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# Empirical Evaluation of Physical Activity Recommendations for Weight Control in Women

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## Abstract

**Purpose—**Recent recommendations advise 30–60 min of physical activity per day to prevent weight gain and 60–90 min to prevent weight regain. No studies have used objective measures of physical activity to verify these public health recommendations. The purpose of this study was to use objective measures to quantify the amount and intensity of physical activity in a weight-loss-maintainer group and an always-normal-weight group, and, thus, empirically evaluate the recommendations for prevention of weight gain versus regain.

**Methods—**The weight-loss-maintainer group ($N$ = 135) lost = ≥ 30.6 kg, maintained ≥ 10% weight loss for 14.2 yr, and had a BMI of 22.0 $kg \cdot m^{-2}$. The always-normal-weight group ($N$ = 102) had a BMI of 21.1 $kg \cdot m^{-2}$ and no history of overweight. Accelerometry was used to assess the amount and intensity of physical activity.

**Results—**The weight-loss-maintainer group spent significantly more minutes per day than the always-normal-weight group in physical activity (58.6 vs 52.1; $P$ = 0.0001), largely because of more time spent in higher-intensity activities (24.4 vs 16.9; $P$ = 0.02). The majority of individuals in the always-normal-weight group engaged in 30–60 $min \cdot d^{-1}$ of physical activity, whereas a greater proportion of individuals in the weight-loss-maintainer group engaged in > 60 min ($P$ = 0.002).

**Conclusions—**Findings support current recommendations that more activity may be needed to prevent weight regain than to prevent weight gain. Including some higher-intensity activity may also be advisable for weight-loss maintenance.

### Keywords

Public Health Guidelines; Exercise Prescription; Weight-Loss Maintainer; Always-Normal Weight

Public health guidelines regarding exercise prescription have been in flux over the years (5, 23,24), partly because of methodologic differences in collecting and interpreting the extant data and differences in the health outcomes of interest (1). With few exceptions (l8), studies examining exercise requirements for weight-loss maintenance have relied on retrospective self-report measures of physical activity and have not included objective measures (4,6).

Given the increasing prevalence of obesity and its health consequences, it is important to have objective data on the amount of physical activity of those who are able to successfully maintain



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a normal body weight. Two groups are of particular interest: those who are normal weight and have been able to maintain a stable normal body weight throughout their lives, and those who are currently normal weight but have reduced from a prior period of being overweight or obese. The recent public health recommendations have specified different levels of activity for these two groups (i.e., 30–60 min for individuals needing to avoid weight gain and 60–90 for individuals needing to avoid weight regain) (24). However, the physical activity of individuals who are successfully maintaining a significant weight loss versus individuals who are maintaining weight stability has never been directly compared using objective measures.

The purpose of this study was to 1) use objective measures to quantify the amount and intensity of physical activity of successful weight-loss maintainers and normal-weight individuals without a history of obesity, and 2) to compare the amount and intensity of physical activity in these two groups relative to current physical activity recommendations. The sample was restricted to females on the basis of previous research showing marked gender differences in physical activity levels (3,7).

## METHODS

### Subjects and Procedures

A convenience sample of women was recruited by placing advertisements in national and local publications and articles about the study in publications that target a general audience. Individuals interested in joining the study were asked to call a toll-free number or to visit our Web site (www.nwcr.ws). Participants were located in all different parts of the United States, but predominantly in New England, California, and the Washington, DC area. Eligibility was confirmed via phone screen.

To be eligible for the study, weight-loss maintainers had to be female, overweight or obese (BMI ≥ 25) at some point in their life, currently normal weight (BMI 18.5–25), and must have lost ≥ 10% of maximum body weight. In addition, to identify individuals who were clearly succeeding at weight-loss maintenance, they were required to have kept off a loss of ≥ 10% for at least 5 yr, and be weight stable (± 10 lb) within the past 2 yr. Participants in the always-normal-weight group had to be female, normal weight (BMI between 18.5–25), and have no history of overweight or obesity (BMI ≥ 25). The criteria for participants in the always-normal-weight group also required that they be weight stable (± 10 lb) for at least 2 yr before enrollment. Of the 490 subjects who responded to advertisements specifying these criteria, 320 were deemed eligible for the current study. Of these, 237 signed written informed consent forms and participated in all study assessments. Participants were paid $50 for completing the study assessments. The study was approved by the institutional review board at the Miriam Hospital in Providence, RI.

### Measures

**Weight and demographics—**Weight and weight history were based on self-report. Participants provided information about marital status, ethnicity/race (Hispanic/non-Hispanic, American Indian, Asian, Black/African American, Native Hawaiian, white, or other), and education. These data were collected for descriptive purposes.

**Physical activity—**All participants in this study wore the RT3 triaxial accelerometer (manufactured by Stayhealthy.com). The RT3 is a relatively new triaxial accelerometer that has replaced the Tritrac. Similar to the Tritrac, the RT3 incorporates accelerometer output into a regression equation to compute energy expenditure (EE) and metabolic equivalents (METs) at 1-min intervals. The RT3 has been shown to be reliable (13) and a good a predictor of oxygen consumption (15). The RT3 and Tritrac have been shown to be comparable with respect to

predicting oxygen consumption (15); the manufacturers also claim the output (counts recorded) of the RT3 and Tritrac are comparable (www.stayhealthy.com), although other research has disputed this (15).

Participants in the current study were sent the accelerometer in the mail in a padded box. On receipt, they were asked to activate the device by pressing a button and to wear it until it read *full*. Participants returned the device in a postage-paid padded envelope. On rare occasions, the battery power of the device expired before our receipt; in these cases, participants were asked to wear the device again. Detailed instructions were provided to participants on proper placement of the device (between the hipbone and belly button at the waistline on the left or right side of the body), when to wear the device (during all waking hours), and using the accelerometry diary (indicating the day and time that device was put on and removed).

For accelerometry data to be valid, a minimum of 4 d with at least 2 h of activity each day was required. The data were analyzed to determine the frequency (minutes per day) and intensity (kilocalories expended) of activity. Based on participants' age and previous recommendations (12,23,25), frequency and intensity of activities $\geq 2$, $\geq 3$, or $\geq 5$ METs were computed, corresponding to low-, medium-, and high-intensity activity. Sedentary physical activity (METs < 2) was excluded from total activity estimates.

### Statistics

Descriptive statistics are presented in the tables as either means ± SD for continuous measures or as percentages for categorical responses. Normality tests were conducted on continuous variables and indicated that the minutes of physical activity data were not normally distributed. Log and square root transformations were attempted to normalize the data but were not successful. Therefore, the two-sample Kolmogorov–Smirnov test was used to examine group differences in distributions of minutes of physical activity. Univariate general linear model analyses were conducted to examine group differences in weekly calories expended in physical activity. Chi-square analyses were used to compare group proportions across categories of physical activity intensity and duration. Independent *t*-tests were used to examine group differences in baseline demographic variables. Both mean and medians of physical activity minutes are reported for ease of interpretation. Matched-pair analyses comparing 50 weight-loss maintainers and 50 normal-weight controls (matched on BMI) on physical activity intensity and duration were also conducted. Because the findings were similar to those presented here, these data are not shown.

The sample size of this study (135 weight-loss maintainers and 102 normal-weight controls) was calculated to provide at least 80% power for detecting effect sizes ranging from 0.28 to 0.37 for continuous outcomes, with a 5% type 1 error rate. In a *post hoc* sample size calculation, using a pooled standard deviation estimate of 20.9 for minutes per day spent in high-intensity activities (defined as METs $\geq 5$), we had > 80% power to detect a difference of 7.7 min between groups.

## RESULTS

Subject characteristics are displayed in Table 1. The weight-loss-maintainer group had reduced from 90.8 ± 17.6 to 60.3 ± 7.2 kg and maintained a $\geq 10\%$ weight loss for over 14 yr. Both groups were normal weight, but the weight-loss-maintainer group weighed significantly more and had a higher BMI: than the always-normal-weight group ($P < 0.0001$). Current BMI was not significantly correlated with minutes of physical activity ($r = 0.09$; $P = 0.14$) or calories expended per week in physical activity ($r = 0.10$; $P = 0.12$).

We first compared the always-normal-weight and weight-loss-maintainer group on daily duration of physical activity of METs ≥ 3. The weight-loss-maintainer group averaged 58.6 ± 33.7 min·d$^{-1}$ (median = 53.8) of activity ≥ 3 METs compared with 52.1 ± 25.3 min·d$^{-1}$ (median = 46.7) in the always-normal-weight group ($P$ = 0.0001 by the Kolmogorov–Smirnov test). We next examined minutes of physical activity broken down by the categories of minutes used in current physical activity recommendations (i.e., < 30, 30–60, or > 60 min·d$^{-1}$) (22). As illustrated in Figure 1, the distribution of minutes across the two groups significantly differed. Whereas most normal-weight individuals did 30–60 min of activity per day, the distribution of weight-loss maintainers was shifted to the right (chi-square = 12.4; $P$ = 0.002).

We also found significant differences between the weight-loss-maintainer group and the always-normal-weight group for time spent in various intensities of physical activity. The weight-loss-maintainer group spent significantly more minutes per day engaged in high-intensity activity (METs ≥ 5) than did the always-normal-weight group ($P$ = 0.02 by Kolmogorov–Smirnov test; Table 2). There were no significant group differences between the weight-loss-maintainer and always-normal-weight groups in the minutes per day spent doing moderate- (METs 3.0–4.9) or low-intensity (METs 2.0–2.9) activities.

Although the physical activity recommendations are given in minutes, not calories, many prior studies (6,8,11,19) have reported calories in physical activity. Total calories expended per week in physical activity (low-, moderate-, and high-intensity combined) differed significantly between the weight-loss-maintainer group and the always-normal-weight group (2657 ± 1403 vs 2249 ± 1125 kcal·wk$^{-1}$, respectively; $P$ = 0.04). This difference was attributable to the fact that the weight-loss-maintainer group expended significantly more calories per week in high-intensity (≥ 5 METs) activities compared with the always-normal-weight group (1137 ± 1119 vs 745 ± 895 kcal·wk$^{-1}$, respectively; $P$ = 0.004). There were no significant group differences in calories expended in sedentary, low-, or moderate-intensity activities.

## DISCUSSION

This study used an objective accelerometry measure to examine the amount and intensity of physical activity of two groups of individuals who are maintaining a normal body weight in the current obeseogenic environment: long-term weight-loss maintainers and normal-weight individuals with-out a history of obesity. Weight-loss maintainers spent more total time being physically active (METs ≥ 3) compared with the always-normal-weight group (an average of 58 vs 52 min·d$^{-1}$, respectively). Moreover, the always-normal-weight group was somewhat more likely to engage in 30–60 min of physical activity per day, whereas a greater percentage of weight-loss maintainers did more than 60 min·d$^{-1}$. These findings are consistent with recent recommendations by the Center for Nutrition Policy and Promotion of the U.S. Department of Agriculture advising 30–60 min of physical activity per day to prevent weight gain and a higher level of 60–90 min·d$^{-1}$ to prevent weight regain (16,24).

The weight-loss-maintainer and always-normal-weight groups also significantly differed in their intensity of physical activity. Although the two groups did comparable minutes of moderate- and low-intensity activity, individuals in the weight-loss-maintainer group spent about 8 min·d$^{-1}$ more in high-intensity activity than the always-normal-weight group. Higher-intensity activity may in itself be helpful for maintenance of weight loss, or it may be just a means of increasing total energy expenditure. Future research should address the issue of whether it is total energy expenditure or the intensity of the activity that is critical for successful weight control on a population level.

Of note, although the average physical activity minutes per day observed in the current study were similar to public health recommendations, there was a great deal of variability in the

amount and intensity of physical activity observed in both groups. Thus, it seems possible to maintain a normal body weight in our current environment with a variety of different physical activity levels.

A strength of the study is that it improved on previous work by providing a more objective measure of physical activity. Although self-report of physical activity and accelerometer measures are correlated (*r* values ranging from 0.25 to 0.43), there is a strong overreporting bias in self-report measures of physical activity (11,14,21). Nonetheless, accelerometers are not as accurate as more costly measures of energy expenditure, such as indirect calorimetry or the doubly labeled water method. Moreover, accelerometers may overestimate or underestimate energy expenditure, depending on the type of accelerometer and regression equation used (8). The RT3 accelerometer used in the current study is relatively new and has received less empirical evaluation than other devices, however, its predecessor, the Tritrac, has been shown to underestimate energy expenditure by 35% (−320 kcal·d$^{-1}$ (−1)) compared with doubly labeled water measurement (9). This underestimation may reflect limitations in tracking expenditure attributable to static exercise, such as carrying a load, bicycling, or walking into a headwind (9). Accelerometer-based estimates of energy expenditure have also been shown to vary considerably depending on the regression equation used to convert the raw motion data into estimates of energy expenditure (8). The formula used to convert the raw data from the RT3 into energy expenditure and METs from physical activity is a proprietary formula and will not be released by the manufacturer (www.stayhealthy.com). The current study used the same instrument and conversion equation in both groups under investigation, thus mitigating some of these concerns. However, it is important to note that different accelerometers or regression equations could have classified the participants differently according to their physical activity intensities (8). Given these limitations, group differences in the intensities of physical activity reported in this paper should be interpreted with caution.

The study is one of the first to objectively compare physical activity in a population of weight-loss maintainers and individuals with no history of obesity. The study population, nonetheless, was limited to a self-selected sample of predominantly Caucasian, middle-aged women. Although current physical activity recommendations do not differ between men and women, prior research (7) suggests that there may be important gender difference in the magnitude of physical activity reported by weight-loss maintainers. Thus, future research is needed to examine physical activity in men who are maintaining significant weight loss or lifetime weight stability to determine the generalizability of the current study's findings.

This present study focused on physical activity, but similar research addressing dietary intake is needed to better determine how weight is being regulated in these two groups. Without information about participants' diet, the reason for the weight-loss maintainers' higher minutes of physical activity remains unclear, It could be that weight-less maintainers are consuming more calories; alternatively, they may be more metabolically efficient than their never-overweight counterparts. These questions need to be addressed in future research.

The assessment of weight was based on self-report. Previous studies have found that self-reported current weight (17,20) and recall of previous weight information (2,19) are reliable measures of actual weight, with an average error of only 1–2 lb. We have previously examined the reliability of these reports in the National Weight Control Registry (10). The correlation between documented (i.e., by a physician or weight-loss counselor) reports of weight and self-reported current weight was 0.97, but the participants underestimated their weight by 2.4 ± 5.6 kg (10). Thus, it is likely that the actual weight of participants in this study was higher than reported. Finally, the groups in this study were assessed at one time point only, which limits more powerful prospective analyses.

In summary, weight-loss maintainers spent more total time each day being physically active and engaged in more minutes of higher-intensity physical activities compared with their never-overweight counterparts. Findings from this study are consistent with current recommendations for greater duration of physical activity for weight-regain prevention than for weight-gain prevention. However, additional research in representative samples is needed to confirm this study's findings. Ways to promote higher-intensity and longer-duration physical activity merit investigation in both prevention and treatment controlled trials.

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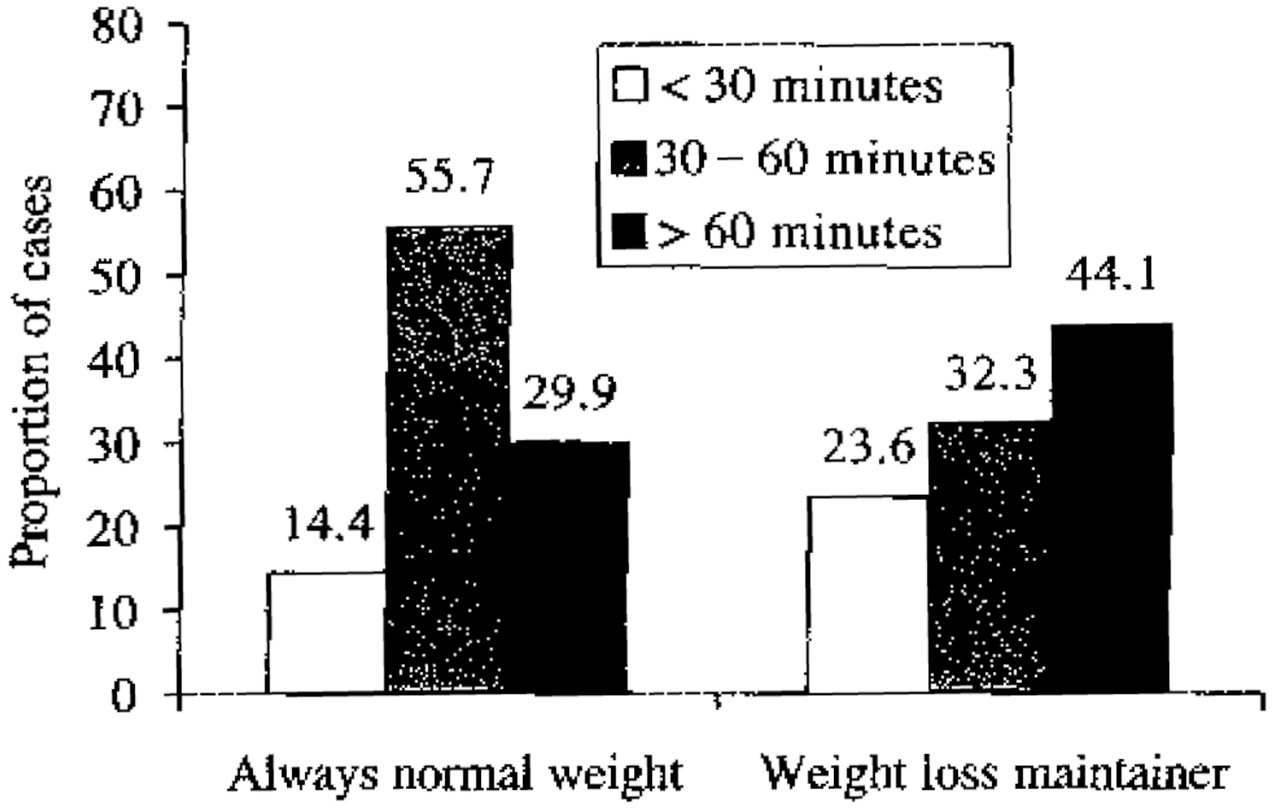


**FIGURE 1.**
Time spent in moderate-intensity or higher (METs ≥ 3) physical activity in the always-normal-weight and weight-loss-maintainer groups.

## TABLE 1

Subject characteristics.

| | Weight-Loss Maintainer Group (*N* = 135) | Always-Normal-Weight Group (*N* = 102) | *P* |
|---|---|---|---|
| Age | 49.1 ± 11.3 | 48.6 ± 11.2 | 0.76 |
| Current weight (kg) | 60.3 ± 7.2 | 56.2 ± 5.7 | 0.0001 |
| BMI | 22.0 ± 1.6 | 21.1 ± 1.3 | 0.0001 |
| % Caucasian | 92.6% | 95.1% | 0.93 |
| % married | 67.4 | 71.6 | 0.83 |
| % college educated or more | 75.5% | 79.4% | 0.84 |
| Lifetime maximum weight (kg) | 90.8 ± 17.6 | 59.4 ± 5.8 | 0.0001 |
| Duration of maintaining ≥ 10% weight loss (yr) | 14.2 ± 9.5 | — | — |

*P* values are based on independent *t*-tests for continuous variables and on chi-square tests for dichotomous variables.

## TABLE 2

Time (min·d$^{-1}$) spent at various intensities of physical activity.

| | **Weight-Loss Maintainer (*N* = 135)** | **Normal-Weight Control (*N* = 102)** | ***P*** |
|---|---|---|---|
| 2.0–2.9 METs | 84.8 ± 29.9 (79.5) | 90.7 ± 36.36 (85.5) | 0.10 |
| 3.0–4.9 METs | 34.2 ± 16.5 (32.7) | 35.2 ± 15 2 (35.3) | 0.64 |
| ≥5.0 METs | 24.4 ± 22.5 (18.7) | 16.9 ± 16.4 (11.6) | 0.02 |

Values represent means ± SD. Median values are identified in parentheses. *P* values are based on Kolmogorov–Smirnov tests.