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Self-Monitoring in Weight Loss: A Systematic Review of the Literature

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ABSTRACT

Self-monitoring is the centerpiece of behavioral weight loss intervention programs. This article presents a systematic review of the literature on three components of self-monitoring in behavioral weight loss studies: diet, exercise, and self-weighing. This review included articles that were published between 1993 and 2009 that reported on the relationship between weight loss and these self-monitoring strategies. Of the 22 studies identified, 15 focused on dietary self-monitoring, one on self-monitoring exercise, and six on self-weighing. A wide array of methods was used to perform self-monitoring; the paper diary was used most often. Adherence to self-monitoring was reported most frequently as the number of diaries completed or the frequency of log-ins or reported weights. The use of technology, which included the Internet, personal digital assistants, and electronic digital scales were reported in five studies. Descriptive designs were used in the earlier studies whereas more recent reports involved prospective studies and randomized trials that examined the effect of self-monitoring on weight loss. A significant association between self-monitoring and weight loss was consistently found; however, the level of evidence was weak because of methodologic limitations. The most significant limitations of the reviewed studies were the homogenous samples and reliance on self-report. In all but two studies, the samples were predominantly white and women. This review highlights the need for studies in more diverse populations, for objective measures of adherence to self-monitoring, and for studies that establish the required dose of self-monitoring for successful outcomes.

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Behavioral weight loss programs typically involve decreased energy intake, increased energy expenditure, and use behavior strategies such as goal setting and self-monitoring. Self-monitoring consists of recording dietary intake and physical activity so that individuals are aware of their current behaviors (1). The use of self-monitoring in behavior change has a strong theoretical foundation.

Self-regulation theory posits that self-monitoring precedes self-evaluation of progress made toward one's goal and self-reinforcement for the progress made (2); thus, the process of changing habits requires well-developed self-regulatory skills (3,4). Self-monitoring is central to this process and includes deliberate attention to some aspect of an individual's behavior and recording some details of that behavior. To change behaviors, individuals need to pay adequate attention to their own actions, as well as the conditions under which they occur and their immediate and long-term effects (5). Thus, successful self-regulation depends in part on the truthfulness, consistency, and timeliness of self-monitoring in relation to the performance of the target behavior; for example, eating (5).

In early weight loss literature (1985-1990), self-monitoring referred only to monitoring diet in paper diaries (6). Subsequently, researchers found that physical activity was significantly associated with weight loss (7). Today, both dietary and physical activity self-monitoring are well-established components of the standard behavioral treatment protocol for weight loss (8,9). More recently, self-weighing has been introduced as another monitoring component (10).

Although self-monitoring has been described as the

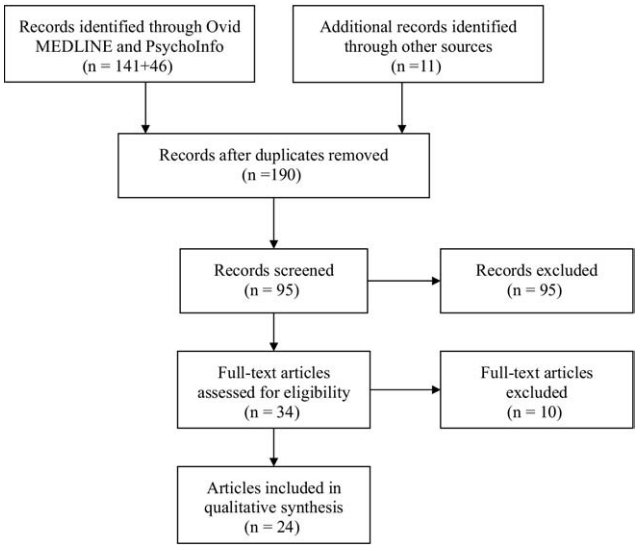

Figure. Systematic review process for weight loss-related self-monitoring methods guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.

cornerstone of behavioral treatment for weight loss (11,12), no one has conducted an examination of this literature. This article provides a systematic review of the empirical literature reporting the effect of self-monitoring diet, physical activity, and weight on weight loss in behavioral treatment studies. In addition, self-monitoring methods, changes over time, and adherence are examined. Based on an evaluation of the reviewed evidence, gaps are identified and recommendations are provided for future directions in research and practice.

METHODS

Search Strategies

An electronic literature search within two databases, Ovid MEDLINE and Ovid PsycINFO, were conducted. Key words included obesity, weight loss, overweight, and self-monitoring. A manual search of the reference sections of the included studies and also other relevant articles was also performed. Search limiters included English language and human beings.

Inclusion and Exclusion Criteria

The inclusion criteria of the studies for review were: conducted in the United States, reported between 1989 and 2009, investigated the effect of self-monitoring on weight loss, and reported the use of self-monitoring diet, physical activity, or self-weighing. Although the literature search covered the past 20 years, no studies published before 1993 met the criteria. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (13) guided the systematic review. The screening and inclusion procedures are reported in the Figure. Initially, 95 relevant articles were identified. Of these, 71 were excluded because the authors did not report the effect of self-monitoring on weight loss outcome. Thus, 24 publications reporting on 22 studies were included in the review. Due to the limited number of studies available for review, no restrictions on design or sample size were placed. Age, sex, ethnicity, and body mass index (BMI) were reported in most studies, for those articles without BMI information, weight at baseline was reported. Retention rates were reported if they were available in the original article.

Extraction of Data for Review

The review focused on the effect of self-monitoring on weight change at the key reporting points, often the midpoint and the end of study. Self-monitoring behaviors were measured using an array of approaches, including therapist evaluation of records, number of diaries completed, self-monitoring derived from questionnaires, and date- and time-stamped electronic diaries. The weight outcome measures included weight loss and prevention of weight regain or maintenance of weight.

For this review we summarized the study, primary intervention and duration; sample characteristics; approach to self-monitoring; and results pertinent to self-monitoring and weight change (Table). Mean and standard deviation of the age, BMI, or weight, and representation by sex and race are reported. If it was an ancillary study or secondary data analysis, the design of the reported study and the parent study are described. The American Heart Association and the American College of Cardiology's method (14) of classifying the evidence was used to guide the evaluation of the level of evidence for the studies reviewed.

RESULTS

Of the 22 studies reviewed (10,12,15-34), most (n=14) used descriptive designs and examined the association of self-monitoring with weight loss (10,12,18-27,31,34). Six were secondary data analyses (10,21,22,34) or ancillary studies (18,19) of existing weight loss programs. Fifteen studies focused on dietary self-monitoring (12,15,16,19,20,22-26,28-30,33,34), one included self-monitoring of exercise (27), and six focused on self-monitoring of weight (10,17,18,21,31,32). Eight were reports from randomized clinical trials testing behavioral weight loss interventions (15-17,28-30,32,33). Six of the trials (15,16,28-30,33) focused on dietary self-monitoring. Three of these studies (28-30) used diaries to self-monitor both physical activity and diet but only one separately reported the effect of self-monitoring physical activity on weight loss (30). Two additional trials focused on self-weighing in a self-regulation framework (17,32).

There were some striking findings when examining the aggregate of these studies. Four studies did not report the racial and ethnic composition of the sample (15,27,28,32). Of the 16 studies that did report race and ethnicity, all but three (26,29,30) had a homogenous sample that was 75% to 100% white. The samples were predominantly female with the representation of women ranging from 41% to 100%; one study did not report sex (15).

Self-Monitoring Dietary Intake

All of the 15 studies that focused on dietary self-monitoring found significant associations between self-monitor-

Table. Studies examining self-monitoring in weight management

Authors, study design/description	Sample	Self-monitoring approach	Outcome/results
Dietary self-monitoring			
Baker and Kirschenbaum, 1993 (12) Descriptive study, 12-18 wks of self-monitoring during a long-term cognitive behavioral treatment program	n=56 85.7% women 85.7% white Age 43.8±12.7 y Weight 246.5±56.4 lb	Self-monitoring booklet: recorded time, location, events, context of food consumption, exercise, mood, fat, and total energy, weight, and other eating-related factors (eg, water consumption, with whom eating.)	At 12 and 18 wk, two staff rated behaviors: whether or not self-monitoring any foods, time and quantity of food, and fat grams eaten. Association of self-monitoring and % weight change: (*r*s 0.35 to 0.65, $P<0.01$).
Boutelle and Kirschenbaum, 1998 (22) Descriptive study, 8-wk self-monitoring among adults in long-term (~17 mos) treatment for obesity	N=59 71.2% women 93.0% white Age 44.5±10.0 y Body mass index 35.5±7.3	Self-monitoring booklet: record foods, fat grams, total energy, and exercise. "any" food—whether the participant recorded at least one food on a given day "every" food—3 separate entries of meals during the day Therapist's ratings: 0-7 0-0 days monitored 7-7 days monitored	At 8 wks, therapist ratings of self-monitoring consistency. Correlation between consistency of self-monitoring and weight change r −0.35, $P<0.007$. At 8 wks, 45.6% of participants self-monitoring all foods on 75%-100% of the days.
Baker and Kirschenbaum, 1998 (24) Descriptive study, ancillary to 1-y cognitive behavior therapy	N=38 84.2% women 84.2% white Age 43.6±12.2 y Weight 244.7±64.8 lb	Self-monitoring booklet: index of six variables for self-monitoring: foods eaten+any food eaten+time food was eaten+quantity eaten+grams of fat consumed−non-monitoring (range −1-+5).	Self-monitoring adherence differed by quartiles in consistency of self-monitoring ($P<0.001$). Highly consistent self-monitors lost more weight than the other groups, F (3,54)=5.09, $P<0.05$.
Boutelle and colleagues, 1999 (23) Descriptive comparison study, randomly assigned to a 2-wk intervention of self-monitoring vs self-monitoring+daily phone calls+mailings to remind of self-monitoring during the 2-wk holiday season	N=57 71.9% women 93.0% white Age 44.5±10.0 y Body mass index 35.5±7.3	Self-monitoring booklet: Self-monitoring ratings same as described above in 1998 study	Group that received self-monitoring reminders was more consistent in self-monitoring than group that did not receive reminder, $P<0.02$. Self-monitoring consistency and weekly weight change, $r=-0.35$, $P=0.007$.
Tate and colleauges, 2001 (16) 2-group, 6-mo randomized controlled trial comparing Internet education for weight loss to Internet behavior therapy	Internet behavior therapy: n=46 89.0% women 77.8% white Age 41.1±11.6 y Body mass index 29.1±3.0 Retention 71.7% Internet education: n=45 89.0% women 77.8% white Age 40.6±9.7 y Body mass index 28.9±3.1 Retention 71.1%	Electronic diary: self-monitoring was emphasized to both groups and both were encouraged to use the self-monitoring Web resources to track diet and exercise; only the behavior therapy group was instructed to submit diaries to the therapist each week via Web site	Behavioral therapy group, total number of diaries submitted was correlated with wt loss, $r=-0.50$, $P=0.001$.
Nothwehr and Peterson, 2005 (25) Descriptive survey, focused on those reported tying to lose weight in a rural population	N=123 73.2% women 100% white Age range: 19-71 y, with majority >50 y Body mass index >25 29% response rate to population-based survey	Questionnaire: focused on self-reported practices of self-monitoring diet and exercise	Self-monitoring scores for total sample were: diet, range 6-24, 13.0±4.2; exercise, range 4-16, 7.7±2.6. Responders trying to lose weight (n=60) self-monitoring score for diet (14.16±4.13) and self-monitoring for exercise (8.25±2.71) were higher than responders (n=63) not trying to lose weight, self-monitoring for (diet 11.92±4.06, $P<0.01$) and for exercise 7.25±2.42, $P<0.05$.
Wadden and colleagues, 2005 (34) Descriptive results on self-monitoring and weight loss using data from a 4-group, 12-mo randomized controlled trial comparing lifestyle intervention to pharmacological therapy	Sibutramine alone: n=55 80.0% women 56.4% white Age 42.1±10.2 y Body mass index 38.2±3.9 86.5% retention at Wk 52 Lifestyle modification alone: n=55 84.0% women 63.6% white Age 43.3±9.7 y Body mass index 37.8±4.2 85.5% retention at Wk 52 Combined therapy: n=60 81.7% women	Paper diary: daily food records and calorie intake and physical activity	The number of records subjects completed was associated with weight loss at 18 wks ($r=0.29$, $P<0.001$), and at 52 wks ($r=0.31$, $P<0.001$).

(continued)

Table. Studies examining self-monitoring in weight management (continued)

Authors, study design/description	Sample	Self-monitoring approach	Outcome/results
	70.0% white Age 44.2±10.8 y Body mass index 37.9±4.2 81.7% retention at Wk 52 Siburamine plus brief therapy: n=54 83.3% women 72.2% white Age 44.9±10.1 y Body mass index 37.6±4.7 81.5% retention at Wk 52		
Tate and colleagues, 2006 (33) 3-group, 6-mo randomized controlled trial of Internet intervention, examined the effect of no counseling, computer-automated counseling, or human E-mail counseling on weight loss	No counseling: n=67 82.0% women 91.0% white Age 49.9±8.3 y Body mass index 32.3±3.7 Retention 88.1% Automated E-mail feedback: n=61 87.0% women 90.0% white Age 49.7±11.4 y Body mass index 32.7±3.5 Retention 72.1% Human E-mail counseling: n=64 84.0% women 87.0% white Age 47.9±9.8 y Body mass index 32.8±3.4 Retention 81.3%	Electronic diary: record weight, daily energy intake, use of meal replacements, and exercise in two counseling groups	Dairy submission was significantly associated with weight loss in automated feedback ($r=-0.69$) and human counseling ($r=-0.56$), Ps<0.001. Subjects in the human counseling group submitted diaries in more weeks than A group, (17.2±8.7 vs 11.4±9.2), $P<0.001$.
Helsel and colleagues, 2007 (15) 16-wk randomized controlled trial, correspondence-based weight-loss intervention; randomized to traditional detailed method of self-monitoring vs abbreviated method	n=42 Sex and ethnicity not reported Detailed self-monitoring: n=21 Age 38.0±5.9 y Body mass index 32.0±1.6 Transitional self-monitoring: n=21 Age 35.0±6.6 y Body mass index 32.5±1.5 Retention: 48% in traditional and 57% in abbreviated diary group	Paper diary: detailing food intake and physical activity duration Abbreviated diary: used check marks to estimate fat content and size of meals and snacks, range of exercise duration, and indication of skipped meals or snacks.	Participants in abbreviated self-monitoring group returned more diaries (15.2±1.4) than in traditional diary group (14.0±2.0), based on completers-only analysis, $P<0.04$. No difference between the groups in the number of meals, snacks, or exercise recorded. Weight loss was associated with number of completed diaries, $r=0.53$, $P<0.05$).
Yon and colleagues, 2007 (20) Comparative study of non-concurrent groups, 6-mo behavioral weight loss treatment	Personal digital assistant group: n=61 91.8% women 100% white Age 48.2±8.7 y Body mass index 32.3±3.4 93.0% retention Paper diary group: n=115 83.5% women 100% white Age 46.1±9.2 y Body mass index 30.9±3.5 81.0% retention	Personal digital assistant: PalmZire 21[a] with Calorie King Diet Diary[b] software Paper diary: recorded food and energy intake, daily exercise and energy expended	No significant differences between groups in weight loss or dietary self-monitoring; no differences in frequency of self-monitoring, attendance, or adherence to energy goals. Frequency of dietary self-monitoring explained 32% of weight loss variance, F (1,144)=72.45 ($P<0.01$).
Carels and colleagues, 2008 (28) Randomized controlled trial, 14-wk self-help or therapist-assisted self-help weight loss program	n=54 78% women Ethnicity not reported Age 46.2 ±8.9 y Body mass index 35.6±7.3	Paper diary: instructed to submit the weekly diary electronically or hard copy	Those who lost 5% of body weight self-monitoring more than twice as many days as those who did not have 5% weight loss, $P<0.01$. Self-monitoring greater during initial 4 wks of program, declined over time. Self-monitoring accounted for 25% of variance in weight loss. No difference in the frequency of self-monitoring between treatment groups.

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Table. Studies examining self-monitoring in weight management (continued)

Authors, study design/description	Sample	Self-monitoring approach	Outcome/results
Burke and colleagues, 2006 (19); 2008 (35) Descriptive study, ancillary to a randomized controlled trial of behavioral treatment for weight loss	n=36 86.1% women 66.7% white Age 42.9±9.9 y Body mass index 34.8±5.2 Phase I (intense treatment 0-6 mo): n=35 Body mass index 34.3±3.9 Phase II (less-intense treatment 6-12 mo): n=13 Body mass index 30.4±5.3 Phase III (maintenance 12-18 mo): n=16, Body mass index 30.9±4.4	Instrumented paper diary: used to compare self-reported adherence to self-monitoring with electronically recorded data (date- and time-stamp of diary opening and closure)	Electronic data demonstrated lack of concordance between self-reported times of self-monitoring and objectively documented times of recording; % of weight loss correlated with frequency of recording in instrumented paper diary, $r=0.51$, $P=0.001$ and % of diary entries made within 15 min of opening the instrumented paper diary, $r=0.43$, $P=0.009$, and % of diary entries of eating within 15 min of instrumented paper diary opening ($r=0.53$, $P=0.001$).
Hollis and colleagues, 2008 (26) Nonrandomized, 6-mo standard behavior intervention for weight loss before second phase maintenance study	n=1685 67.3% women 56.3% white Age 54.8±9.1 y Body mass index 34.3±4.8	Paper diary: record daily food intake and physical activity	Significant association between number of diaries submitted and weight loss. Number of food records/wk had a greater impact on weight loss at 6 mo among non–African Americans than African Americans, regardless of sex
Burke and colleagues, 2009 (29,36) 3-group, 24-mo randomized controlled trial of behavioral intervention; examined effect of 3 self-monitoring approaches on weight loss and self-monitoring adherence	n=210 84.8% women 78.1 % white Age 46.8±9.0 y Body mass index 34.0±4.5 Retention: 91% at 6 mo	Paper diary vs personal digital assistant: 3 approaches to self-monitoring: paper diary vs personal digital assistant with dietary and exercise software vs personal digital assistant plus feedback message delivered daily and tailored to diary entries. Personal digital assistant included date- and time-stamp to measure adherence to self-monitoring.	Median adherence to self-monitoring in the paper diary group (55%) compared to the combined personal digital assistant group (90%), $P<0.0001$. Was a significant indirect group effect on % weight change through self-monitoring adherence (estimate=2.0, 95% confidence interval 1.12-3.59).
Shay and colleagues, 2009 (30) 12-wk randomized controlled trial examined 3 self-monitoring methods: paper diary, Web-based diary, and personal digital assistant diary	n=39 (completers only) 41% women 59% white Age 35.3±9.3 y Body mass index 33.0±3.4 53.4% retention at 12 wk	All diaries from Calorie King[b] with the same nutrition and exercise information provided to all groups via different methods. Paper diary: pocket-size diary Web-based diary: Calorie King[b] weight management and exercise program Personal digital assistant: Tungsten/e^2 Palm[a]	No group difference in weight ($P>0.05$). The total number of days adherent to diet self-monitoring was associated with weight loss at 6 wk ($r=-0.40$, $P=0.013$) and 12 wk ($r=-0.37$, $P=0.021$). No significant correlation between the total number of days adherent to exercise self-monitoring and weight loss at 6 wk and 12 wk. The number of days self-monitoring diet or exercise was not significantly correlated with weight loss
Self-monitoring of exercise			
Carels and colleagues, 2005 (27) Descriptive study, 6-mo behavioral weight loss program	n=40 83% women Ethnicity not reported Age 43.4±9.4 y Body mass index ≥30	Physical activity diary: record exercise type and duration; diaries collected every 4-5 wk during 21-mo period. Weekly exercise self-monitoring computed from diaries	Weekly exercise increased over the study, 130 min/wk in first 7 wk to 208 min/wk in final 7 wk. Greater self-monitoring associated with fewer difficulties related to exercise, $r=-0.48$, $P<0.01$; self-monitoring related to greater weight loss, $r=0.44$, $P<0.05$, and to greater weekly exercise, $r=0.52$, $P<0.01$.
Self-weighing			
Linde and colleagues, 2005 (10) Descriptive study examining cross-sectional and longitudinal association between self-weighing frequency and weight in samples from two 24-mo trials	Pound of Prevention: A weight gain prevention trial: n=1,226 81% women 87% white Age 34.5±6.5 y Body mass index 27.2±5.9 Weigh-to-Be: A weight loss trial: N=1,800 72% women 91% white Age 50.7±12.4 y Body mass index 34.2±6.0	Questionnaire: Pound of Prevention: "How frequently do you weigh yourself?" asked at baseline, 12 and 24 mo. Response categorized to "Never, every other month, every month, every week, and every day." Recommended weighing at least once/wk Weigh to Be: "How often do you weigh yourself?" asked at baseline, 12 and24 mo. Responses collapsed to "Never, every other month, every month, every week, and every day." Recommended self-weighing no more than once/wk	Pound of Prevention study: Only daily weighing at 12 and 24 mo associated with weight loss, other frequency categories associated with weight gain. Weigh to Be study: monthly, weekly and daily weighing associated with weight loss at 12 and 24 mo; more frequent self-weighing associated with greater 24-mo weight loss or less weight gain. Self-weighing frequency increased in both treatment groups, but weighing frequency decreased in the Pound of Prevention study control group

(continued)

Table. Studies examining self-monitoring in weight management (continued)

Authors, study design/description	Sample	Self-monitoring approach	Outcome/results
Wing and colleagues, 2006 (32) 3-group randomized controlled trial, 18-mo trial	n=314 Internet group: n=104 82.9% women Ethnicity not reported Age 50.9±9.3 y Body mass index 28.1±4.6 Face to Face group: n=105 80.8% women Age 51.0±10.3 y Body mass index 28.7±4.7 Control group: n=105 82.9% women Age 52.0±10.8 y Body mass index 29.1±5.0 92.7% retention at 18 mo	Home monitoring scale: provided scale and telemonitoring system with color zones to guide weight gain prevention behaviors. Participants in the intervention groups asked to submit weight weekly through telephone or Internet.	Both intervention groups increased daily self-weighing, was associated with lower risk of regaining ≥2.3 kg, $P<0.001$. Weight gain 2.5±6.7 kg in face-to-face group vs 4.7±8.6 kg in Internet group vs 4.9±6.5 in control group. Significant difference in weight gain only between face-to-face and control groups, $P=0.05$. Compared to intervention groups, more subjects in control group regained 2.3 kg, $P<0.001$. Adherence to self-weighing: % of subjects who reported weekly weight decreased over time (84% to 56% in face-to-face group and82% to 55% in Internet group), between group difference, $P>0.05$. Proportion of participants in each group that reported weighing themselves ≥daily different at 6, 12, and18 mo; for all pairwise comparisons, $P<0.001$.
Butryn and colleagues, 2007 (31) Descriptive, longitudinal survey of participants in the National Weight Control Registry who had completed the self-weighing self-monitoring at entry into National Weight Control Registry and at 1 y	n=3,003 75.1% women 94.8% white Age 48.0±12.6 y Body mass index 25.3±4.8 82% retention	Questionnaire: Self-weighing frequency categories were "at least daily," "several times/wk or weekly," and "less than weekly." Questionnaire administered at entry into National Weight Control Registry and 1 y later	At entry, 36.2% of participants reported self-weighing at least once/d. More frequent self-weighing associated with older age, lower maximum body mass index and body mass index at registry entry. At 1 y, subjects who had decreased self-weighing frequency (17.7% of sample) gained more weight than subjects who increased frequency (9.6%), or stayed the same (72.7%), weight gain of 4.0±6.3 kg, 1.1±6.5 kg, and 1.8±5.3 kg, respectively, $P<0.001$. From entry to 1-y: Weight change ranged from 2.2 kg with ≥ weekly self-weighing vs 2.3 kg with <daily self-weighing vs 1.7 kg with <1 x/wk self-weighing, $P=0.12$
Gokee-LaRose and colleagues, 2009 (17) 2-group randomized controlled trial: behavioral self-regulation vs adapted standard behavioral treatment lasting 20 wk	n=40 87.5% women 75% white Age 29.1±3.9 y Body mass index 33.4±3.4 Retention: 93% for post-treatment (10 wk) and 88% for F/U (20 wk)	Questionnaire vs electronic scale: Standard behavior treatment group subjects told not to weigh themselves at home during first 10-wk period and then once weekly after intervention ended. Subjects in behavioral self-regulation group given digital memory scales to self-weigh daily at home. Digital memory scale: stored 31 d of weight data, subjects were asked to bring their scales to clinic after 1 mo, post-treatment (10 wk) and follow up (20 wk). Questionnaire: administered at baseline, 10 and 20 wk "During the past month, how often did you weigh yourself?" Responses included "several times a day," "one time each day," "several times a week," "less than once a month," and "never weighed myself"	At 20 wks, self-weighing frequency associated with weight loss across groups, $P=0.01$. Adherence to self-weighing: 95% of subjects in behavioral self-regulation group reported self-weighing daily. Electronic scale data confirmed that 100% of subjects had stored weights at 1 mo and that 95% had stored weights at 10 wk. Both groups had significant weight loss at 10 and 20 wks ($P<0.001$) with no group×time difference. Daily self-weighing was not associated with any adverse psychological symptoms
VanWormer and colleagues, 2009 (18) Prospective cohort design to examine subjects in weight-loss trial that encouraged frequent self-weighing. Measurements at baseline, 6 and12 mo	n=100 91% women 86% white Age 46.5±8.7 y Body mass index 38.4±5.3 Retention: 78% at post-treatment and 47% at follow-up	Home telemonitoring scale: automatically transmitted self-monitoring weights via modem	Proportion of sample lost ≥5% weight at 6-mo post treatment was higher among subjects who self-weigh at least weekly than subjects who self-weigh less than weekly, $P<0.001$, no difference at 12 mo follow-up.
Welsh and colleagues, 2009 (21) Descriptive study, secondary analysis of data from a 6-mo randomized controlled telephone-based weight loss trial	n=63 79% women 82% white Age 49.5±1.4y Body mass index 34.2±0.5	Questionnaire: self-reported self-weighing frequency collapsed into three categories: once a month or less, weekly, and daily	Self-weighing frequency at 6 mo was associated with weight change at 6 mo ($F=3.6$, $P=0.04$), no significant association was found between self-weighing and body satisfaction at 6 mo ($P=0.90$).

[a]Palm, Inc, Sunnyvale, CA.
[b]Wellness Solutions, Inc, El Cajon, CA.
NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

ing and weight loss. Eight studies used paper diaries only (12,15,22-26,34); the remainder used variations of the paper diary and/or an electronic diary (16,19,20,28-30,33). The measurement and analysis of dietary self-monitoring varied considerably. In four earlier studies (12,22-24), participants were instructed to record exercise, mood, eating situation, water consumption, and other behavioral variables associated with eating (eg, time and with whom food was consumed). The measurement of self-monitoring in these four studies included monitoring six variables: any or all foods eaten, the time of eating, the quantity of food, fat grams consumed, absence of monitoring, or the degree of diary completeness (12,22-24). When evaluating the effect of self-monitoring, the investigators either generated a weekly monitoring index based on these six diet-related variables, or used the therapists' judgment score to create ordinal categories of self-monitoring completeness. In those studies employing therapist judgment scores, the investigators found that individuals with self-monitoring records deemed to be the most complete lost significantly more weight than those who had less complete records, and that weight loss was higher during weeks with higher self-monitoring completeness (12,22-24). These findings are similar to those of more recent studies by Yon and colleagues (20) and Burke and colleagues (35) who evaluated self-monitoring in terms of frequency of self-monitoring. Other recent investigations used the number of diaries returned as a measure of self-monitoring; however, the completeness of the returned diary was not described (15,33). Others have used a total score of their self-designed surveys to assess self-reported frequency of self-monitoring (25). Adherence to self-monitoring, was defined as recording at least the amount of food that would be equivalent to 50% of the energy goal for the day in a recent report from a clinical trial (36). Studies that used the Internet reported the number of diaries submitted without specifying the degree of completeness (16).

The advent of computer-based technology, including the Internet, for use in self-monitoring has spawned a new generation of studies. In 2001, Tate and colleagues (16) reported that the number of diaries submitted to a behavioral weight loss program delivered via the Internet was significantly related to weight loss. Yon and colleagues (20) compared the results of a weight loss study employing personal digital assistant (PDA) self-monitoring to a prior study that used paper diary self-monitoring and found no between group differences in the amount of weight lost or self-monitoring adherence. Shay (30) conducted a 12-week randomized trial and compared three approaches: paper diary vs an Internet-based diary vs a PDA diary and found no group differences in weight loss (30). A recently completed 2-year, randomized clinical trial compared self-monitoring with a paper diary vs a PDA with daily tailored feedback messaging vs a PDA without feedback messaging. Findings at 6 months revealed that, compared to the paper diary group, the PDA groups combined were more adherent to self-monitoring and that dietary self-monitoring in this group had a significant indirect effect on percent weight loss (29,36).

Self-Monitoring Physical Activity

Five studies discussed the use of paper diaries to record exercise behaviors (15,22-24,27,30). However, only one of these studies specifically examined the role of self-monitoring exercise in relation to weight loss (27). Participants were asked to record their daily exercise type and duration. Exercise self-monitoring was defined as the number of weeks physical activity diaries were completed. The findings revealed that consistent self-monitors of exercise not only achieved significantly greater weight loss but also experienced fewer difficulties with exercise and exercised more often.

Self-Monitoring Weight

Most recently, researchers have advocated weight self-monitoring to increase participants' awareness of their weight and its relation to energy intake and expenditure (18,31,32). One investigator conducted descriptive ancillary studies to two ongoing trials by using a single-item survey to assess self-reported frequency of self-weighing among the trial participants (10). In both trials, a weight gain prevention trial and a weight loss trial, Linde and colleagues (10) administered the survey at three time points. In the weight gain prevention trial, only daily weighing was associated with weight losses, and less frequent weighing was associated with weight gain. However, in the weight loss trial monthly, weekly, and daily self-weighing were associated with weight losses; more frequent self-weighing was associated with a greater 24-month weight loss. Two randomized trials addressed daily self-weighing within a self-regulation framework as the main intervention strategy (17,32). Wing and colleagues (32) examined the effect of self-weighing among three groups: face-to-face, Internet-based, and a control in an 18-month trial focused on prevention of weight regain. Results revealed that both of the intervention groups increased their daily self-weighing, which was significantly associated with a lower risk of weight regain. As detailed in the Table, adherence to self-weighing decreased over time in both groups. Gokee-LaRose and colleagues (17) compared two behavioral self-regulation approaches in a 20-week clinical trial. Participants in one group were instructed to obtain daily weights using a digital memory scale. Participants in a second group received an adapted standard behavioral treatment group in which they were instructed not to weigh themselves until Week 11 and then to obtain weekly weights. At 20 weeks, frequency of weighing was significantly associated with weight loss; however, there was no significant difference in weight loss between the two groups. Use of the electronic scale provided objective data to confirm the self-reported adherence to self-weighing, which was >95% of the days. Vanwormer and colleagues (18) conducted a prospective cohort study to examine the effect of a behavioral weight loss program with a scale that transmitted weights daily to the investigators. The study showed that greater weight loss was associated with increased frequency of self-weighing, especially among those who self-weighed at least weekly.

Approaches to Self-Monitoring and Associated Tools

Researchers have used various approaches and tools for self-monitoring. One 16-week weight loss study compared traditional paper diaries to a group that used the same traditional diaries for 8 weeks and then transitioned to self-monitoring using abbreviated checklists (15). The number of diaries completed in the transition group was significantly higher than in the traditional paper diary group; however, no significant difference in weight loss was observed between the two groups. Tate and colleagues (16,33) conducted two studies that used a structured Internet program and found that the total number of submitted diaries was significantly related to weight loss.

Dietary software programs that have been used in self-monitoring research include DietMatePro (PICS, Inc, Reston, VA) and Calorie King (Wellness Solutions, Inc, El Cajon, CA), and an exercise program, CalcuFit (PICS, Inc). In 2007, Yon and colleagues (20) reported the results of the first PDA-based self-monitoring study. They conducted a study of non-concurrent groups, one using a paper diary and one using a Palm Zire 21 (Palm, Inc, Sunnyvale, CA) with Calorie King Dietary Diary software, and found that the use of a PDA was comparable to the use of paper diaries in dietary self-monitoring, since there were no differences in weight loss or dietary self-monitoring between the groups. More recently, Burke and colleagues (29) tested the use of a PDA with DietMatePro and CalcuFit, each with date- and time-stamp functions for each self-monitoring entry. Participants did not encounter major difficulties in learning how to use the PDAs (Palm Tungsten/e^2, Palm, Inc) and reported that using a PDA was more socially acceptable for self-monitoring than recording in a paper diary (29). Although stand-alone PDAs have become obsolete, in part because they lack wireless connectivity, many of their features have been incorporated into smart phones and are increasingly more available today.

The telemonitoring scale (Thin-Link, Cardiocom, LLC, Chanhassen, MN) described by Vanwormer and colleagues (18) transferred weight data automatically to the research center through a telephone land line. Other scales are available for monitoring weight at home and transmitting the data in real time. Gokee-LaRose and colleagues (17) reported using a scale that stores weight data for 31 days eliminating the need for individual recording of daily weights.

Adherence to Self-Monitoring

Detailed measurement of adherence to self-monitoring has been reported infrequently; thus, little is known about the extent to which people adhere over time.

Measures of adherence reported in the literature included the number of diaries submitted (15,16,33), therapists' ratings of the completeness of diaries (12,22,24), scores on a survey of self-monitoring (10,25,31), or the number of self-reported weights over a specified period (17,18,32) . This variability in the measurement method makes it impossible to compare adherence across studies.

An instrumented binder was used in the only study that objectively measured dietary self-monitoring adherence, which was conducted as an ancillary study to a behavioral weight loss trial (35). Paper diaries were enclosed in a canvas binder that had photosensors unobtrusively embedded in the spine to detect when the binder was opened and closed; a circuit board stamped the date and time of each opening and closure, which served as a surrogate for the time of recording. The electronic data were compared to the self-reported record of self-monitoring and revealed that there was little concordance between the self-reported and electronically documented data (35,37). Moreover, the timing of self-monitoring in relation to eating was also significantly related to weight loss. This study also documented the phenomena of backfilling, which occurred when the person submitted a diary that was completed for the days that the diary was never opened (35).

Weight of the Evidence

Based on the aggregate data from the studies reporting on self-monitoring diet, physical activity, and weight, a grade was applied for the level of evidence for each of the self-monitoring strategies The evidence was determined to be one of the following four: Class IIa, which states that the weight of evidence or opinion is in favor of the treatment; Class IIb, the usefulness/efficacy is less well established by evidence or opinion; Level A includes data obtained from multiple randomized clinical trials and Level B, which includes data obtained from a single randomized trial or nonrandomized studies.

The level of evidence was most influenced by the strength of the study designs and the methodology employed. The studies featuring dietary self-monitoring included five randomized clinical trials (15,16,28-30). While this design is the strongest, several had methodologic weaknesses, including small sample (15,28,30) and less than desirable retention (15,30), whereas another study used non-concurrent groups to compare paper diaries and PDAs (20). Based on these factors, the level of evidence for the studies reporting on dietary self-monitoring is Class IIa, Level A. The one study that examined exercise self-monitoring was a descriptive study of short duration with a small sample (27). Thus, this evidence is Class IIb, Level B.

The six studies that focused on self-weighing included two randomized controlled trials, three descriptive designs, and one prospective cohort study. Except for one study (17), all had large samples with good retention; however, one study had a large sample but inadequate retention at follow-up. Only Wing and colleagues (32) used a three-group design with a large sample and compared self-weighing to a control condition. Gokee-LaRose and colleagues (17) used an objective measure of self-weighing rather than reliance on self-report. The findings from these studies indicate evidence at the level of Class IIa, Level A.

DISCUSSION

The studies reviewed in this paper represent the state of the science pertaining to self-monitoring as a strategy to increase a person's awareness of targeted behaviors and the circumstances that surround those behaviors. This review included 22 studies that focused on self-monitoring diet, physical activity or exercise, and self-weighing.

Each study contributed to the body of evidence supporting the role of self-monitoring; more frequent self-monitoring was consistently and significantly associated with weight loss compared to less frequent self-monitoring. Because of the variability in how self-monitoring diet or exercise was measured, it was not possible to report the exact frequency of self-monitoring that made the difference in weight outcomes. In the self-weighing studies, there was a significant weight loss difference between weighing daily to weekly and those self-weighing less often, which was confirmed by a systematic review of the self-weighing literature (38).

Most of the included studies used a descriptive design and had some methodological weaknesses (15,17,20,28); only six were randomized clinical trials (15-17,23,28,29,39). These limitations influenced the level of evidence and, thus, impacted the conclusions and subsequent recommendations that can be made from this review. The strongest point was the consistent support for self-monitoring in the studies that spanned the review period. However, because of the homogeneity of the samples, the generalizability of the findings was limited to white, overweight, or obese women. This represents a major limitation in the understanding of the acceptability, adherence to, and effect of self-monitoring among minority groups and men. This also speaks to where future research needs to focus.

An additional methodological weakness of the reported studies was the assessment of self-monitoring and the room for measurement bias. With the exception of the early studies (12,22-24) that used therapists to grade diaries on several activities (eg, foods eaten, time of eating, quantity of food) and a recent trial that defined self-monitoring adherence (29), none of the studies reported criteria by which they evaluated self-monitoring or how they defined completeness of diaries or log-in recordings. The study that revealed how participants reported recording in food diaries on days when the diary was never opened documented the fallacies of self-reported diary data (35). The use of technology and electronic devices that date-and time-stamp the self-monitoring behavior (the diary entry or the actual weighing) provided an objective validation of these self-reported behaviors (29,35).

One group examining adherence to self-monitoring defined a completed diary as one that included the recording of at least 50% of the recommended energy intake; an incomplete or a missing diary was defined as nonadherent for that week. Similar to what has been reported in the literature (16), there was a gradual decline in self-monitoring adherence, which worsened when the treatment sessions decreased in frequency. At the end of the intervention, only 25% of the sample continued to self-monitor (40,41).

The increased use of technology with dietary and exercise software programs might lessen the burden of self-monitoring and thus enhance adherence. Having easy access to an extensive database of foods, including many restaurant items, eliminates the need to look up nutrient values of the foods eaten and calculate totals consumed. The available software programs also permit one to save frequently eaten meals and, thus, eliminate the need for repeated searching and entry. Beasley and colleagues (42) reported that it took new users of a dietary software program 8 to 10 minutes to enter a meal, which is comparable to or less than recording a meal in a paper diary (42). It should be noted that these were new users, and as with any software, there is a learning curve and it takes time to learn the shortcuts. However, more studies are needed to determine if time is saved with the use of technology-supported diaries.

Sex and ethnicity have been reported to influence self-monitoring behaviors (26,43). One study revealed that men completed significantly more diaries than women (26). This same study found that the number of food records completed had a stronger association with weight loss among African Americans when compared to non–African Americans, regardless of sex (26). Using data from in-depth interviews focused on the experience of self-monitoring, other researchers reported that the best recorders were those who were engaged in a structured weight loss program for the first time (43). Similar to the findings reported by Hollis and colleagues (26), men were more adherent than women. Other factors that supported good adherence to self-monitoring included support from significant others; for example, a spouse assisting with determining nutrient content of foods (43). Butryn and colleagues (31) reported that participants in the National Weight Control Registry who self-weighed more frequently were older, had a lower maximum BMI, and a lower BMI at entry into the Registry (31). If, as the literature suggests, greater self-monitoring adherence results in greater weight loss, these findings have implications for the design of weight loss interventions. Structured programs may be best for enhancing self-monitoring adherence. To maximize weight loss, researchers and clinicians may want to target the following groups for additional encouragement with their self-monitoring efforts: women, African Americans, and those who previously tried and failed a weight loss program, have limited social supports, or who have very high BMIs. Of course additional research would be required to support these conclusions.

The progress that has been made since the first descriptive study of dietary self-monitoring was reported is substantial. The inclusion of self-monitoring physical activity more than 10 years ago, and more recently self-weighing, has expanded the behavioral treatment approach. However, the absence of studies that isolated the effect of self-monitoring physical activity or exercise on weight change leaves a void in this area. With the increasing sophistication and availability of objective measures of physical activity, this is a rich area for further investigation to validate self-reported adherence and self-monitoring reports.

One question not answered in the literature is the dose of self-monitoring required for successful outcomes. Ideally, researchers and clinicians would like to recommend the frequency of dietary and exercise self-monitoring needed for weight loss or the prevention of weight gain. Although the evidence supports self-monitoring as much as possible, the evidence supporting any dose is lacking at this time. The evidence supporting self-weighing frequency is also limited; however, the data regarding dose are clearer and suggest that self-weighing at least weekly may provide a benefit. Much work remains to be done to determine the dose (ie, intensity, frequency, and duration) of self-monitoring that is feasible and needed to support behavior change. Related but also unexamined questions are the effect of interventionist feedback on self-monitoring adherence, and

the nature and frequency of interventionist feedback needed to sustain self-monitoring behavior.

CONCLUSIONS

Although there were methodologic limitations to the studies reviewed, there was ample evidence for the consistent and significant positive relationship between self-monitoring diet, physical activity, or weight and successful outcomes related to weight management. The review identified several gaps, including the optimal frequency and duration of self-monitoring diet and exercise, the effectiveness of self-monitoring among subpopulations under-represented in weight loss studies, and the need for objective means to validate the self-report measures. It is important to continue these lines of research so that the strategy of self-monitoring in behavioral treatment of weight management can be strengthened.

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