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Self-weighing Frequency is Associated with Weight Gain Prevention over Two Years among Working Adults

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Abstract

Background—Little is known about the association between self-weighing frequency and weight gain prevention, particularly in worksite populations.

Purpose—The degree to which self-weighing frequency predicted two-year body weight change in working adults was examined.

Method—The association between self-weighing frequency (monthly or less, weekly, daily or more) and 24-month weight change was analyzed in a prospective cohort analysis (n=1,222) as part of the larger HealthWorks trial.

Results—There was a significant interaction between follow-up self-weighing frequency and baseline body mass index. The difference in weight change ranged from −4.4±0.8 kg weight loss among obese daily self-weighers to 2.1±0.4 kg weight gain for participants at a healthy weight who reported monthly self-weighing.

Conclusion—More frequent self-weighing seemed to be most beneficial for obese individuals. These findings may aid in the refinement of self-weighing frequency recommendations used in the context of weight management interventions.

Keywords

self-weighing; weight gain prevention; worksite; adults

Introduction

Excess body weight is a major public health issue in many countries, with obesity afflicting about 34% of U.S. adults (1–4). Obesity is associated with a consistently strong risk of incident high blood pressure (5), dyslipidemia (6), type 2 diabetes (7), and some forms of cancer (8). Obesity prevalence has at least doubled over the past three decades and current trends suggest that working age adults gain an estimated 1 kg annually (9, 10). Unfortunately there is limited support for weight loss programs as a population-level solution. Only 15% of individuals who intentionally lose 5 kg or more of their body weight successfully keep it off beyond five years (11, 12). Systematic reviews (13, 14) and meta-analyses (15, 16) on the topic of long-term weight management support the assertion that weight loss followed by long-term avoidance of weight regain is elusive. Others have advocated for a more realistic focus of intervention efforts that target the prevention of

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weight gain across the entire population versus weight loss for those at highest risk (10, 17, 18). There is some evidence that some weight gain prevention interventions are effective (19), particularly if they emphasize moderate caloric consumption, increased physical activity, and frequent self-weighing as key behavioral foci (1, 20).

Self-monitoring of body weight, or self-weighing, has received the least (and most controversial [21, 22]) attention as a behavioral self-management strategy. It is proposed to work via self-regulation in that an individual who self-weighs often will stay focused on changes in their weight. This creates more opportunities for internal reinforcement of small accomplishments, thus the individual is empowered to quickly identify lapses in their progress and make behavioral adjustments to maintain goals or weight homeostasis.

Two systematic reviews concluded that higher self-weighing frequencies are associated with greater weight loss and less weight (re)gain (23, 24). One study examined frequent self-weighing in the context of a weight gain prevention trial over a long timeframe (25). Follow-up analyses from that study found that participants who self-weighed daily (−0.8 kg/m^2) or weekly (0.3 kg/m^2) held a significant BMI change advantage relative to participants who self-weighed monthly (0.8 kg/m^2), semi-monthly (0.8 kg/m^2), or never (1.1 kg/m^2) over two years (26). Secondary analyses by Wing and colleagues (27) revealed that within an Internet-based intervention group, a significantly smaller proportion of participants who self-weighed daily (40%) regained ≥2.3 kg over 18 months follow-up relative to participants who did not self-weigh daily (68%). A randomized controlled trial by Levitsky, et al. (28) found that college females in a self-weighing intervention (0.1 kg) gained significantly less weight relative to controls (3.1 kg) who did not track weight over 10 weeks. Two cross-sectional samples found that 60% (29) and 80% (30), respectively, more respondents who were successful at preventing weight regain reported weekly or daily self-weighing (relative to participants that regained weight). Linde, et al. (31) observed that women in a large heath plan who reported daily self-weighing were almost 2 kg/m^2 less in body mass relative to women who reported never self-weighing.

Few large studies targeting weight gain prevention in worksites have been conducted. No studies to date have specifically examined the utility of frequent self-weighing for weight gain prevention exclusively in worksite populations, where the ability to promote large scale increases in self-weighing is arguably strong. This is an important gap in the literature because self-weighing is commonly recommended as part of weight management programs (1), but little is known about what sub-groups, if any, stand to benefit most (23). This study involved a secondary analysis of data from the HealthWorks trial. The hypothesis was that weekly or daily self-weighing frequency would be associated with less weight gain relative to monthly or less self-weighing over two years in a group of employed adults.

Methods

This analysis was conducted with data from the HealthWorks trial. The HealthWorks trial evaluated the effectiveness of an environmental intervention on 2-year body weight change among working adults. HealthWorks used a worksite randomized design that included six organizations in the Minneapolis-St. Paul, MN metropolitan area. Three worksites received a weight gain prevention intervention and three others received no treatment. Measures were taken at baseline and 24-months. Procedures were approved by the University of Minnesota Institutional Review Board. All participants signed informed consent forms.

Participants and recruitment

Study eligibility requirements for participating worksites were: ≥250 employees, willingness to provide a worksite liaison and advisory group to help coordinate activities, onsite food services, onsite stairways and elevators, willingness to allow for intervention and measurement procedures, and willingness to be randomized to the treatment or control arm. Participating companies represented a mix of industries including finance, healthcare, beauty, insurance, higher education, and energy. Within each participating worksite, study eligibility requirements for individual participants were: at least 50% full time equivalent position, day shift, present onsite at least half of position, and willingness to complete study assessments. Individual employee recruitment was conducted over a 4-week period and included sending a site-wide announcement inviting participation and up to 9 proactive telephone calls from study staff further inviting study participation.

Intervention overview

Briefly, the HealthWorks intervention focused on changes to the work environment designed to support regular physical activity, reduced caloric consumption, and self-weighing. These included healthy food/beverage price and access modifications, aesthetic stairwell enhancements, free access to pedometers and website step tracking tools, improved scale access for self-weighing purposes, worksite advisory groups, site-wide publicity of nutrition and physical activity programs, including announcements, signage, and monthly healthy living newsletters. Of particular relevance to this analysis were the environmental modifications to improve scale access. To promote regular self-weighing, environmental modifications were made to improve scale access. Four balance beam scales were placed at various locations in worksite buildings that were easily accessible and frequently used, such as rest rooms. Each scale location also included an opportunity for anonymously reporting progress in weight control. For those employees who were interested in sharing their (de-identified) weight data, a station was set up with a short data form for employees to record their date of weigh-in and body weight. Employees could then drop their information into a locked box. Feedback on aggregate level trends in the number of people using the worksite scales and cumulative weight changes were reported descriptively in the monthly healthy living newsletters. Note that this self-reported weight data was not used in this paper.

Measures

The independent variable was self-weighing frequency. It was assessed at both baseline and 24-month follow-up using a single-item, self-reported measure that asked “How often do you weigh yourself?” There were seven ordinal response options that included: never, about once a year or less, every couple of months, once a month, once a week, once a day, or more than once a day. This form of assessing self-weighing frequency has been used in large randomized-controlled trials (25, 32) and widely across the published scientific literature in this area, but no formal validity studies have been published that correlate self-reported to directly observed self-weighing frequency. For purposes of analysis, the 24-month self-weighing frequency measure was used as the primary predictor variable and was collapsed into three dummy categories, including: Daily, Weekly, or Monthly or less (reference category). These three categories were based on the non-linear association observed between self-weighing frequency and weight change in secondary analyses from two large randomized-controlled trials (26), as well as conclusions from systematic literature reviews (23, 24) where weekly self-weighing was the point at which weight change benefits meaningfully occurred and daily self-weighing offered a modest, statistically significant benefit over weekly self-weighing.

The dependent variable was body weight change. Body weight was measured at baseline and 24-month follow-up using a calibrated digital scale by a trained study staff person. Participants were weighed in light street clothing and without shoes. Weight was recorded to the nearest 0.1 kg. Body weight change was analyzed continuously based on the difference in body weight (i.e., change score) between baseline and 24-month follow-up.

Covariates considered for inclusion were baseline: age, sex, race/ethnicity, education, marital status, randomized condition, self-weighing frequency, smoking, diabetes, high blood pressure, depression, number of weight loss attempts in the past two years, perceived pounds needed to gain before attempting weight loss, number of scales in the home, and BMI. For BMI, height was measured to the nearest millimeter using a wall-mounted ruler and the BMI metric was calculated by dividing weight in kg by height in meters squared. Participants were assigned to one of three BMI categories, including: obese: ≥30.0 kg/m^2, overweight: 25.0–29.9 kg/m^2, and healthy weight: <25.0 kg/m^2. Few previous studies analyzing the association between self-weighing frequency and weight change utilized multivariate models, and those that did typically found no statistically or clinically significant covariates to report (26, 33), or analyzed self-weighing only with other self-monitoring covariates (30). As such, there was little direct empirical guidance to inform the selection of covariates. Each considered covariate was initially examined to determine whether or not it would be tested for inclusion in the final model. This was done by examining the univariate association between each considered covariate, the independent variable, and the dependent variable. Any covariate that was found to have $p<0.05$ in its association with the independent and dependent variable was included in the final model.

Statistical analyses

All analytical procedures were conducted using SAS Version 9.2 (Cary, NC). Because the intervention and control groups were statistically indistinguishable in terms of weight change (data not shown), these two groups were combined in this analysis in order to improve power. No imputations were made for missing variables and a complete-case framework was utilized in that participants with missing values for any predictor or outcome measure were listwise deleted.

A multivariate general linear regression model (PROC GLM) was used to examine the association between self-weighing frequency categories and body weight change. The primary predictor in this analysis, self-weighing frequency at the 24-month follow-up, was modeled categorically as described above with the "Monthly or less" group used as the reference category. First, a basic model was created to examine the crude relationship between self-weighing frequency categories and weight change. Next, effect modification was examined by creating a two-way interaction term between self-weighing frequency and each covariate (separately), and entering it into the crude model. Interaction terms with $p<0.05$ were retained in subsequent models. Any remaining covariates that were not found to be effect modifiers were retained in the final model as independent predictors.

Results

Across all six worksites, 1,747 employees enrolled in the HealthWorks trial and completed baseline assessments, and 1,407 (81%) completed the 24-month follow-up assessment. Overall follow-up rates were unremarkable between intervention (81%) and control (80%) arms. Of the 1,747 enrollees, 1,222 met the eligibility criteria for this analysis. Table 1 outlines the descriptive characteristics of the included and excluded analytical samples. HealthWorks participants could be described as mainly non-Hispanic White, middle-aged, females. Missing follow-up data was primarily due to participants leaving employment at one of the worksites that participated in the HealthWorks study. Differences in baseline characteristics were statistically indistinguishable between the analytical dataset and the remaining 525 participants that left the workforce or declined study follow-up, with the exceptions of age, sex, hypertension, and depression (see Table 1). Participants who were younger at baseline, female, reported having depression, or were normotensive were somewhat more likely to be excluded. Mean±sd weight change between baseline and 24-month follow-up was 0.65±6.06 kg, with 53% of participants having maintained their weight (i.e., gained ≤1 kg relative to baseline). The proportion of participants in each self-weighing frequency category at the 24-month follow-up was: monthly or less (55%), weekly (28%), and daily or more (17%). As outlined in Table 2, initial crude examinations of the considered baseline covariates found that baseline self-weighing frequency, smoking, and BMI were suitable covariates to be tested for interaction.

The initial crude model indicated that both daily (β±se=−1.79±0.48, t=3.76, p<0.001) and weekly (β±se=−0.92±0.40, t=2.29, p=0.022) self-weighing at the 24-month follow-up were significantly associated with weight change. Specifically, participants who reported self-weighing daily and participants that reported self-weighing weekly had lost about 1.8 kg and 0.9 kg, respectively, more than participants who reported self-weighing monthly. Further modeling revealed a significant interaction between follow-up self-weighing frequency and baseline BMI category. The final multivariate regression model with all included beta terms and directions of association is displayed in Table 3. To aid in the interpretation of these findings, Figure 1 graphs the least-squares adjusted weight change by each category of self-weighing frequency and baseline BMI. The direction of the interaction indicated that the greatest weight loss was observed for participants who were obese at baseline and reported self-weighing daily at the 24-month follow-up (mean±se −4.4±0.8 kg). In contrast, the largest weight gain was observed for participants who were at a healthy BMI at baseline and reported self-weighing monthly at the 24-month follow-up (2.1±0.4 kg).

Discussion

Consistent with previous research (23, 24), more frequent self-weighing was associated with a more favorable weight change profile in the HealthWorks trial. The association between weight change and self-weighing frequency was modified by baseline BMI category in that the benefits of regular self-weighing were most pronounced among obese participants. Specifically, daily self-weighers lost weight across all BMI categories, but obese participants who reported daily self-weighing clearly lost the most weight over two years relative to all other combinations of baseline BMI and self-weighing frequency. As would be expected in the general American adult population (10), monthly self-weighers gained nearly 2 kg on average over two years, with little distinction between BMI categories within the monthly level of self-weighing (see Figure 1). This suggests that more frequent self-weighing is associated with slower weight gain and, for obese individuals in particular, may encourage weight loss.

Interestingly, baseline self-weighing frequency was also significant in our final model, but it was in an unexpected direction in that, when viewed independently, participants who reported daily or weekly self-weighing at baseline actually gained more weight prospectively relative to those who reported self-weighing monthly at baseline. This finding is notable because few previous longitudinal studies have examined baseline self-weighing frequency as a covariate. Doing so in future research may be important to improve the precision of effect estimates for measurements of self-weighing frequency that occur during or after an active intervention phase. The more frequent assessment of changes in (or variability of) self-weighing frequency over time is an area worthy of further investigation. No statistical interaction between baseline and follow-up self-weighing frequency was observed, but there is other cohort evidence suggesting that participants who start out at higher levels of self-weighing frequency but then decrease their self-weighing over time gain more weight compared to those who increase their self-weighing frequency over time (33). The degree to which an increase in self-weighing frequency over time is causally related to weight loss, or is merely an indicator of intervention adherence, remains an open question.

More frequent self-weighing seemed to be most beneficial for individuals that are presumed to need it most; namely those that are obese. A persistent question in regard to weight management program design involves what the optimal level of self-weighing frequency should be. Some have suggested that a blanket recommendation of “at least weekly” is the closest to evidence informed advice researchers can currently give (23, 34). In light of the findings observed in the current research, this recommendation can perhaps be further tailored. Assuming the HealthWorks sample represents the broader adult population, perhaps the most relevant advice should be to self-weigh at least weekly to prevent weight gain and daily for weight loss, particularly for obese individuals.

From a methodological perspective, these analyses had several strengths. Sample sizes in published weight management literature rarely exceed 1,000 participants and it is not uncommon for attrition rates to exceed 50% in studies with longer follow-up timeframes (16). HealthWorks had a relatively long 2-year follow-up and recruited over 1,700 participants, with 70% of all enrollees retained in these analyses. There were enough participants in this study to statistically detect other covariates that had previously been unstudied, but it should be noted that this was a non-experimental analysis and thus the covariate relationships should be viewed as suggestive until experimental evidence is obtained. This study adds to the evidence base in this area and could potentially help refine recommendations on the optimal frequency of self-weighing in other programs.

Perhaps the most significant limitation to internal validity was the reliance on a single-time self-reported measure of self-weighing frequency. Though commonly used in the scientific literature to assess self-weighing, virtually no validity work has been done in this area. Also, the outcome variable was an absolute measure of weight change, which is the subject of some debate (35) because a given absolute weight change can carry different clinical benefits depending on the baseline size of the individual. As is the case in nearly all self-weighing studies to date, there remains a temporality issue in that the exposure and outcome are essentially measured (and are occurring) during a parallel timeframe and are not experimentally manipulated. As such, follow-up self-weighing frequency could have been either a cause or a consequence of weight change, even after adjustment for baseline self-weighing frequency. Participants with missing data were excluded and there was some evidence of not missing at random. Although this can potentially bias effect estimates, listwise deletion was used in this study because of the non-experimental nature of the analysis and the tendency for linear regression techniques to yield robust coefficients so long as missingness is not predicted by the outcome variable (36). Since the latter is unknown, more research is needed in this area to determine optimal analytical techniques to account for missing data in self-weighing studies.

Obesity remains a significant health challenge and interventionists must continue to refine available therapies to meet the population’s needs. If weight management initiatives begin to shift their focus more toward the prevention of weight gain instead of weight loss, as was done in the HealthWorks trial, promoting an increase in self-weighing frequency may add a net weight change benefit over time. More experimental studies designed to determine the precise independent contribution of more refined levels of self-weighing frequencies are needed. In addition, future research should also focus on examining self-weighing frequency as a dependent variable so that it can be better understood as a behavior in its own right, along with what program factors reinforce its regular practice. Self-weighing is a very straightforward, low-cost, self-management strategy that many people can engage in with relative ease given wide access to scales. Worksites in particular are well positioned to make environmental oriented modifications to their work spaces that can increase the propensity for employees to self-monitor their weight and, if needed, take corrective action to head off systemic weight gain.

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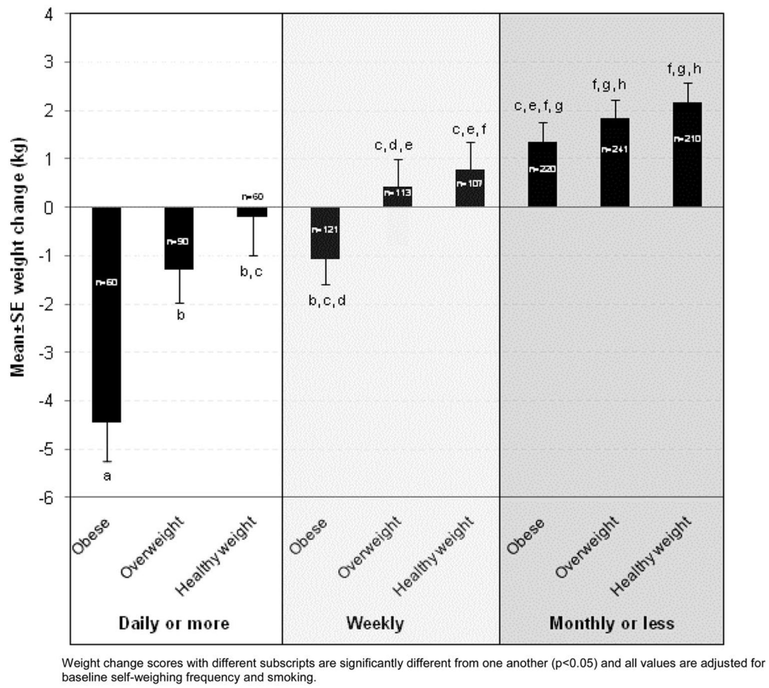

Figure 1.
Least-square adjusted weight change by follow-up self-weighing frequency and baseline body mass index categories of HealthWorks study participants (n=1,222).

Table 1

Descriptive baseline characteristics of those included and excluded from the analytical sample from all 1,747 HealthWorks participants. [a]

Baseline measure	Included in analytical sample (n = 1,222)	Excluded from analytical sample (n = 525)	p
Age (y)	44.2 ± 10.3	39.5 ± 11.1	<0.001
Sex			
Male	479 (39%)	175 (33%)	0.033
Female	743 (61%)	343 (65%)	
Not reported	0 (0%)	7 (1%)	
Race/Ethnicity			
White, non-Hispanic	1,071 (88%)	407 (78%)	0.052
Not White, or Hispanic	151 (12%)	77 (15%)	
Not reported	0 (0%)	41 (8%)	
Education level			
No college degree	486 (40%)	181 (34%)	0.381
College degree or higher	736 (60%)	302 (58%)	
Not reported	0 (0%)	42 (8%)	
Marital status			
Married or living with partner	829 (68%)	349 (66%)	0.281
Not married or living with partner	393 (32%)	146 (28%)	
Not reported	0 (0%)	30 (6%)	
Randomized study condition			
Intervention	541 (44%)	211 (40%)	0.114
Control	681 (56%)	314 (60%)	
Self-weighing frequency			
Daily or more	160 (13%)	77 (15%)	
Weekly	329 (27%)	119 (23%)	0.239
Monthly or less	733 (60%)	281 (54%)	
Not reported	0 (0%)	48 (9%)	
Current cigarette smoker			
Yes	171 (14%)	68 (13%)	0.876
No	1,051 (86%)	408 (78%)	
Not reported	0 (0%)	49 (9%)	
Medical conditions[b]			
Diabetes	46 (4%)	13 (2%)	0.309
High blood pressure	257 (21%)	74 (14%)	0.011
Depression	274 (22%)	129 (25%)	0.032
Weight loss attempts past 2 yrs (n)	2.9.0 ± 8.0	3.3 ± 9.9	0.424
Required weight gain for action (lb)	8.4 ± 9.7	7.9 ± 10.9	0.319
Scales in home (n)	0.8 ± 0.5	0.8 ± 0.5	0.564
Body mass index			
Obese: ≥30.0 kg/m^2	401 (33%)	170 (32%)	0.854

Baseline measure	Included in analytical sample (n = 1,222)	Excluded from analytical sample (n = 525)	p
Overweight: 25.0–29.9 kg/m^2	444 (36%)	186 (35%)	
Healthy weight: <25.0 kg/m^2	377 (31%)	169 (32%)	

[a]All values are reported as mean ±standard deviation or frequency (% of sample total).

[b]Variable does not sum to 100% of sample because participants could select multiple responses.

Table 2

Univariate, unadjusted association matrices between each considered baseline covariate and: (1) the primary predictor, and (2) the outcome (n=1,222).

	Primary predictor[a]	Outcome[b]
Covariates	**Self-weighing frequency at 24-month follow-up (weekly or more vs. monthly or less)**	**Weight change between baseline and 24-month follow-up (kg)**
Age (y)	1.004 (p=0.463)	−0.033 (p=0.054)
Sex (male vs. female)	0.823 (p=0.100)	−0.547 (p=0.127)
Race/ethnicity (non-White or Hisp vs. White non-Hisp)	0.731 (p=0.079)	−0.668 (p=0.205)
Education (No college degree vs. college degree)	0.731 (p=0.079)	0.214 (p=0.546)
Marital status (married/partner vs. not married/partner)	1.133 (p=0.313)	−0.664 (p=0.074)
Randomized study condition (intervention vs. control)	1.257 (p=0.048)	0.373 (p=0.286)
Baseline self-weighing[c] (weekly or more vs. monthly or less)	11.238 (p<0.001)	0.594 (p=0.094)
Current cigarette smoker[c] (yes vs. no)	0.425 (p<0.001)	0.875 (p=0.080)
Diabetes (yes vs. no)	0.521 (p=0.045)	−0.763 (p=0.403)
High blood pressure (yes vs. no)	1.043 (p=0.765)	−0.710 (p=0.095)
Depression (yes vs. no)	0.866 (p=0.298)	0.658 (p=0.114)
Weight loss attempts past 2 yrs (n)	1.027 (p=0.006)	−0.031 (p=0.149)
Required weight gain for action (lb)	0.955 (p<0.001)	0.023 (p=0.190)
Scales in home (n)	1.901 (p<0.001)	−0.052 (p=0.870)
Body mass index[c] (obese vs. not obese)	1.003 (p=0.982)	−1.497 (p<0.001)

[a]Values for the primary predictor are reported as odds ratio (p-value) for a one-unit change (continuous) or relative to reference category (categorical). Values less than 1 indicate that as the covariate increases (or relative to the reference category for categorical covariates), the odds of weekly or more self-weighing decrease relative to monthly or less self-weighing.

[b]Values for the outcome are reported as weight change in kg (p-value). Negative values indicate that as the covariate increases (or relative to the reference category for categorical covariates), weight decreases.

[c]Covariate considered for entry into the final multivariate model because associated p-value was <0.05 for the primary predictor or outcome.

Table 3

Final multivariate linear regression model depicting the association between weight change and follow-up self-weighing frequency, with interactions and covariates, in HealthWorks participants.

	Weight change (kg)		
Model predictors	β^a	**SE**	**p**
n = 1,222			
Intercept	1.197	0.426	0.005
Current cigarette smoker			
Yes	0.635	0.492	0.197
No (ref)	---	---	---
Baseline body mass index			
Obese: ≥30.0 kg/m^2	−0.803	0.570	0.159
Overweight: 25.0–29.9 kg/m^2	−0.299	0.558	0.592
Healthy weight: <25.0 kg/m^2 (ref)	---	---	---
Baseline self-weighing frequency			
Daily or more	3.446	0.628	<0.001
Weekly	1.395	0.439	0.002
Monthly or less (ref)	---	---	---
Follow-up self-weighing frequency			
Daily or more	−2.267	0.937	0.016
Weekly	−1.301	0.729	0.075
Monthly or less (ref)	---	---	---
Interaction (baseline body mass index × follow-up self-weighing)			
Obese × Daily	−3.457	1.221	0.005
Obese × Weekly	−1.048	0.970	0.280
Overweight × Daily	−0.801	1.132	0.479
Overweight × Weekly	−0.066	0.973	0.946
Healthy weight × Monthly (ref)	---	---	---

[a] *B*-values are equal to weight change (kg). Positive values indicate increased weight relative to the reference category and negative values indicate decreased weight relative to the reference category.