



Smokers' physical activity and weight gain one year after a successful versus unsuccessful quit attempt



Keith P. Gennuso^{a,*}, Keith M. Thraen-Borowski^b, Tanya R. Schlam^{c,d}, Tara L. LaRowe^e, Michael C. Fiore^{c,d}, Timothy B. Baker^{c,d}, Lisa H. Colbert^b

^a Department of Population Health Sciences, University of Wisconsin–Madison, 507A Warf Office Building, 610 Walnut St, Madison, WI 53726, USA

^b Department of Kinesiology, University of Wisconsin–Madison, 2057 Gymnasium–Natorium, 2000 Observatory Dr, Madison, WI 53706, USA

^c Center for Tobacco Research and Intervention, Department of Medicine, University of Wisconsin–Madison, 1930 Monroe St, Suite 200, Madison, WI 53711, USA

^d Department of Family Medicine, University of Wisconsin–Madison, 1930 Monroe St, Suite 200, Madison, WI 53711, USA

^e Department of Family Medicine, University of Wisconsin–Madison, 1100 Delaplaine Ct, Madison, WI 53714, USA

ARTICLE INFO

Available online 2 August 2014

Keywords:

Smoking cessation
Weight gain
Physical activity
Walking
Obesity

ABSTRACT

Objective: To examine whether smokers' physical activity is related to weight change following a quit attempt.

Method: Data were analyzed for participants ($n = 683$) of a randomized controlled trial comparing the efficacy of different smoking cessation pharmacotherapies (Wisconsin, 2005–2008). Activity (assessed via pedometry) and body weight were measured in the days surrounding the quit day and again one year later, at which time 7-day point-prevalence abstinence from smoking was assessed. We examined the effects of quitting, physical activity, and their interaction, on a one-year weight change with relevant covariate adjustment.

Results: Participants were predominantly female (57%), 46 ± 11 years of age (mean \pm SD), and took 7544 ± 3606 steps/day at baseline. Of those who quit, 87% gained weight. A main effect was found for quitting ($p < 0.001$), but not physical activity ($p = 0.06$). When pattern of activity was examined across the 1-year study period, quitters who decreased their physical activity had significantly greater weight gain than quitters who increased their physical activity ($p < 0.01$) or maintained a high level of activity ($p = 0.02$).

Conclusion: Physical activity is associated with an attenuation of the weight gain that often occurs after quitting smoking.

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Introduction

Smokers are generally lighter and leaner than non-smokers (Froom et al., 1999; Kvaavik et al., 2004; Lissner et al., 1992), and concern about weight gain may prevent some smokers from undertaking a quit attempt (Klesges et al., 1988; Meyers et al., 1997). This concern is warranted as quitters have approximately a 5.8-fold risk of major weight gain when compared to non-quitters (Williamson et al., 1991) with a weight gain averaging 4–9 kg, depending on gender and time since quitting (Klesges et al., 1997; O'Hara et al., 1998; U.S. Dept of Health and Human Services, 2001). Although quitting smoking is clearly desirable and beneficial to health, the weight gain associated with quitting could carry its own set of negative consequences, and it would be beneficial to identify factors that can influence weight gained after cessation.

Physical activity is a modifiable factor relevant to weight gain and weight maintenance in the general population (Westerterp et al., 1992). Smokers, however, despite their lower weights, tend to be less active in their leisure-time than their non-smoking peers (Britton et al., 2000; Kvaavik et al., 2004; McTiernan et al., 1998; Revicki et al., 1991). Given this background, exercise alone or in combination with other treatments has been examined for its ability to ameliorate weight gain associated with smoking cessation (Farley et al., 2012). A meta-analysis of interventions suggests that although weight gain is not impacted at the end of treatment, there is a modest effect (~ 2.0 kg) at one-year post-treatment (Farley et al., 2012). Only one prior longitudinal study has looked specifically at weight gain and activity in smokers who quit (Kawachi et al., 1996). To date, the benefits of physical activity in ameliorating weight gain associated with smoking cessation are inconclusive.

One limitation of prior research is that it has focused on specific activity domains rather than on total physical activity. Prior observational research focused on leisure-time or occupational activity and structured exercise, while intervention studies have used structured exercise (French et al., 1996; Kawachi et al., 1996; Williamson et al., 1991).

* Corresponding author at: Department of Population Health Sciences, 507A Warf Office Building, 610 Walnut St, Madison, WI 53726, USA. Tel.: +1 608 262 4380 (office); fax: +1 608 262 6404.

E-mail address: gennuso@wisc.edu (K.P. Gennuso).

Although smokers tend to engage in less leisure-time physical activity than non-smokers, they tend to engage in higher levels of occupational activity (French et al., 1996; Sternfeld et al., 1999). Thus, focusing on only a single type of activity may produce a misleading or insensitive test of the relation between activity and post-cessation weight gain. In addition, it is often difficult to create persistent, large differences in overall activity levels through intervention programs (Richards et al., 2013). However, such differences can be identified through observational studies that quantify naturally occurring activity levels. The current study sought to better understand the relation between quitting smoking, physical activity, and weight gain at one year after the target quit day. We hypothesized that quitters who maintained higher levels of physical activity would gain less weight than quitters who were less active.

Methods

Study population

Participants were enrolled in the Wisconsin Smokers' Health Study (WSHS)—a 3-year smoking cessation trial examining the efficacy of different pharmacotherapies conducted in Madison and Milwaukee, WI beginning in 2005 (Piper et al., 2009). Data for this analysis came from baseline data through one year of follow-up (2005–2008) of WSHS participants ($n = 1504$). Participants were recruited through various media and flyers. Inclusion criteria included smoking >9 cigarettes/day on average for at least the past 6 months, having an alveolar carbon monoxide level greater than 9 ppm, and being motivated to quit smoking (≥ 8 on a 1–10-point scale where 10 is 'highly motivated to quit'). Exclusion criteria included using other non-cigarette forms of tobacco, taking bupropion, having current psychosis or schizophrenia, or having contraindications to the various pharmacotherapies. This study was approved by the University of Wisconsin Health Sciences Institutional Review Board and participants gave written informed consent before participating.

Physical activity assessment

Participants wore a Yamax Digiwalker SW-701 pedometer for at least 7 consecutive days around the time of their target quit day and again at one year after the target quit day. Participants were asked to wear the pedometer during all waking hours, except for water-based activities, and to record their wear times and steps taken daily in a log. Participants were given a pedometer and a log ~1 week prior to their target quit day (Y0), and they continued to wear the pedometer until their next clinic visit ~1 week after their target quit day. At one year after the target quit day, participants again recorded their daily steps for approximately one week (Y1) (502 participants did not attend the Y1 visit).

The data were cleaned and scored using several criteria. We excluded: (a) days with <10 h of wear or days with >50,000 or <500 steps; (b) participants with <3 valid days of wear, because this level of wear is not a reliable measure of normal activity level (Tudor-Locke et al., 2005); and (c) participants with <2000 steps/day who also reported malfunctioning pedometers. After these exclusions, 804 of the study's participants had valid data at both Y0 and Y1. Steps/day averages were calculated for each participant from all valid days for Y0 and, separately, for Y1. To better characterize regular activity, we also calculated an "averaged" measure of activity by averaging the steps/day from Y0 and Y1. Additionally, to examine both relative level of activity, and change in activity level over time, we constructed a "pattern" index of activity by categorizing participants based on their steps/day compared to the sample median at Y0 (7161 steps) and the sample median at Y1 (7250 steps) as either low/low (i.e., low at Y0 and low at Y1), low/high, high/low, or high/high.

Smoking status and other measures

Smoking status at Y1 was assessed using point-prevalence abstinence defined as self-reported abstinence over the past 7 days biochemically confirmed by an expired carbon monoxide level of less than 10 ppm (Jarvis et al., 1987) using a Micro-3 Smokerlyzer (Bedfont Scientific, Williamsburg, Virginia). Weight and height were measured using standard protocols, one week before and one year after the target quit day. Age, gender, race, marital status, income, education level, smoking history, and alcohol use were queried with

questionnaires. Total energy intake was assessed using a semi-quantitative food frequency questionnaire (Willett et al., 1985).

Statistical analysis

Characteristics of the quitters versus non-quitters were compared using independent t-tests and Chi-Square analyses. Analysis of covariance and general linear models were used to assess the main effects of average steps/day (the mean of Y0 and Y1 scores), quit status at Y1, and their interaction, on one-year weight gain, and effect sizes were calculated. Three additional parallel models were run with the following serving as the independent variable: 1) the pattern variable (change in activity from Y0 to Y1), 2) Y0 activity in quartiles, and 3) average steps/day in quintiles. To address the hypothesis that quitters who maintained higher levels of physical activity would gain less weight than quitters with less activity, the linear trend and pairwise differences across categories of both total activity and change in activity were calculated amongst the quitters. The following covariates were assessed individually as potential confounders in the models: age, sex, race, education level, income, marital status, self-reported health status, total energy intake, study site, study treatment, cigarettes smoked/day prior to the target quit day, pack-years of smoking, and motivation to quit. Age and sex were retained in the models, as were variables that influenced the weight change scores as predicted by steps/day (education, income, cigarettes/day, and total energy intake). In two sensitivity analyses to address the effect of missing data, we first compared characteristics of those with and without pedometer data using independent t-tests and Chi-Square analysis. Subsequently, we reran the main models using maximum likelihood estimation so that all 804 with pedometer data were included in the models (rather than just the 683 with weight and complete covariate data). $p < 0.05$ was considered statistically significant.

Results

Of the 804 participants with valid pedometer data, 99 did not have weight data at both time points, and a further 22 were missing relevant covariates for a final analytic sample of 683. These 683 (compared to participants from the parent study who did not have valid data) tended to: be older (45.5 vs. 43.9 years, $p = 0.005$), be more likely to have a college degree or higher education (25% vs. 19%, $p = 0.05$), have higher income ($p = 0.001$), be more likely to be White (88% vs. 80%), and be more likely to be abstinent at Y1 (39% vs. 14%). At Y0, the participants in our study were 45.5 ± 11.1 years of age, 57.4% were female, and their median activity level was 7007 (IQR = 5064, 9538) steps/day. Regardless of quit status, the mean weight gain was 2.5 ± 5.4 kg across the one year period. Amongst those unable to quit, 59% gained some weight, while amongst quitters, 86% gained weight by Y1. Differences in participant characteristics by quit status are depicted in Table 1.

There was no interaction between quartiles of "averaged" activity (the mean of Y0 and Y1 activity) and quit status with weight gain ($p_{\text{interaction}} = 0.63$, $\eta^2 = 0.003$, Fig. 1). Those who quit gained substantially more weight across the one year follow-up than those who did not quit ($p_{\text{quit}} < 0.001$, $\eta^2 = 0.12$), and activity was only modestly related to weight gain ($p_{\text{steps}} = 0.06$, $\eta^2 = 0.01$). No statistically significant interaction or main effect of physical activity was found when we further examined Y0 steps/day in quartiles, or average steps/day in quintiles. Results were unchanged when we examined weight gain as a percentage of baseline weight using the same analytic strategy (data not shown). Results were also unchanged when we used maximum likelihood estimation to account for missing data.

Using the "pattern" index of activity, there were main effects on weight gain at Y1 for both quitting smoking ($p_{\text{quit}} \leq 0.0001$, $\eta^2 = 0.08$) and for changing activity level ($p_{\text{steps}} = 0.002$, $\eta^2 = 0.02$) (Fig. 2), with the largest weight change (regardless of quit status) seen amongst those who decreased their steps/day from Y0 to Y1 (4.93 ± 0.60 kg), and the smallest weight change seen amongst those who were consistently active (2.25 ± 0.34 kg). Similar to the earlier analysis, there was no interaction between pattern of activity and quitting in predicting weight change ($p_{\text{interaction}} = 0.33$, $\eta^2 = 0.005$);

Table 1
Participant characteristics by year 1 (Y1) quit status (point-prevalence abstinence).^a

	Quit (n = 267)	Not quit (n = 416)
Age (years)	45.8 ± 11.4	45.4 ± 10.8
Female (%)	58.9	55.1
White (%)	92.1	86.0 ^b
Prequit cigarettes/day	19.8 ± 8.8	22.3 ± 9.6 ^c
Pack years	27.5 ± 20.4	31.7 ± 21.6 ^b
Baseline BMI (kg/m ²)	28.8 ± 6.2	28.6 ± 6.0
Baseline weight (kg)	84.0 ± 20.7	82.3 ± 19.2
One year weight change (kg)	4.8 ± 5.7	1.0 ± 4.7 ^c
Education (%)		
<High school	3.0	6.0
High school	21.0	23.8
Some college	46.4	47.8
≥College	29.6	22.4
Household income (%)		
<\$25,000	14.2	22.1
\$25,000–\$49,999	35.6	35.3
\$50,000–\$74,999	23.6	22.1
≥\$75,000	26.6	20.4 ^b
Baseline energy intake (kcal/day)	1780 (1433, 2347)	1903 (1494, 2326)
Baseline steps/day	7020 (5226, 9538)	6982 (4979, 9551)
Mean steps/day across year	7090 (5464, 9519)	6906 (5172, 9627)

^a Data analyzed for participants from a randomized controlled trial comparing the efficacy of different smoking cessation pharmacotherapies (Wisconsin, 2005–2008). Presented as mean ± SD, % of group, or median (25th percentile, 75th percentile).

^b p < 0.05.

^c p < 0.001.

however, amongst the quitters, those who either maintained a high level of activity or increased their activity from low to high gained significantly less weight (3.50 ± 0.89 kg and 4.22 ± 0.57 kg, respectively) than those who decreased their activity from Y0 to Y1 (7.07 ± 1.04 kg; p < 0.01 and p = 0.02, respectively). The significance of the interaction and main effect terms was unchanged when we used maximum likelihood estimation to account for missing data.

Discussion

Consistent with previous studies, quitting smoking was strongly associated with weight gain. The average 4.8 kg of weight gain seen in our quitters is consistent with the 4–5 kg gains that have previously been reported (Aubin et al., 2012). Activity averaged across the Y0 and Y1 time points was modestly and not significantly related to weight gain in the whole sample (p = 0.06), and did not interact with quitting in

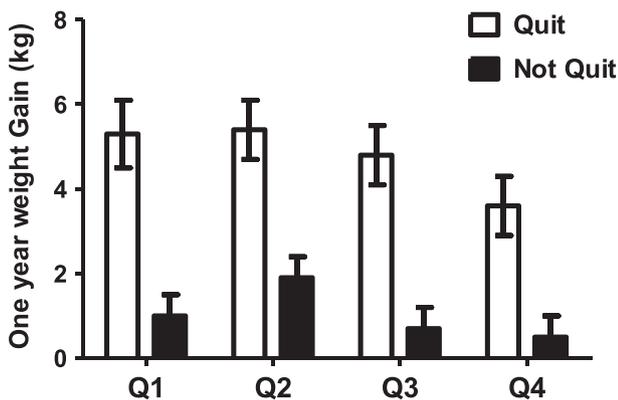


Fig. 1. Weight gain (mean ± SE) from baseline (Y0) to year 1 (Y1) by Y1 quit status (point-prevalence abstinence) and quartile of “averaged” mean steps/day (the mean of the Y0 and Y1 scores). Data analyzed for participants from a randomized controlled trial comparing the efficacy of different smoking cessation pharmacotherapies (Wisconsin, 2005–2008). Adjusted for age, sex, Y0 weight, education, income, cigarettes/day, and caloric intake. Steps/day for quartiles 1 through 4 respectively are: <5341, 5341–7137, 7138–9721, and >9721 steps/day. p_{interaction} = 0.63, p_{quit} ≤ 0.001, p_{steps} = 0.06.

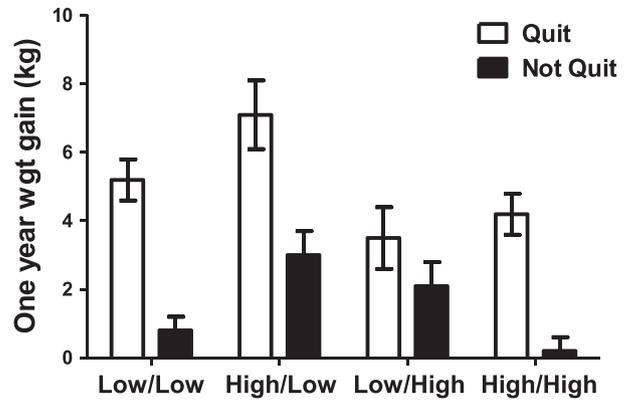


Fig. 2. Weight gain (mean ± SE) from baseline (Y0) to year 1 (Y1) by Y1 quit status (point-prevalence abstinence) and steps/day status (low or high) at Y0 and again at Y1. Data analyzed for participants from a randomized controlled trial comparing the efficacy of different smoking cessation pharmacotherapies (Wisconsin, 2005–2008). Adjusted for age, sex, Y0 weight, education, income, cigarettes/day, and caloric intake. Steps/day was split at the median value at Y0 (7161 steps/day) and at Y1 (7250 steps/day), and participants were classified as low or high at each time point. p_{interaction} = 0.33, p_{quit} ≤ 0.0001, p_{steps} = 0.002.

predicting weight gain (i.e., the weight gain associated with quitting was similar across levels of activity). It is possible that activity was not strongly related to post-quit weight gain because we only measured activity at two time points. Also, we have no information about the intensity of the steps taken; if the steps were of light intensity, the caloric difference between the quartiles of activity may not be great.

While average activity was not related to weight gain, consistently high activity at both time points or increasing activity from Y0 to Y1 was associated with reduced weight gain relative to a pattern of a reduction in activity. The weight gain differences associated with these different patterns of activity were meaningful: a difference of 3–4 kg on average (Fig. 2). This suggests that maintaining high levels of activity or increasing levels of activity may be effective in preventing some weight gain, whether or not an individual succeeds in a quit attempt. It should be noted that the activity level of our sample was not exceptionally high, even in the highest quartile of steps/day, and it is unknown whether greater amounts of activity further attenuate weight gain associated with quitting beyond what was seen in the current study. Future research should explore this possibility. Regardless, the data certainly suggest that smokers who quit should not reduce their activity levels after quitting.

This study's findings that averaged participation in physical activity did not fully protect against weight gain one year after smoking cessation are consistent with previous observational studies and randomized controlled trials. Marcus et al. did not find a significant difference between exercising and inactive control groups in two smoking cessation trials for women (Marcus et al., 1999; Marcus et al., 2005). In another intervention study including both genders that paired nicotine replacement therapy with either exercise counseling or health education, changes in weight, BMI, and body fat percentage were similar between groups directly following the 7-week intervention and at the 12 month follow-up (Ussher et al., 2003). Lastly, in the Nurses' Health Study (Kawachi et al., 1996), women who successfully quit smoking and either decreased or did not change their self-reported physical activity experienced greater weight gain over a two year follow-up period than quitters who reported increasing their activity.

Strengths of the current study include: physical activity was measured objectively, the sample is large with a range of activity levels, and abstinence was biochemically confirmed. This study also has its limitations. First, this associational study is vulnerable to various threats to causal inference. For instance, weight gain may have suppressed participants' activity levels rather than activity affecting weight gain. Also, quitting is often prompted by and associated with illness, and illness

may have reduced participants' activity and promoted weight gain. Therefore, the results do not permit strong inference regarding observed relations. A second limitation is that some participants in the parent study did not wear the pedometer at both Y0 and Y1, which restricted our sample substantially. The data indicate that those who complied were different from the larger study sample, and thus, our conclusions are limited by this subsample. Third, we cannot be certain that participants wore the pedometer and filled out their activity logs appropriately; however, our data cleaning strategies were designed to minimize the effects of violations of this assumption. A fourth limitation is that, although this study's use of a pedometer is generally a strength, pedometers clearly cannot capture all types of activities and do not provide information regarding the intensity of the activity. It is also possible that the participants were reactive to the pedometer and increased their steps beyond normal while being monitored. Finally, the representativeness of the sample is a potential limitation; participants in randomized clinical trials do not necessarily represent the general population of smokers. The participants in this research do, however, appear similar in many ways to smokers in the nationally representative NHANES sample, although they have a higher rate of obesity and tend to smoke more heavily (LaRowe et al., 2009).

Conclusion

Consistent with previous reports, in this study smoking cessation resulted in weight gain in most participants. Smokers should not, however, avoid quitting for this reason, because quitting has been linked to reduced risk of chronic diseases, such as cardiovascular disease, regardless of any associated weight gain (Clair et al., 2013). In the current study, quitters who increased their physical activity or maintained a high level of activity from the days surrounding their target quit day to 1 year later had significantly less weight gain than quitters who decreased their activity. Quitters, and in fact, all smokers, should be encouraged to attain or maintain a high level of physical activity to attenuate weight gain.

Conflict of interest statement

Medication was provided to participants at no cost under a research agreement with GlaxoSmithKline; no part of this manuscript was written or edited by anyone employed by GlaxoSmithKline. The authors are solely responsible for the analyses, content, and writing of this article.

Acknowledgments

This research was conducted at the University of Wisconsin–Madison and was supported by grant P50 DA019706 from the National Institutes of Health/National Institute on Drug Abuse (NIH/NIDA); by grant M01 RR03186 from the General Clinical Research Centers Program of the National Center for Research Resources, NIH; by grant 1K05CA139871 from NIH; and by the Wisconsin Partnership Program. This work was carried out while Dr. Schlam was a Primary Care Research Fellow supported by a National Research Service Award (T32HP10010) from the Health Resources and Services Administration to the University of Wisconsin–Department of Family Medicine.

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