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Physical activity patterns and prevention of weight gain in premenopausal women

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Abstract

BACKGROUND—Studies of the association between physical activity (PA) and weight maintenance have been inconsistent.

METHODS—We prospectively examined the association between PA patterns and prevention of weight gain among 46,754 healthy premenopausal women, aged 25–43 years in 1989. Participants reported their PA and weight in 1989 and 1997. The primary outcome was gaining >5% of baseline weight by 1997 (62% of the population).

RESULTS—Compared with women who maintained <30 minutes/day of total discretionary activity over 8 years, women were less likely to gain weight if they sustained 30+ minutes/day (Odds Ratio OR=0.68, 95% confidence interval [CI] 0.64–0.73) or increased to 30+ minutes/day in 1997 (OR=0.64, 95%CI=0.60–0.68). Among women whose only reported activity was walking, risk of gaining weight was lower in those who sustained 30+ minutes/day over 8 years (OR=0.66, 95%CI=0.49–0.91), and brisk walking pace independently predicted less weight gain. For a 30 minutes/day increase between 1989 and 1997, jogging/running was associated with less weight gain than brisk walking or other activities. Greater duration of PA was associated with progressively less weight gain, but even an 11–20 minutes/day increase was beneficial; the benefits appeared stronger among those initially overweight. Sedentary behavior independently predicted weight gain.

CONCLUSIONS—Sustained PA for at least 30 minutes/day, particularly if more intense, is associated with a reduction in long-term weight gain, and greater duration is associated with less weight gain. Sedentary women of any baseline weight who increase their PA will benefit, but overweight women appear to benefit the most.

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Keywords

weight gain prevention; loss; maintenance; weight change; obesity; physical activity; duration; type; intensity

Introduction

Over the past 30 years, the prevalence of obesity in US adults has more than doubled, from 12.8% in 1976–1980 to 34% in 1999–2004 (1–3), and more than 64% are overweight (BMI ≥25) (3). Women have tended to gain more weight than men with time (4). This epidemic is placing a great burden on the public's health, as excess body fat increases risk of many conditions, including osteoarthritis (5), musculoskeletal problems (6), gallstones (7), dyslipidemia (8), cardiovascular disease (9), diabetes (10), postmenopausal breast cancer (11), and poor self-esteem (12).

Obesity results from energy intake exceeding energy expenditure. Although some studies showed an association between physical activity (PA) and weight loss (13–18), weight loss maintenance (15–23), and less weight gain (19), other studies have found no association between PA and weight maintenance (24–26). Fewer studies have examined change in PA and change in weight, and the findings have been inconsistent (19). This discrepancy may be due to differences in activity assessments and weight maintenance definitions, as well as to various limitations, including a lack of longitudinal studies with long follow-up, small sample sizes, lack of adjustment for potential confounders, and lack of adjustments for baseline body weight. In addition, information is needed on the type and amount of exercise necessary to prevent weight gain in those who have never been obese, and to prevent additional weight gain in those with excess weight (27, 28).

To examine these issues in premenopausal women, a period in adult life with major weight gain, we used data from the Nurses' Health Study II to investigate the duration and type of PA required to prevent weight gain over eight years.

METHODS

Sample

The Nurses' Health Study II is an ongoing prospective study of 116,608 female nurses aged 25–43 years in 1989 when they responded to a mailed questionnaire about their medical history, lifestyle, and health-related behaviors. Follow-up questionnaires have been mailed biennially. Physical activity (PA) was assessed on the 1989 and 1997 questionnaires, and a food frequency questionnaire has been included every 4 years starting 1991. Additional details have been reported elsewhere (29).

For this investigation we excluded women who did not report their height in 1989 (n=230), PA, and weight in 1989 and 1997 (n=0), who were pregnant while reporting weight or within 12-month postpartum of reporting weight (n=17,497), or had chronic conditions impairing exercise (n=3,727). Further exclusions through 1997 included not being premenopausal (n=28,432); reporting activity values >240 minutes/day (n=7,498); reporting

myocardial infarction, stroke, diabetes (n=7,841), or cancer (n=2,472); reporting extreme weight values <37 Kg or >182 Kg (n=2,157) or extreme weight changes of >91 kg lost or >150 kg gained (n=0). After these exclusions, 46,754 women remained in the analysis.

Assessment of Physical Activity and Sedentary Behavior

In 1989 and 1997, participants were asked to report the average time spent per week in the previous year in each of the following activities: walking or hiking, jogging (slower than 10 minutes/mile), running (10 minutes/mile or faster), bicycling, calisthenics/aerobics/aerobic dance/rowing machine, tennis/squash/racquetball, lap swimming, or other aerobic recreation (e.g. lawn mowing). For each activity, women chose one of the 11 duration categories that ranged from zero to ≥11 hours per week. Women also reported their usual walking pace at baseline and 1997: easy (<2 miles per hour [mph]), average (2–2.9 mph), brisk (3–3.9 mph), very brisk (≥4 mph), or unable to walk. Women were also asked to report the average number of daily climbed stair flights. Minutes per day of stair climbing were estimated from the number of reported flights. Total discretionary activity was the sum of the duration reported in each of the nine activities, most of which are considered moderate to vigorous exercise, except for walking at an easy or average pace, which is considered a light activity. The questionnaire has been validated in a random representative sample of NHS II participants (n=147) (29). Using past-week activity recalls and 7-day activity diaries as the referent methods, the correlations between activity reported on questionnaires and reported by recalls or by diaries were 0.79 and 0.62, respectively. Self-reported weight and height were strongly correlated in adults (r=0.97) with measured weight and height (30).

Activity cut-points were based on activity distribution in our cohort and on physical activity (PA) recommendations from the Centers for Disease Control and Prevention and the American College of Sports Medicine (31, 32). In our sample, the mean value at baseline was 37 minutes/day (min/d) for total discretionary activity; the median value was 24 min/d. Based on benefits for different health outcomes, at least 30 minutes to 1 hour of moderate to intense exercise is recommended for adults on most days of the week (33). We thus chose a cut-off point of 30 min/d for low versus high total discretionary activity. Participants were cross-classified by their reported 1989 and 1997 activity levels, which yielded 4 groups [hi89hi97; hi89lo97; lo89hi97; lo89lo97]. In additional analyses, total discretionary activity in 1989 and 1997 was categorized into 5 groups (<10; 11–20; 21–30; 31–60; 61–240 min/d); each category in 1989 was cross-classified with the five 1997 categories, which yields 25 groups. This allowed us to assess potential dose-response relationship between PA changes and weight gain compared with one common reference group (lo89lo97). Similar analyses were repeated for walking and for jogging/running activities.

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 1997 (“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, at desk]?”). Because the total of two separate questions is often more than that from one question, the median values for

baseline (8 hours/week) and 1997 (16 hours/week) were used as cut-points to examine changes in inactivity.

Other Risk Factors

Weight and height were assessed at baseline (1989), and weight was assessed on each follow-up questionnaire. Baseline body mass index (BMI; kg/m^2) was calculated from self-reported baseline height and weight.

Because some components of dietary intake have been predictive of weight gain, they were included in the analysis. Using a food frequency questionnaire, intakes of sugar-sweetened beverages, energy-adjusted (34) trans-fat and dietary fiber were assessed in 1991 and 1995; an indicator variable for missing values of these covariates (10% in 1991 to 12% in 1995) was created, and both values (1991 and 1995) were included in the model to account for the changes in these covariates. Baseline and final values of smoking (never, past, or current) and of alcohol (1989; 1995) were included in the model. Oral contraceptive use (never, past, current), parity (nulliparous, 1, 2, 3 or more births), and anti-depressant intake (never, past, current) were also assessed and the most current data available (1997) was used in the analysis. All these risk factors, in addition to inactivity and baseline age were controlled for in our models.

Outcome definitions

The primary outcome was defined as gaining more than 5% of weight from baseline in 1989 to the 8-year follow-up. The secondary outcome was 8-yr weight change from 1989 to 1997.

Statistical Methods

In the first set of analyses, logistic regression was used to estimate the odds ratio (OR) of gaining > 5% of baseline weight at 8-year follow-up with change in activity duration in this period as the primary predictor. The independent associations of walking and jogging/running with weight gain were also assessed. In these analyses, we examined women who exclusively walked and engaged in very little other activity (<10min/d) and women who exclusively jogged/ran with little walking (<20min/d) or other activities (<10min/d). We focused on these particular types of activity because walking was the most common activity, and because jogging and running tend to reflect unambiguous vigorous activity, as opposed to biking or swimming, which may be performed at very different intensity levels.

In a second set of analyses, the association of activity subtypes with 8-year weight change was analyzed using a partition model in a multiple linear regression analyses after adjusting for the same covariates mentioned above. Weight change was modeled as weight in 1997 as the outcome and baseline weight as a covariate. Thus, results are presented as 8-year average weight change, without considering any fluctuations in weight between 1989 and 1997. Activity, represented as continuous variables, was partitioned among brisk walking, non-brisk walking, jogging/running, other activities (biking, swimming, mowing, aerobics, tennis, stair climbing). Estimates from these linear regression models represent the effect of increasing one type of activity by 30 min/d, while holding constant other activity levels. In two other linear models, the lowest and highest activity categories in 1989 were cross-

classified with the 5 categories in 1997. We also conducted linear regression analyses stratified by baseline BMI using 25 and 30 cut-offs. Because there were no important differences across the age strata, we do not present results stratified by age.

RESULTS

Baseline median total discretionary activity was 24 min/d, and 12.3% of the women reported ≤5 min/d. Walking was the most popular activity in this cohort, contributing to 42.2% of the total min/d. Active women had a lower BMI at baseline, consumed more calories; alcohol; fiber, and less *trans*-fat and sugar-sweetened beverages (Table 1). They were also less likely to smoke, had a higher usage of oral contraceptives, fewer pregnancies, and spent fewer hours sitting at home. Though 72.1% of the women were able to avoid gaining >5% of their 1989 weight by 1991, this percentage dropped to 38% after 8 years. While these women (38%) maintained a high level of PA averaging around 36 min/d (median=26 min/d) during the 8-year follow-up, their counterparts gradually decreased their PA from an average baseline of 36 min/d to an average of 28 min/d (median=19 min/d).

Total discretionary physical activity pattern and prevention of weight gain

Compared to women with less than 30 min/d of activity in both 1989 and 1997, those who engaged in ≥30 min/d of activity in both 1989 and 1997 or who increased their activity pattern from low (<30 min/d) to high (≥30 min/d) in 1997 were less likely to gain weight (ORs = 0.68, 95% CI 0.64–0.73, and 0.64, 95% CI 0.60–0.68, respectively; Table 2A). Thus, as long as the activity level was high in 1997, women were less likely to gain weight whether or not the activity level was high at baseline. Conversely, as long as the activity level was low in 1997, women were at risk of gaining weight irrespective of the baseline activity level. Sedentary behavior was independently associated with an increased risk of weight gain. Multivariate results were not very different from age-adjusted results, suggesting little confounding.

Walking pattern and weight gain prevention

With a cut-off of 30 min/d, women who maintained a high level of walking (OR=0.66, 95% CI 0.49–0.91) and women who increased to that level (OR=0.65, 95% CI 0.57–0.75) were less likely to gain weight (Table 2B). In the same multivariate model, maintaining a brisk pace (OR=0.69; 95%CI=0.58–0.82) was found to be a significant predictor for weight gain prevention as opposed to maintaining an average (OR=0.89; 95%CI=0.75–1.05) or easy pace (referent). Women who increased to average (OR=0.77; 95%CI=0.63–0.95) or to brisk (OR=0.60; 95%CI=0.50–0.72) were also significantly less likely to gain weight.

Jogging/running pattern and weight gain prevention

Women who maintained ≥ 20 min/d of jogging or running had a significantly lower odds of weight gain after 8-years (OR=0.37, 95% CI 0.20–0.70) compared to less active women (Table 2C). Compared to walking, jogging/running offered more protection against weight gain, and an increase in duration of jogging/running was associated with lower odds of weight gain (OR=0.45, 95% CI 0.32–0.61).

Changes in physical activity types and weight gain

In logistic models evaluating changes in min/d of activity types between 1989 and 1997, odds of weight gain were somewhat elevated for those who were highly active in 1989 (60–240 min/d) but decreased their PA in 1997 to 0–10 min/d (OR=1.23, 95%CI=1.06–1.41), or to 11–20 min/d (OR=1.21, 95%CI=1.04–1.40), but not to 21–30 min/d (OR=0.97, 95%CI=0.84–1.12). Furthermore, even a small increase in total discretionary activity to 11–20 min/d in 1997 was associated with reduced odds of weight gain (OR=0.75, 95%CI=0.68–0.83), compared with the reference category (lo89lo97). There was a significant overall trend of lower odds of weight gain with increased PA over time (overall P for trend <0.001), and a similar inverse dose-response relationship was seen at all levels of baseline activity (figure 1A). A similar pattern for weight gain was seen with changes in walking (figure 1B, overall p for trend<0.001) or jogging/running (figure 1C, overall p for trend<0.001), with no apparent threshold.

Physical activity types and weight change

On average, women gained 5.7 kg between 1989 and 1997. In linear regression models using change in physical activity (PA) as a continuous variable controlling for baseline activity, a 30 min/d increase in activity between 1989 and 1997 was associated with less weight gain (−1.03 kg, 95%CI= −1.10, −0.97) (Table 3). When we partitioned change in total discretionary activity, the estimated weight gain for a 30 min/d increase was less for jogging/running (−2.54 kg; 95%CI= −2.83, −2.24) than for brisk walking (−1.32 kg; 95%CI = −1.44, −1.20), non-brisk walking (−0.15 kg; 95%CI = −0.29, −0.01), or other activities (−1.06 kg; 95%CI = −1.17, −0.96).

We observed that for the same activity increase by 30 min/d between 1989 and 1997, the benefit of increased activity was greatest among overweight (−1.69 kg; 95%CI = −1.90, −1.48) and obese women (−2.91 kg; 95%CI = −3.30, −2.52) as compared to normal weight women (−0.70 kg; 95%CI = −0.75, −0.64). An increase of 30 min/d of slow walking was associated with less weight gain only in obese women. We also examined different 8-year activity increases among women who were initially low in activity level (0–10 min/d; see figure 2A), and activity decreases among women who were initially high in activity level (61–240 min/d; see figure 2B), stratified by baseline BMI. With increasing amounts of discretionary PA, less weight gain was seen in all BMI groups, with lower weight gains with greater duration of PA (P-trend<0.001 for all BMI groups), and even 11–20 min/d increase was beneficial. In addition, for the same increment in PA, obese women appeared to benefit the most. On the other hand, for the same decrease in PA, obese women gained more weight than overweight or lean women (Figure 2B). All of the above results were consistent when we looked at relative weight gain (percent weight gain from baseline).

The variation in weight was large, which can be appreciated by the 10^{th} and the 90^{th} percentile in weight change. For instance, over the eight years, the average (unadjusted) weight gains were 5.7 kg for all women (10^{th} percentile= −0.9 kg; 90^{th} percentile= 14.5 kg). Similarly, while women who remained inactive (<10 min/d) over the 8 years gained 6.8 kg (10^{th} percentile= −0.45 kg; 90^{th} percentile=15.9 kg), those who increased their activity up to

21–30 min/d gained less weight on average (4.6 kg; 10th percentile= −2.3 kg; 90th percentile=12.7 kg).

DISCUSSION

In this large cohort of women, greater duration of daily physical activity (PA) was associated with less weight gain over eight years and a significant dose-response relationship was evident. Benefits were seen with an increase in PA as little as 11–20 min/d, and we found no evidence of an upper threshold. For the same activity duration, jogging/running appears to be the most protective against weight gain, indicating that the intensity of an activity can modify the duration necessary to prevent gain. Brisk walking was an independent predictor of less weight gain. Sedentary behavior was associated with weight gain independent of activity level, and the benefit of increased PA appeared to be greater in overweight/obese women than in normal weight participants.

National PA recommendations, which were developed to reduce the risk of developing chronic disease morbidities, have changed over time. These have included from 20-minute of continuous vigorous PA on at least 3 days/week (31, 33); 30 min/d of moderate PA on most days of the week (31, 35–37); 60 min/d of moderate to vigorous PA on most days of the week while not exceeding caloric intake to prevent unhealthy weight gain in adults (38); at least 60 to 90 min/d moderate-intensity activity while not exceeding caloric intake requirements to sustain weight loss (38); 30–60 minutes of moderate to vigorous PA on 5 or more days of the week (39); and 150 minutes/week (21 min/d) (32, 40) to 250 minutes/week (36 min/d) of moderate-intensity (32), or 75 minutes/week (11 min/d) of vigorous-intensity aerobic physical activity (40). In our 8-year prospective investigation among premenopausal women, 30 or more min/d of total discretionary PA were associated with lower likelihood of weight gain, but our findings suggest a dose-response relationship with no clear threshold suggesting that persons may benefit more by exceeding the minimum recommended amounts of PA. Even a small increase in sedentary women (up to 11–20 min/d) appears beneficial. These findings are consistent with most other longitudinal studies (23) and health related statements (37). One cross-sectional study of 4,769 male runners (41) and another longitudinal study of 4,599 men and 724 women (42) showed that long-term maintenance of a given fitness level was not sufficient to prevent aging-related weight gain, and that increasing amounts of activity may be needed to maintain weight with increasing age. These findings are not entirely incongruent with ours which suggest that maintaining a high level of activity (or increasing it) reduces – but does not prevent- the risk of age-related weight gain. In fact, using linear regression models, the estimated amount of discretionary PA needed to prevent weight gain (zero average weight gain from 1989 to 1997 during 8 years) was 3.7 hours/day for women with BMI<25; 2.6 hours/day for women with 25≤BMI<30; and 1.6 hours/day for women with BMI>30. Additionally, the estimated amount of discretionary PA required to prevent a weight gain of 5% or more was 1.6 hours/day for women with BMI<25; 1.5 hours/day for women with 25≤BMI<30; and 0.75 hours/day for women with BMI>30. Because it is hard for many people to spend so much time in discretionary PA, a combination of PA and other strategies, such as restrained energy intake, may be needed to avoid age-associated weight gain. It should be kept in mind that these results cannot be generalized to all women because of the following reasons: 1) more

exercise may be needed after an intentional weight loss to maintain the loss; 2) our sample did not include men or women in their 20s; 3) we excluded women who had recently been pregnant at the time that they reported weight because they had additional weight to lose; and 4) we allowed for up to 5% weight gain in our definition of weight gain prevention. In fact, the estimated amount of PA varied between 1.6 hours/day in lean women and 45 min/d in obese women when we allowed <5% weight gain. Notably, according to NIH (4), losing 5 to 10% of baseline body weight is considered a clinically significant weight loss to reduce the risk factors of diabetes and heart disease. This explains our rationale for selecting 5% as the cut-off and anything below 5% to be within the weight maintenance range.

Schmitz et al.(23) found that among 2,617 young adult men and women (18–30 years) followed for 5 years, body weight could be maintained whether or not PA was maintained Also, Owens and colleagues (43) found that baseline activity was associated with weight gain prevention at 3-year follow-up in a study of 500 peri-menopausal women (42–50 years). Our results seemed to indicate otherwise as attenuation of weight gain appeared to depend on the activity during the later part of follow-up; women who remained or became highly active towards the end of the follow-up experienced less weight gain regardless of their baseline activity. Also, our results appeared to indicate that baseline activity was not associated with 8-year weight gain prevention. These discrepancies may reflect their smaller sample size and their shorter follow-up.

Among women whose only type of activity was walking, walking pace and duration were both important for long-term weight gain prevention. Non-brisk walking was not associated with weight gain prevention except for obese women. Our results are consistent with other studies (13, 36).

Comparing the different PA types, our findings strongly suggest that the form of PA is not as important as total energy expenditure. For instance, whether 600 kcalories/day were spent by jogging for 30 min/d or by brisk walking for 60 min/d, total energy expenditure mattered the most for weight gain prevention regardless of PA type.

Baseline BMI modified the association with total PA pattern, as women with excess weight benefited more than their leaner peers at any level of PA. These results are consistent with other longitudinal studies (15, 23, 44). One interpretation is that heavier individuals tend to burn more calories per activity unit (say walking a mile) as compared to lean individuals (45); Hence, once the body weight drops, more PA is needed to maintain the reduced body weight.

There are several limitations to the present study. First, dietary data were initially collected in 1991 while other baseline data were collected in 1989. However, in this analysis, excluding the dietary variables from the models did not meaningfully affect the results. Second, we could not look at the change in TV viewing as an independent predictor, because it was not included as a separate question on the 1989 questionnaire, although it has been consistently associated with obesity (46). Therefore, we used total hours of sitting at home in 1989 and we combined the time sitting watching TV/VCR with other sitting at home for 1997 to evaluate the change from 1989 to 1997. Third, the sample was not a random sample

from the United States. Moreover, we did not include women who were pregnant or recently pregnant. Thus it is not clear whether these results can be generalized to pregnancy-related weight gain. However, the relationship between pregnancy and weight gain is more complicated and deserves a separate investigation (47). Fourth, there may be other confounders that may contribute to weight gain and to lower activity such as viral, bacterial, endocrinal, or genetic factors were not accounted for in our analysis because the information was not available to us. Fifth, there may be other types of activities such as weight training or sleep that could have an impact on the body weight; we could not account for these variables because they were not included in all of our questionnaires. Also, our measurements of PA were inevitably imperfect, which will have tended to underestimate the benefits of PA and overestimate the amount of PA needed to prevent weight gain. While objective measures of PA may have been desirable, the validity of our PA questions has been documented (29).

Despite these limitations, there are several strengths to our study. First, it included a large sample of women followed with repeated assessments over an 8-year period. Second, we were able to control for sedentary behavior by using the total number of hours sitting at home. Moreover, information on a wide variety of potentially confounding behavioral and demographic variables was collected at each assessment, which allowed us to assess activity patterns and weight change associations independent of these potential confounders. Finally, we were able to exclude women with conditions affecting weight, such as pregnancy-related or post-delivery weight gain.

Our findings underscore the importance of specifying both, the duration and the intensity of PA for weight gain prevention, though other factors related to both weight gain and activity may affect the association. Increased duration of PA was associated with progressively less weight gain, and even an 11–20 min/d increase was beneficial; the benefits appeared stronger among those initially overweight; nevertheless, lean women benefited as well. Sedentary behavior was independently associated with weight gain. The results offer further justification for recommending that adults of any weight engage in activity on a daily basis.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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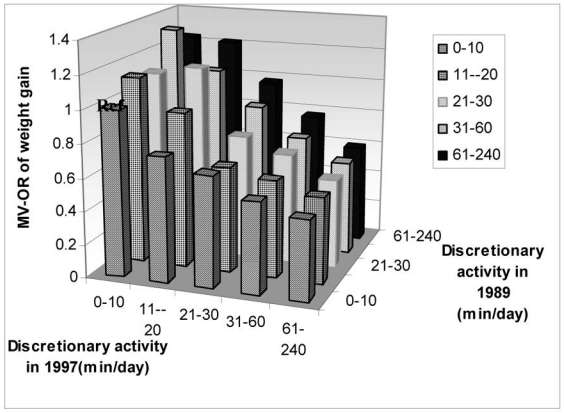

Figure 1A. Change in total discretionary physical activity (min/day)

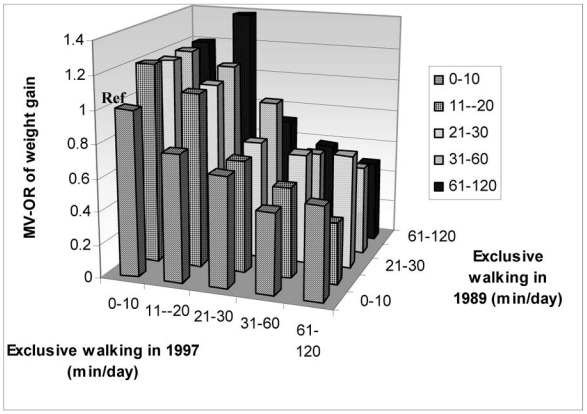

Figure 1B. Change in exclusive walking (min/day)

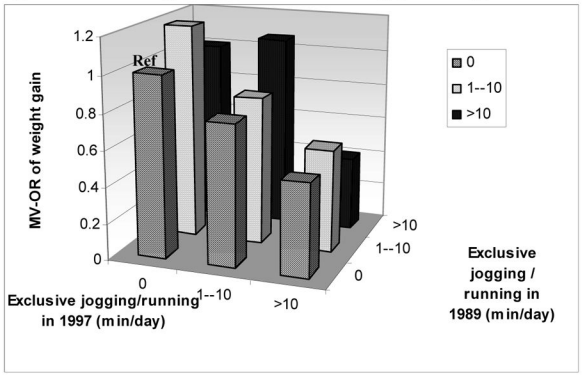

Figure 1C. Change in exclusive jogging/running (min/day)

Figure 1.

Figures 1A–B–C. The reference category (Ref) reflects women who were initially low in physical activity in 1989 and who remained in this low category in 1997.

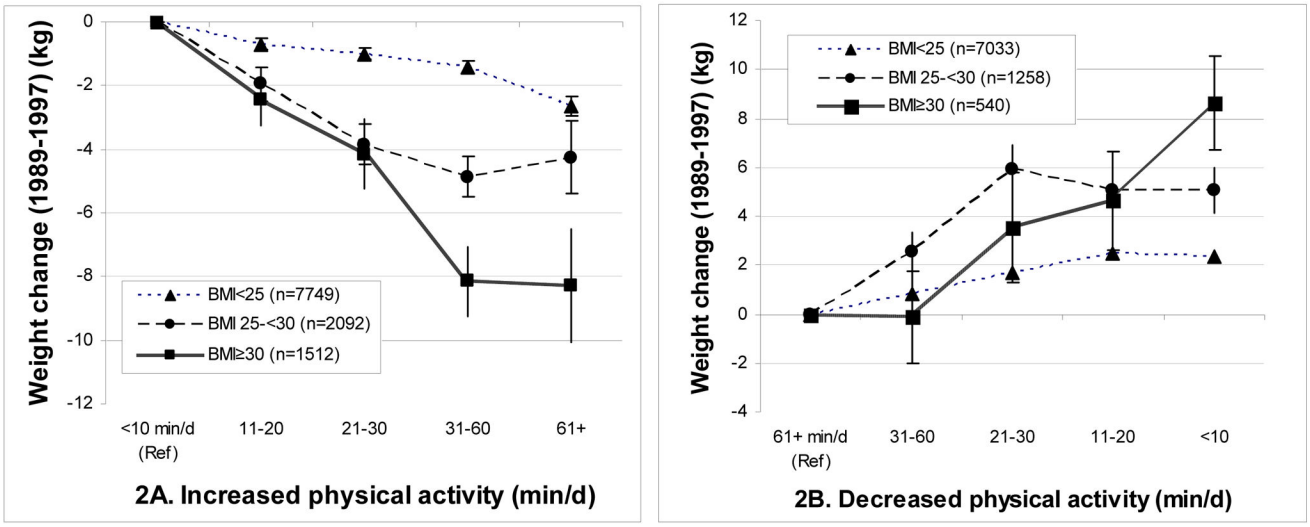

Figure 2. Association of 8-year change in total discretionary activity with 8-year weight change, stratified by 3 levels of 1989 BMI

Figure 2A includes only women who were initially low in physical activity (<10 min/d) at baseline (1989), (n=11,353). The figure reflects the slope of weight change if women remained in the low physical activity category in 1997 (reference), or if they increased their activity in 1997 to 11–20 min/d or more, for each BMI category

Figure 2B includes only women who were initially high in physical activity (61+ min/d) at baseline (1989), (n=8,831). The figure reflects the slope of weight change if women remained in the high physical activity category in 1997 (reference), or if they decreased their activity in 1997 to 31–60 min/d or less, for each BMI category.