Changes in Weight and Physical Activity over Two Years in Spanish Alumni

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ABSTRACT

Purpose: To investigate the relationship between baseline leisure-time physical activity and changes in leisure activity during follow-up on long-term weight changes.

Methods: We evaluated prospectively 11,974 participants (university graduates) who participated in a dynamic cohort (Seguimiento Universidad de Navarra cohort) with an average follow-up of 27 months. Self-reported data from validated mailed questionnaires were used. Baseline leisure activity was assessed with a previously validated questionnaire.

Results: After adjusting for age, hours sitting down, smoking status, snacking, fiber intake, and consumption of sugar-sweetened beverages, fast food, and alcohol, participants who decreased their leisure activity during follow-up experienced a significant increase in body mass index (BMI; relative change): for men, 0.9% (95% confidence interval [CI] = 0.5–1.2%); for women, 1.0% (95% CI = 0.6–1.3%). Participants who increased their leisure activity during follow-up experienced a significant reduction (relative change) in BMI: for men, −0.8% (95% CI = −1.1% to −0.5%); for women, −0.6% (95% CI = −0.9% to −0.4%). This inverse association between changes in leisure activity and weight gain was significantly stronger for participants with a baseline BMI ≥25 kg m−2, but the absolute magnitude of this interaction effect was trivial. Baseline physical activity was not significantly associated with weight changes after 2 yr of follow-up.

Conclusion: Longitudinal changes in leisure activity during follow-up were inversely associated with changes in body weight. The true relationships between leisure activity and body weight are likely to have been larger than observed, owing to attenuation of effects by measurement error in self-reported data.

Key Words: EXERCISE, OBESITY, EPIDEMIOLOGY, BODY MASS INDEX, LIFE STYLES, SUN

Overweight is a serious public health concern worldwide (37). According to the World Health Organization in 2005, around 1.6 billion adults were overweight and at least 400 million were obese (36). In the United States in 2003–2004, more than 66% of the population over 20 yr old were overweight and almost half of them were obese (20).

In 2000, Fogelholm and Kukkonen-Harjula (9), after a systematic review of physical activity and weight gain in adults, concluded that studies with follow-up periods longer than 2 yr were needed, and there was also a need for studies comparing the effects of physical activity on weight change separately for men and women. Since then, the results of several new cohort studies have been available. However, the relationship between physical activity and overweight has not been totally clarified because several of the studies showed a protective effect of physical activity on weight gain (28,32) but others did not (2,22). The effect of physical activity in participants with different baseline body mass index (BMI) is not known. Hemmingsson and Ekelund (10) found a stronger effect of physical activity among obese participants than among nonobese in a cross-sectional study, and they recommended prospective studies to validly assess this issue.

The objective of our study was to ascertain the association between baseline leisure-time physical activity and
weight change and also the association of changes in leisure-time physical activity during follow-up and weight gain, separately for men and women. For this purpose, we used the data of the dynamic Seguimiento Universidad de Navarra (SUN) cohort.

METHODS

Study population. The SUN project (University of Navarra follow-up) is a prospective dynamic cohort study designed to evaluate the role of diet, physical activity, and other exposures on the occurrence of several diseases including obesity (17,27). After the initial questionnaire, additional follow-up questionnaires are mailed every 2 yr to all participants.

The recruitment of participants, all of whom are university graduates, started in 1999 and it is permanently open because the study was designed to be a dynamic cohort. Up to March 2007, the SUN data set had already included 17,418 participants who completed their baseline questionnaire (Q_0). All participants who answered the baseline questionnaire before December 31, 2004, were eligible for these analyses (n = 13,967). We retained 12,604 (90.3% of men and 90.1% of women) participants who had successfully completed the 2-yr follow-up questionnaire (Q_2) up to March 2007. Participants with missing values for baseline BMI or for BMI changes were also excluded (n = 203). We conducted the statistical analyses excluding also participants who were extreme outliers (31) (i.e., those who were greater than three times the interquartile range apart from the percentile 25 or the percentile 75) for baseline BMI, BMI change, or baseline leisure activity (n = 427). Finally, data of 11,974 participants were used in the analyses.

All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this study. The study was approved by the Institutional Review Board at the University of Navarra. Informed consent was implied by the voluntary completion of the baseline questionnaire.

Assessment of physical activity. Assessment of leisure activity at baseline was done through questions about participation in 17 different activities during the leisure time and the time spent on each activity. We also inquired about the number of months per year that every activity was practiced due to the seasonal nature of some activities (e.g., swimming or skiing). We used the compendium of physical activities (1) to quantify the total number of MET-hours per week for all recreational physical activities. This estimate adequately correlated (Spearman \( \rho = +0.51; \ P < 0.001 \)) with energy expenditure measured in a validation subsample of the cohort (15).

Assessment of follow-up change in physical activity was done through a question in Q_2, where participants answered if their physical activity had increased, decreased, or did not change. Taking into account the distribution of physical activities and the data collected for the validation and the development of the physical activity questionnaire, we estimated that when a participant selected the option “increase” or “decrease” in physical activity, his or her average change was 1 h wk\(^{-1}\) of moderate-intensity (3.5–6 MET) physical activity.

Assessment of other variables. The number of hours sitting down per week was estimated by multiplying by 5 the hours sitting down in a typical weekday and adding twice the average estimate for a typical weekend day.

A semiquantitative food-frequency questionnaire (136 items), previously validated in Spain (13), was used to assess dietary habits. The intake of total fiber, alcohol, fast food, and sugar-sweetened soft drinks was adjusted for total energy intake (residual method) (34).

Assessment of the outcome. Participants’ weight was recorded at Q_0 and Q_2, which was completed at least 2 yr after baseline (median follow-up time = 27 months). Self-reported BMI has been previously validated in a subsample of the cohort (mean relative error = 2.64%; correlation coefficient = 0.94; 95% confidence interval [CI] = 0.91–0.97) (4).

The outcomes were 1) change in BMI after 2 yr of follow-up (continuous variable: BMI in Q_2 minus BMI in Q_0 [kg m\(^{-2}\)]) and 2) an increase in body weight of \( \geq 5 \) kg after 2 yr of follow-up (dichotomous variable, cutoff point \( \geq 5 \) kg).

Statistical analysis. To get a power of 0.9, assuming a two-sided alpha error of 0.05 and an SD of the compared variable of 3 kg m\(^{-2}\), the estimated minimum sample size was 527 participants in each category to be able to detect a difference between means of 0.6 kg m\(^{-2}\). These estimates are conservative taking into account that we used a regression model with smaller residual errors.

Multiple regression models were used to assess either the associations between baseline leisure activity (choosing the lowest tertile as the reference category) or the changes in leisure activity during follow-up (no change as the reference category) and BMI changes. To test interaction (effect modification) in the prespecified subgroup analyses, we built a product term between the grouping variable (two categories) and a three-category ordinal variable (\(-1 = \) reduced leisure activity; 0 = no change in leisure activity; +1 = increased leisure activity). To obtain uniformity of errors (11) and effects across categories of physical activity, a logarithmic transformation of BMI was used to fit the multiple regression models. The outcome was log-transformed BMI in Q_2 minus log-transformed BMI in Q_0. Therefore, the results of these models should be interpreted as ratios of geometric means (5). The results are shown as relative changes in BMI (percent changes in geometric means).

Logistic regression models were fit to assess the relationship between baseline leisure activity (tertiles) or changes in leisure activity during follow-up (decrease, no change, or increase) and risk of weight gain (at least 5 kg after 2 yr
of follow-up). Participants exposed to the highest tertile of baseline leisure activity and who also increased their leisure activity during follow-up were the reference category.

We fit a crude (univariate) model and a multivariate model after additional adjustment for age (continuous), hours sitting down (tertiles), smoking (current, past, never), between-meal snacking (yes/no), consumption of sweetened beverages (tertiles), fast food (tertiles), alcohol (tertiles), and total fiber intake (continuous). We computed the magnitude of the changes in the estimates for the odds ratio (OR) introduced, after controlling for each of these variables.

As an additional analysis, to assess reverse causation, we also studied the relationship between baseline BMI (as the exposure, categorized in quintiles) and changes in leisure activity during follow-up (as the outcome, dichotomized) using a logistic regression model. We categorized the outcome variable in two ways: increase versus no change and decrease versus no change of leisure activity during follow-up. Tests of linear trend across quintiles of baseline BMI were performed by assigning the median values for each quintile and treating them as continuous variables.

We also repeated the main analyses with standardized BMI changes as the outcome, using the corresponding standardized differences (the absolute difference in the means divided by the SD in either group, here assumed to be the average of the SD of baseline BMI and that of BMI after 2 yr) (6).

All models were estimated separately for men and women. All P values presented are two tailed; P < 0.05 was considered statistically significant.

RESULTS

The baseline weight was 78.3 ± 10.3 kg for men and 58.8 ± 8.1 kg for women, and the baseline BMI was 25.4 ± 3.0 kg·m⁻² for men and 22.0 ± 2.8 kg·m⁻² for women.

The average 27-month BMI gain was 0.18 ± 1.09 kg·m⁻² for men and 0.24 ± 1.11 kg·m⁻² for women. The baseline leisure activity was 22.4 ± 21.1 MET·h·wk⁻¹ for men and 16.4 ± 16.6 MET·h·wk⁻¹ for women. For the average male participant, this could be equivalent to walk 6.5 h·wk⁻¹. For the average female participant, this could be equivalent to walk 4.7 h·wk⁻¹. The most frequently practiced physical activities were walking, mountain climbing, running (men), cycling (men), and dancing or aerobics (women). Baseline characteristics of participants are shown in Table 1.

After adjusting for potential confounders, participants who decreased their leisure activity during follow-up experienced a significant increase in BMI: for men, 0.41 kg·m⁻² (95% CI = 0.31–0.52 kg·m⁻²); for women, 0.57 kg·m⁻² (95% CI = 0.47–0.67 kg·m⁻²). The corresponding standardized differences (the absolute difference in the means divided by the average of the SD of baseline BMI and that of BMI after 2 yr) were 0.14 for men and 0.19 for women. Men who increased their leisure activity during follow-up experienced a nonsignificant reduction in BMI of −0.02 kg·m⁻² (95% CI = −0.12 to 0.08 kg·m⁻²), whereas women who increased their leisure activity experienced a slight weight gain of 0.19 kg·m⁻² (95% CI = 0.10–0.28 kg·m⁻²) (standardized difference = 0.07). After logarithmic transformation of the dependent variable, we also estimated changes of BMI as a percentage of baseline BMI (Table 1).

A monotonic dose–response pattern showing greater gains in BMI associated with reductions in leisure activity was observed across all categories of baseline leisure activity, both for men and for women (Fig. 1). Baseline tertiles of leisure activities were not related to significant changes in BMI after 2 yr of follow-up.

Participants with a baseline BMI ≥ 25 kg·m⁻² had a greater decrease of BMI associated with increases in physical activity than those with baseline BMI < 25 kg·m⁻². When we assessed this interaction using log transformation of BMI changes, the product term was statistically significant: P = 0.01 for men and P = 0.04 for women. However, differences in the decrease of BMI associated with increases in physical activity were trivial. Among those with BMI ≥ 25 kg·m⁻², the relative decrease was −1.1% (95% CI = −1.5% to −0.8%) for men and −1.0% (95% CI = −1.8% to −0.2%) for women, whereas among participants with a baseline BMI < 25 kg·m⁻², the estimates were −0.4% (95% CI = −0.9% to 0.0%) for men and −0.6% (95% CI = −0.8% to −0.3%) for women. Also, participants with a baseline BMI ≥ 25 kg·m⁻² had a significantly greater BMI gain associated with decreased physical activity. Among them, the relative increases were 1.0% (95% CI = 0.5–1.4%) for men and 1.6% for women.

| TABLE 1. Distribution of the participants according to their baseline leisure activity.⁴ |
|----------------------------------|-----------------|-----------------|-----------------|
|                                | Lowest | Middle | Highest |
| Male                            |        |        |        |
| Sample size                     | 1628   | 1629   | 1628   |
| Age (yr)                        | 48.2 ± 12.2 | 48.8 ± 12.6 | 46.7 ± 13.1 |
| Leisure activity (MET·h·wk⁻¹)   | 3.8 ± 2.9 | 17.0 ± 4.8 | 46.0 ± 18.5 |
| BMI (kg·m⁻²)                    | 25.8 ± 3.1 | 25.5 ± 2.9 | 25.0 ± 2.7 |
| Current smokers (%)             | 25.7   | 26.5   | 17.9   |
| Snacking (yes) (%)              | 29.1   | 26.7   | 27.6   |
| Sweetened beverages (%)         | 29.1   | 27.8   | 31.1   |
| (highest tertile) (%)           |        |        |        |
| Fast food (highest tertile) (%) | 31.5   | 30.0   |        |
| Sitting down (h·d⁻¹) (%)        | 5.8 ± 2.2 | 5.7 ± 2.1 | 5.5 ± 2.1 |
| Alcohol (g·d⁻¹) (%)             | 11.1 ± 15.7 | 10.6 ± 13.3 | 11.2 ± 14.3 |
| Total fiber intake (g·d⁻¹)      | 25 ± 14 | 27 ± 13 | 29 ± 14 |
| Female                          |        |        |        |
| Sample size                     | 2372   | 2423   | 2294   |
| Age (yr)                        | 40.0 ± 9.9 | 41.2 ± 10.5 | 40.5 ± 10.5 |
| Leisure activity (MET·h·wk⁻¹)   | 1.9 ± 1.5 | 11.6 ± 4.0 | 35.0 ± 13.9 |
| BMI (kg·m⁻²)                    | 22.1 ± 3.0 | 22.2 ± 2.8 | 21.9 ± 2.6 |
| Current smokers (%)             | 31.1   | 23.4   | 20.4   |
| Snacking (yes) (%)              | 44.3   | 38.7   | 38.2   |
| Sweetened beverages (%)         | 26.2   | 20.4   | 19.9   |
| (highest tertile) (%)           |        |        |        |
| Fast food (highest tertile) (%) | 43.1   | 39.1   | 36.8   |
| Sitting down (h·d⁻¹) (%)        | 5.3 ± 2.3 | 5.1 ± 2.2 | 5.1 ± 2.2 |
| Alcohol (g·d⁻¹) (%)             | 3.7 ± 5.5 | 3.9 ± 5.9 | 4.4 ± 6.6 |
| Total fiber intake (g·d⁻¹)      | 29 ± 17 | 30 ± 16 | 32 ± 17 |

⁴ Means ± SD are shown unless stated otherwise.
(95% CI = 0.5–2.6%) for women, whereas for participants with a baseline BMI < 25 kg·m⁻², the increases in BMI associated to decreased activity were 0.8% (95% CI = 0.3–1.2%) for men and 0.9% (95% CI = 0.5–1.2%) for women. No interaction on BMI change was found between changes in leisure activity and age or smoking. No statistically significant interaction on BMI change was found between changes in leisure activity and sweetened beverages, fast food, or snacking.

Men or women who decreased their leisure activity during follow-up exhibited a statistically significant higher risk of gaining ≥5 kg compared with participants who were initially in the highest tertile of baseline leisure activity and who also increased their leisure activity during follow-up. Among men, after adjusting for relevant confounders, the OR for decreased leisure activity was 3.76 (95% CI = 2.32–6.09) in the highest baseline tertile, 2.66 (95% CI = 1.61–4.40) in the middle baseline tertile, and 2.99 (95% CI = 1.82–4.93) in the lowest baseline tertile. Among women, these estimates were 2.70 (95% CI = 1.80–4.07), 2.23 (95% CI = 1.46–3.41), and 2.84 (95% CI = 1.84–4.38), respectively. Among men, the OR for weight gain (≥5 kg) associated with no change in leisure physical activity were 1.57 (95% CI = 0.99–2.50) in the highest baseline tertile, 2.15 (95% CI = 1.36–3.38) in the middle baseline tertile, and 1.94 (95% CI = 1.23–3.05) in the lowest baseline tertile. Among women, these estimates were 1.39 (95% CI = 0.96–2.02), 1.48 (95% CI = 1.03–2.12), and 1.54 (95% CI = 1.08–2.20), respectively. Finally, in men who increased their physical activity, the OR for weight gain (≥5 kg) were 1.47 (95% CI = 0.87–2.48) in the middle baseline tertile and 2.19 (95% CI = 1.33–3.60) in the lowest baseline tertile; women had an OR of 1.58 (95% CI = 1.08–2.33) and 1.28 (95% CI = 0.96–2.02), 1.48 (95% CI = 1.03–2.12), and 1.54 (95% CI = 1.08–2.20), respectively. Among men, the OR for weight gain (≥5 kg) was 1.8% (95% CI = 1.08–2.20) in the lowest tertile tertile who increased their leisure activity during follow-up exhibited a statistically significant higher risk of weight gain (P = 0.20). In women, the sole difference was that women in the medium tertile of baseline leisure activity who did not change their leisure activity did not have a significantly higher risk of gaining three or more kilograms, although the P value approached the significance limit (P = 0.09).

When we assessed the possibility of reverse causation (leisure activity as the outcome), we observed that men with a greater baseline BMI tended to increase their leisure activity during follow-up (P for trend = 0.006, data not shown). However, women with a greater baseline BMI were more likely to decrease their leisure activity during follow-up (P for trend = 0.001).

**DISCUSSION**

In this prospective study, changes in leisure activity during follow-up (after 27 months) were inversely associated with changes in body weight.

Several cohort studies that have evaluated the relationship between physical activity and weight gain have reported a negative association between physical activity and weight gain (26,28,30,32,33), although others have not (2,22). Finally, there are also reports of a significant inverse association between physical activity at follow-up (rather than at baseline) and weight change (35). DiPietro et al. (8) found that improvements in cardiorespiratory fitness also attenuated weight gain during follow-up. Similarly to our study, participants who were “unfit” and became “fit” (calculated as the difference in maximal treadmill between the first and the second examination; mean interval = 1.8 yr) lost weight (between first and last examination; mean follow-up = 7.5 yr), but those who were “fit” and went...
on being “fit” did not lose weight. In our study, during follow-up (27 months), weight changes were relatively small, but if this trend goes on, these changes would be really important as they accumulate after several years. Although it is unrealistic to think that a continuous increase in physical activity will be maintained in the long term, men of our cohort who were in the highest tertile of baseline physical activity had a similar weight benefit when they increased their physical activity. Besides, they had a lower baseline BMI, although baseline physical activity did not prevent weight gain after 2 yr of follow-up. Petersen et al. (21) reported that their data did not support that baseline physical inactivity was associated with obesity, but they interpreted that obesity may lead to a sedentary lifestyle and physical inactivity (reverse causation). Although we have found this association suggesting inverse causation in women, we have not found evidence of it among men; indeed, men with a higher baseline BMI tended to increase their leisure activity during follow-up. It is not fully clear whether physical activity may really prevent weight gain or it is that weight gain may lead to worse exercise adherence. The design of our study may help to rule out that weight gain may lead to worse adherence to physical activity among educated men. However, using a longitudinal analysis, we provide prospective evidence to support that in both sexes, a reduction in leisure activity does lead to gaining weight.

Although changes in BMI in our cohort were not large, they can be realistically assumed because they were actually attained by free-living subjects using no special intervention program. Randomized controlled trials of exercise programs have also found only modest weight reductions with increased physical activity. Slentz et al. (29) found that participants who were instructed to jog the equivalent of 32 km·wk⁻¹ but not to restrict their caloric intake lost only 2.9 kg in 8 months. Miller et al. (19) reviewed 493 intervention studies of exercise, diet, and diet plus exercise on weight loss. Average weight loss through exercise, diet, and diet plus exercise was 2.9 ± 0.4, 10.7 ± 0.5, and 11.0 ± 0.6 kg, respectively, in the systematic review.

When we repeated the analyses adjusting also for baseline BMI, the results hardly changed. Interestingly, baseline BMI showed a statistically significant interaction with changes of leisure activity during follow-up that was maintained after log transformations, although the magnitude of this interaction effect was trivial in our study. However, our results are consistent with those by Hemmingsson and Ekelund (10), suggesting that the association between physical activity and BMI may be weak among nonobese individuals. Our overall results are also consistent with some previous cross-sectional surveys conducted in the European Union (18), reporting that leisure activity was strongly associated with obesity and overweight (14,16).

Confounding may partially account for the observed inverse association because participants with higher leisure activity also reported healthier lifestyles. However, after adjusting for several potential confounders, the associations between changes in leisure activity during follow-up and weight changes remained statistically significant. Residual confounding is a potential concern, particularly due to potential nondifferential misclassification in some of the self-reported variables that we have used to adjust our estimates. This may partially explain the tiny magnitude of some of our results. However, we think it is not very likely because most crude and multivariate adjusted associations were similar, and we found quite similar results using different analytical approaches.

We did not control for socioeconomic status (SES) because our cohort is quite homogeneous about SES. All participants in the cohort have a university degree (restriction was used to control for SES as a confounding factor). Although a similar educational level does not imply a similar income, educational level has proven to be influential in the evaluation of SES (7). Studies that take into account occupation, income, employment status, and education have shown that education is the strongest determinant of socioeconomic differences (24).

Another potential concern is the possibility of an inaccurate assessment of leisure activity. Although the validation study showed sufficient accuracy (15), we acknowledge that self-reported leisure activity may potentially present some degree of measurement error, which may have contributed to underestimate true relationships between leisure activity and weight changes in our study. The mean leisure activity (MET·h·wk⁻¹) in this cohort is fairly similar to that observed in other cohorts using analogous questionnaires (12,23). Differences in the distribution of participants according to age, sex, and BMI might explain the small differences found in average values of MET-hours per week. Body weight was also self-reported, and thus misclassification is inevitable. Nevertheless, the validity of self-reported weight was studied in a representative subgroup of the cohort (4). However, we acknowledge that self-reported weight change and self-reported leisure activity change have not been specifically validated in our cohort.

We acknowledge that the SUN cohort is not representative of the general population because it consists exclusively of university graduates of Spain, where a higher educational level is associated with a lower prevalence of obesity (3). However, it is biologically implausible that the effect of physical activity on weight gain can be modified by educational levels (25). On the other hand, our study has some strengths including its prospective design, the high retention, and the availability of validation studies in subsamples of the cohort.

When participants who reported extreme (low or high) values for total energy intake (<800 or >4000 kcal·d⁻¹ for men and <500 or >3500 kcal·d⁻¹ for women) were excluded, results hardly changed. We did not find any association between baseline self-reported intensity of physical activity or walking speed and weight gain after 2 yr of follow-up.
The epidemic of obesity is growing rapidly. Our study provides support for approaching the prevention of weight gain through the promotion of leisure activity, promoting especially positive changes in the usual level of leisure activity among middle-aged adults. However, further studies with longer follow-up and accurately measured data are needed to confirm and better quantify these associations.

REFERENCES