol intake, and physical activity. However, both smoking status and physical activity were self-reported, which may lead to some misclassification of quitters and continuing smokers and exposure status. A validation study has shown a weak correlation between self-reported expenditure from the WHI physical activity questionnaire and objectively measured total energy expenditure.²⁸ We also did not collect data on the exact point at which women quit between the baseline and year 3 visits. Thus, new quitters in our study may have included women who quit smoking just a few days before the year 3 visit and women who may have quit for several years prior to the questionnaire. If the length of time since quitting is associated with both changes in physical activity and weight gain, there may be residual confounding for which we could not adjust.

CONCLUSION

Our data demonstrate that among postmenopausal women who quit smoking, even modest increases in physical activity can attenuate weight gain after quitting. Future studies should determine if weight gain may be reduced through the combination of both increased physical activity and diet modification. Thus, quitters should be advised to maintain active life styles to attenuate weight gain.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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For a list of all the investigators who have contributed to WHI science, please visit: <https://www.whi.org/researchers/Documents%20Write%20a%20Paper/WHI%20Investigator%20Long%20List.pdf>

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Table 1

Baseline characteristics of 4717 women who were current smokers at baseline and changes in weight and physical activity by quitting status during the next 3 years

| | Continuing smokers Mean (STD) ^a or % (N=3435) | Quitters (n=1282) | P value |
|--|--|----------------------|---------|
| Age (mean, years) | 59.3 (5.4) | 59.4 (5.4) | 0.8 |
| Non- Hispanic white (%) | 79.0 | 79.7 | 0.5 |
| Education | | | <0.0001 |
| College degree or higher (%) | 31.0 | 36.3 | |
| Prior hormone use | | | 0.2 |
| Never | 48.6 | 46.2 | |
| Estrogen alone | 26.4 | 27.2 | |
| Estrogen plus progestin | 21.2 | 21.6 | |
| Mixed | 3.9 | 5.1 | |
| Alcohol intake (servings per week) | 3.7 (7.1) | 3.8 (6.9) | 0.7 |
| Diet | | | |
| Total energy intake (kcal) | 1631.6 (754.2) | 1624.8 (725.0) | 0.8 |
| Total HEI-2005 score | 60.3 (11.4) | 62.2 (11.1) | <0.0001 |
| Body mass index | 26.5 (5.2) | 27.3 (5.6) | <0.0001 |
| Waist/hip ratio (WHR) | 0.8 (0.1) | 0.8 (0.1) | 0.8 |
| Waist (cm) | 84.7 (12.8) | 86.0 (13.1) | 0.001 |
| Physical activity (MET-hrs/wk)^b | 8.6 (10.8) | 10.6 (12.5) | <0.0001 |
| Smoking intensity (cigs smoked per day) | 15.9 (10.0) | 10.0 (10.4) | <0.0001 |
| Weight gain (kg) | 0.4 (5.3) | 3.5 (5.6) | <0.0001 |
| Physical activity change (MET-hrs/wk)^b | 0.3 (10.0) | 1.1 (11.5) | 0.02 |

^aSTD – Standard deviation;

^bMET-hrs/wk – Metabolic equivalent (MET)-hours/week

Table 2

Association between total physical activity and weight gain after quitting smoking

| | Age-adjusted weight gain (kg) Coefficient (95% CI) | Multivariate -adjusted weight gain (kg) Coefficient (95% CI) ^b |
|---|---|--|
| Method 1: Change of PA^a in continuous | | |
| Quit (main effect) | 3.09 (2.74 3.43) | 3.45 (3.09 3.80) |
| Change of PA (main effect) | -0.03 (-0.05 -0.02) | -0.04 (-0.05 -0.02) |
| Method 2 | | |
| Continuing smokers | Reference | Reference |
| Quitters with decrease in PA (-5 MET-h/wk) | 3.59 (2.93 4.25) | 3.88 (3.22 4.54) |
| Quitters with no change in PA (within ±5 MET-h/wk) | 3.08 (2.62 3.54) | 3.44 (2.98 3.90) |
| Quitters with increase in PA | | |
| 5-<15 MET-h/wk | 2.87 (2.18 3.56) | 3.16 (2.47 3.85) |
| 15 MET-h/wk | 2.13 (1.16 3.11) | 2.55 (1.59 3.52) |
| Method 3 | | |
| Continuing smokers | Reference | Reference |
| Quitters | | |
| Low-low ^c | 3.60 (3.00 4.20) | 4.02 (3.42 4.62) |
| Low-high | 2.92 (2.19 3.65) | 3.22 (2.50 3.95) |
| High-low | 4.66 (3.80 5.52) | 4.94 (4.08 5.79) |
| High-high | 2.36 (1.88 2.83) | 2.63 (2.15 3.12) |

^aPA – physical activity (Metabolic equivalent (MET)-hours/week)

^bIn the multivariate models, we adjusted for age at enrollment, race/ethnicity, education, smoking intensity, history of hormone therapy use, alcohol intake, total energy intake, total HEI-2005 score, baseline body mass index, baseline physical activity (not for the method 3), and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs).

^cSince 5 Met-hours/week is a median value for physical activity at baseline and year 3, we used 5 as a cut-point for low or high for physical activity.

Table 3
P values for pairwise comparisons for weight gain after quitting smoking among physical activity change categories *

| Method 2 (PA ^a changes in quitters) | No change | Increase (5-<15) | Increase (>=15) | Method 3 (PA pattern in quitters) | Low-high | High-low | High-high |
|---|-----------|---------------------|-----------------|--------------------------------------|----------|----------|-----------|
| Decrease | 0.25 | 0.12 | 0.02 | Low-low | 0.08 | 0.07 | 0.0002 |
| No change | | 0.47 | 0.09 | Low-high | | 0.002 | 0.17 |
| Increase (5-<15) | | | 0.30 | High-low | | | <.0001 |
| Increase (>=15) | | | | High-high | | | |

^aPA – physical activity (Metabolic equivalent (MET)-hours/week).

* Pairwise comparisons were performed in the multivariate-adjusted models. In the models, we adjusted for age at enrollment, race/ethnicity, education, smoking intensity, history of hormone therapy use, alcohol intake, total energy intake, total HEI-2005 score, baseline body mass index, baseline physical activity (not for the method 3), and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs).

Table 4

Associations between change of physical activity and weight gain after quitting smoking stratified by BMI (kg/m²) at baseline

| | Normal weight (BMI<25) (n=2035) | Overweight (25 BMI<30) (n=1643) | Obesity (BMI 30) (n=1039) | P for interaction ^d |
|---|---|---|---|--------------------------------|
| | Multivariable -adjusted weight gain (kg, 95% CI)^b | Multivariable -adjusted weight gain (kg, 95% CI)^b | Multivariable -adjusted weight gain (kg, 95% CI)^b | |
| Method 1: Change of PA^a in continuous | | | | <0.0001 |
| Quit (main effect) | 3.21 (2.75 3.67) | 3.16 (3.58 3.74) | 4.07 (3.11 5.03) | |
| Change of PA (main effect) | 0.003 (-0.02 0.02) | -0.05 (-0.08 -0.03) | -0.1 (-0.15 -0.05) | |
| Method 2 | | | | 0.04 |
| Continuing smokers | Reference | Reference | Reference | |
| Quitters with decrease in PA (-5 MET-hrs/wk) | 3.01 (2.13 3.90) | 3.92 (2.78 5.07) | 5.28 (3.37 7.18) | |
| Quitters with no change in PA (within ±5 MET-hrs/wk) | 3.17 (2.54 3.79) | 3.28 (2.52 4.03) | 3.95 (2.77 5.13) | |
| Quitters with increase in PA | | | | |
| 5-<15 MET-hrs/wk | 3.30 (2.45 4.159) | 2.30 (1.10 3.49) | 3.94 (1.99 5.89) | |
| 15 MET-hrs/wk | 3.70 (2.41 4.98) | 1.83 (0.35 3.30) | 1.52 (-1.38 4.43) | |
| Method 3 | | | | 0.3 |
| Continuing smokers | Reference | Reference | Reference | |
| Quitters | | | | |
| Low-low ^c | 4.40 (3.47 5.33) | 3.74 (2.78 4.70) | 3.97 (2.60 5.37) | |
| Low-high | 3.75 (2.81 4.68) | 2.28 (1.04 3.52) | 3.71 (1.82 5.61) | |
| High-low | 4.62 (3.42 5.82) | 4.19 (2.82 5.57) | 6.49 (4.32 8.66) | |
| High-high | 2.21 (1.61 2.81) | 2.62 (1.80 3.44) | 3.37 (1.89 4.85) | |

^aPA – physical activity (Metabolic equivalent (MET)-hours/week).

^bIn the multivariate models, we adjusted for age at enrollment, race/ethnicity, education, smoking intensity, history of hormone therapy use, alcohol intake, total energy intake, total HEI-2005 score, baseline physical activity (not for the method 3) and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs).

^cSince 5 Met-hours/week is a median value for physical activity at baseline and year 3, we used 5 as a cut-point for low or high for physical activity.

^dP for interaction refers to the p-value for the interaction of baseline BMI category and change of physical activity between baseline and year 3 visit.

Table 5

Association between total physical activity and weight gain after quitting smoking among a subset of women (n=1442) who were in the diet modification trial

| | Diet modification trial | | P for interaction ^d |
|---|---|---|--------------------------------|
| | Intervention arm (547 women) | Controls arm (895 women) | |
| | Multivariable -adjusted weight gain (kg) Coefficient(95% CI) ^b | Multivariable -adjusted weight gain (kg) Coefficient(95% CI) ^b | |
| Method 1: Change of PA^a in continuous | | | 0.9 |
| Quit (main effect) | 3.33 (2.13 4.54) | 3.21(2.49 3.94) | |
| Change of PA (main effect) | -0.05 (-0.10 0.005) | -0.05 (-0.09 -0.02) | |
| Method 2 | | | 0.7 |
| Continuing smokers | Reference | Reference | |
| Quitters with decrease in PA (< 5) | 4.02 (1.38 6.67) | 3.48 (1.98 4.97) | |
| Quitters with no change in PA (within ±5) | 3.68 (2.09 5.26) | 3.10 (2.16 4.05) | |
| Quitters with increase in PA | | | |
| 5-<15 | 2.66 (0.34 4.98) | 3.78 (2.45 5.12) | |
| 15 | 1.45 (-1.31 4.20) | 1.05 (-1.12 3.23) | |
| Method 3 | | | 0.3 |
| Continuing smokers | Reference | Reference | |
| Quitters | | | |
| Low-low ^c | 4.41 (2.42 6.40) | 3.44 (2.24 4.64) | |
| Low-high | 1.88 (-0.21 3.96) | 3.05 (1.49 4.61) | |
| High-low | 6.68 (2.84 10.52) | 3.88 (2.07 5.69) | |
| High-high | 2.75 (1.06 4.45) | 2.80 (1.79 3.81) | |

^aPA – physical activity (Metabolic equivalent (MET)-hours/week)

^bIn the multivariate models, we adjusted for age at enrollment, race/ethnicity, education, smoking intensity, history of hormone therapy use, alcohol intake, total energy intake, total HEI-2005 score, baseline body mass index, baseline physical activity (not for the method 3), and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs).

^cSince 5 Met-hours/week is a median value for physical activity at baseline and year 3, we used 5 as a cut-point for low or high for physical activity.

^dP for interaction refers to the p-value for the interaction of DM arms and change of physical activity between baseline and year 3 visit.