

Systematic Review of Maintenance of Behavior Change Following Physical Activity and Dietary Interventions

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Objective: In the past decade, there has been no systematic review of the evidence for maintenance of physical activity and/or dietary behavior change following intervention (follow-up). This systematic review addressed three questions: 1) How frequently do trials report on maintenance of behavior change? 2) How frequently do interventions achieve maintenance of behavior change? 3) What sample, methodologic, or intervention characteristics are common to trials achieving maintenance? **Design:** Systematic review of trials that evaluated a physical activity and/or dietary behavior change intervention among adults, with measurement at preintervention, postintervention, and at least 3 months following intervention completion (follow-up). **Main Outcome Measures:** Maintenance of behavior change was defined as a significant between-groups difference at postintervention and at follow-up, for one or more physical activity and/or dietary outcome. **Results:** Maintenance outcomes were reported in 35% of the 157 intervention trials initially considered for review. Of the 29 trials that met all inclusion criteria, 21 (72%) achieved maintenance. Characteristics common to trials achieving maintenance included those related to sample characteristics (targeting women), study methods (higher attrition and pretrial behavioral screening), and intervention characteristics (longer duration [>24 weeks], face-to-face contact, use of more intervention strategies [>6], and use of follow-up prompts). **Conclusions:** Maintenance of physical activity and dietary behavior change is not often reported; when it is, it is often achieved. To advance the evidence, the field needs consensus on reporting of maintenance outcomes, controlled evaluations of intervention strategies to promote maintenance, and more detailed reporting of interventions.

Keywords: follow-up, exercise, nutrition, relapse prevention, behavior change

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Engaging in regular, moderate-intensity physical activity and following a healthy diet are important for the promotion of physical and mental well-being (Australian Institute of Health & Welfare, 2008; U. S. Department of Health & Human Services, 2000) and the prevention and management of many chronic diseases (Chobanian et al., 2003; Eyre, Kahn, & Robertson, 2004; Sigal, Kenny, Wasserman, Castaneda-Sceppa, & White, 2006). There is a large research base on interventions targeting physical activity and/or dietary behavior change among adults, utilizing a variety of intervention delivery modalities (i.e., individual and group counseling, telephone counseling, tailored print, website-delivered interventions), and intervention settings (i.e., workplace, community, health care services). Findings support the efficacy of selected interventions in producing moderate, short-term improvements in physical activity and/or diet (Ammerman, Lindquist, Lohr, & Hersey, 2002; Eakin, Lawler, Vandelandotte, & Owen,

2007; Goldstein, Whitlock, & DePue, 2004; Kahn et al., 2002; Neville, O'Hara, & Milat, 2009a, 2009b; U.S. Preventive Services Taskforce, 1996). However, few intervention trials include evaluations of the maintenance of behavior change—defined here as a follow-up evaluation of a behavioral outcome occurring at least 3 months postintervention contact. Given the importance of maintenance of outcomes to informing translation of evidence-based health behavior interventions into practice (Glasgow, Goldstein, Ockene, & Pronk, 2004; Owen, Glanz, Sallis, & Kelder, 2006), a critical review of the extant literature is needed (Glasgow, Lichtenstein, & Marcus, 2003; Ory, Jordan, & Bazzarre, 2002).

In 2000, *Health Psychology* published a supplementary issue on maintenance of health behavior change, with reviews on interventions targeting physical activity (Marcus et al., 2000), diet (Kumanyika et al., 2000), smoking (Ockene et al., 2000), and weight loss (Jeffery et al., 2000). The purpose of that supplement was to generate recommendations for the next generation of research into maintenance of behavior change (Orleans, 2000). Marcus and colleagues reviewed the literature on maintenance of physical activity behavior change following intervention (Marcus et al., 2000). They concluded that a comprehensive review was *not* possible, due to the paucity of reports of maintenance of behavior change and the inconsistency in physical activity measurement across trials. Marcus and colleagues also highlighted the lack of reporting of specific maintenance strategies in interventions. Similarly, Kumanyika and colleagues reviewed the literature on maintenance of dietary change following intervention

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(Kumanyika et al., 2000) and concluded that while there was some evidence that dietary behavior change could be maintained, the generalizability of the outcomes of dietary trials was poor. A review of the literature on multiple health behavior interventions was not included in the supplement, because of the small number of such trials at the time.

Since 2000, there have been multiple reviews examining long-term maintenance of outcomes in weight-loss interventions (Brown et al., 2009; Curioni & Lourenco, 2005; Franz et al., 2007) and smoking cessation interventions (Hajek, Stead, West, Jarvis, & Lancaster, 2009; Lancaster, Hajek, Stead, West, & Jarvis, 2006; Le Foll, Aubin, & Lagrue, 2002). However, while it appears that there has been an increase in the reporting of physical activity and/or dietary maintenance outcomes in intervention literature, there have been no subsequent reviews.

In the current review, maintenance of behavior change was defined as sustaining a statistically significant behavior change achieved by the end of an intervention, for at least 3 months thereafter. Three questions were addressed:

1. How frequently do physical activity and dietary intervention trials report on maintenance of behavior change?
2. How frequently do interventions achieve maintenance of behavior change?
3. What sample, methodological, or intervention characteristics are common among trials achieving maintenance of behavior change?

Methods

Search Strategy

Two structured searches of PubMed, Web of Science, Medline and PsycInfo were conducted for articles published between January 2000 and August, 2009. One search included the search terms (physical activity OR exercise) and the other included (diet OR nutrition). In both searches the following terms were also included: (intervention OR program) AND (follow-up OR maintenance) AND (behavior change OR behaviour change). The PubMed and Web of

Science searches were limited to adults and the Medline and PsycInfo searches included (NOT child* OR adolescence*) as search terms. All terms were searched for in the title, abstract, or keywords. All searches were limited to English language publications.

Study Inclusion Criteria

Studies included in this review were those that: evaluated a physical activity and/or dietary behavior change intervention at a minimum of three time points (i.e., preintervention, postintervention, and at least 3 months after completion of the intervention); reported on physical activity and/or dietary intake/behaviour outcomes at each time point (theoretical constructs [e.g., motivational readiness, intention] were not accepted as direct measures of behavior); randomized participants to a control or comparison group; reported on between-groups statistical differences at end-of-intervention and follow-up (or provided group descriptive statistics allowing this to be computed); and, targeted adults. Studies were included in the review if they targeted other health behaviors (e.g., smoking cessation) as well as physical activity or diet, but these other behavioral outcomes were not considered in the review. Studies were included that targeted behavior change across the prevention spectrum (i.e., primary prevention trials to secondary prevention trials focusing on chronic disease self-management or weight loss) provided that behavioral outcomes were reported. If multiple postintervention follow-up assessments were reported, then the longest follow-up (i.e., longest duration from the end of intervention) was used for the purpose of this review.

Data Extraction

All abstracts from the database search were independently assessed by two authors (B.F., M.N.) based on the inclusion criteria previously listed, and discrepancies were verified by a third author (E.E.). The data shown in Figure 1 were extracted from each eligible trial, with a focus on sample, methodologic, and intervention characteristics and intervention outcomes. All variables related to physical activity and

Category	Details
Study type	first author, year of publication, country, primary prevention (PP) or secondary prevention (SP)
Sample characteristic	sample size at time of randomization, description of participants, mean age, gender distribution
Intervention characteristic	intervention duration, frequency and mode of intervention delivery, number and type of behavior change strategies, extent of post-intervention contact, other targeted behaviors
Study methods	study design, length of follow-up, comparison group contact type and frequency, behavioral measurement tools, method of accounting for missing data at follow-up, adjustment for baseline values in analyses or acknowledgement of differences between study groups at baseline, retention rate of randomized participants at end-of-intervention and follow-up, description of randomization process, pre-trial screening based on behavioral criteria
Intervention outcomes	study group means (standard deviations) or medians (confidence intervals), reported statistical significance of between-group differences (p values)

Figure 1. Details extracted from each eligible trial.

/or dietary outcomes were reviewed, excluding theoretical constructs (e.g., readiness, intentions), aerobic fitness, and micronutrient intake (e.g., folate, sodium). If between-groups significance was not reported for each behavioral outcome at each assessment point, it was calculated using an online *t* test calculator (www.graphpad.com/quickcalcs) when sufficient descriptive statistics by study group were available. This calculation was necessary for at least one behavioral outcome in six studies (Study No. 19, 20, 21, 23, 28, 29 as listed in Table 1).

Methodological Quality

A methodological quality score (0–5), derived from the CONSORT statement for randomized controlled trials (Moher, Schulz, & Altman, 2001), was calculated. One point was awarded for each criterion met, which included the following: 1) adequate description of the randomization process; 2) either an objective or validated subjective behavioral measurement tool; 3) adjustment for baseline behavior in statistical analyses or no difference between study groups at baseline reported; 4) retention of at least 70% of randomized participants at the follow-up assessment; and, 5) whether missing data at follow-up were handled adequately for examining maintenance of behavior change (i.e., having less than 10% of data missing at follow-up or reporting that data were missing at random, otherwise missing data at follow-up were imputed by carrying forward baseline values).

Intervention Strategies

Using the taxonomy developed by Abraham and Michie (Abraham & Michie, 2008), two authors (B.F., M.N.) independently coded behavior change strategies described in each intervention (see Appendix A in supplementary materials for listing of 26 strategies). Disagreements in coding classifications were discussed between the two authors and were clarified against the article's description of the strategy. Trials were categorized based on the number of behavioral strategies employed (i.e., >6 or ≤ 6 , dichotomized based on median number of strategies reported across trials). Three strategies of particular relevance to maintenance were: relapse prevention (following initial behavior change, identification of situations likely to result in failure to maintain new behavior and plan to avoid or manage these situations); follow-up prompts (contact that occurs following the end of the main part of the intervention, either before or after the postintervention assessment, that has been reported specifically as reinforcing previous intervention content rather than delivering additional material); and, self-monitoring (participant-held written record of a specified behavior). Relapse prevention and follow-up prompts were considered to directly influence maintenance because they are administered after an initial behavior change or after the initial intervention period. Self-monitoring has been associated with long-term maintenance of weight loss (Wing & Phelan, 2005) and in a recent meta-analysis, was the only strategy associated with increased

Table 1
Summary of Studies Included in Review ($n = 29$)

No.	First author, year	Country	<i>n</i>	Brief sample description	Duration of intervention	Length of follow-up
<i>Physical activity interventions</i>						
1	Basler, 2007	Germany	170	older adults with chronic back pain	5 weeks	6 months
2	Bock, 2001	USA	150	healthy inactive adults	6 months	6 months
3	Connell, 2009	USA	157	women caring for spouse with dementia	6 months	6 months
4	DeVet, 2009	Netherlands	709	healthy adults	1 day or 3 months	6 months
5	Hughes, 2006	USA	215	older adults with osteoarthritis	8 weeks	10 months
6	Jimmy, 2005	Switzerland	161	healthy inactive adults	7 weeks	12 months
7	Kirk, 2004	Scotland	70	healthy inactive adults	6 months	6 months
8	Marshall, 2003	Australia	462	healthy adults	1 day	4 months
9	Moore, 2006	USA	250	outpatients with recent cardiac event	11 weeks	10 months
10	Nour, 2007	Canada	113	older adults	6 weeks	8 months
11	Pinto, 2008	USA	86	women treated for breast cancer	12 weeks	6 months
12	Rejeski, 2009	USA	106	older adults	12 months	2 yrs
13	Rogers, 2009	Canada	41	inactive women with breast cancer	12 weeks	3 months
14	Vallance, 2008	Canada	377	breast cancer survivors	3 months	6 months
15	van der Ploeg, 2006	Netherlands	1202	rehabilitation patients	8 weeks	43 weeks
<i>Diet interventions</i>						
16	Elder, 2006	USA	357	American Latino women	12 weeks	12 months
17	Elder, 2000	USA	732	Latino adult students	1–2 weeks	3 months
18	Fries, 2005	USA	754	healthy adults	4 weeks	12 months
19	Prochaska, 2005	USA	5407	primary care patients	12 months	12 months
20	Prochaska, 2004	USA	2460	parents of 9th grade students	12 months	12 months
21	Sallit, 2009	USA	216	weight-concerned female smokers	12 weeks	9 months
22	Stevens, 2003	USA	616	women with high cholesterol	6–9 weeks	12 months
<i>Physical activity and diet interventions</i>						
23	Burke, 2003	Australia	137	healthy adult couples	4 months	4 months
24	Clark, 2004	UK	100	patients with Type 2 diabetes	12 weeks	12 weeks
25	Greaney, 2008	USA	880	older adults	12 months	12 months
26	Lindsay, 2009	UK	108	adults with coronary heart disease	6 months	6 months
27	Sternfeld, 2009	USA	787	adult workplace employees	16 weeks	16 weeks
28	Thoolen, 2009	Netherlands	197	patients with Type 2 diabetes	3 months	3 months
29	von Gruenigen, 2008	USA	45	overweight endometrial cancer survivors	6 months	6 months

effect sizes in physical activity and diet interventions (Michie et al., 2009). The correlation of the coding of the total number of strategies employed in each study between the two authors was high (Spearman's correlation = 0.96). The percent agreement and Cohen's kappa for agreement between the two authors for coding each strategy is shown in Appendix A. For the three strategies that were of particular interest in this review, the percent agreement between authors' coding was 97% (self-monitoring), 86% (use of follow-up prompt), and 100% (relapse prevention).

Defining Maintenance of Behavior Change

A physical activity, dietary or combined intervention trial was considered to demonstrate maintenance of behavior change if a statistically significant between-groups difference in favor of the intervention group was reported at end-of-intervention *and* at follow-up for at least one behavioral outcome. The rationale for this lenient definition is threefold. First, most diet and combined intervention trials, and some physical activity intervention trials, report on multiple behavioral outcomes (e.g., fiber, fat, fruit, vegetables) and/or on multiple aspects of the same behavior (e.g., physical activity minutes/week, percent meeting physical activity guidelines) and/or across multiple measures of the same behavior (e.g., objective and subjective), often without specifying which is the primary outcome. Second, statistical power differs across analyses for various outcomes, making change more difficult to detect for some (i.e., categorical vs. continuous outcomes). Third, in intervention trials with multiple target behaviors, maintenance of improvement for even a single behavior is beneficial and warrants the intervention being judged as at least partially successful (Prochaska, Velicer, Nigg, & Prochaska, 2008). The rationale for not applying a threshold-based, behavior-specific maintenance criterion (e.g., a maintained change of at least 30 min of moderate intensity physical activity or one serving of fruit and vegetables) was based on the heterogeneity of behavioral outcomes and measurement tools across trials and the infrequent reporting of magnitude of behavior change between end-of-intervention and follow-up.

To assess "completeness" of maintenance, each trial was also categorized using a more conservative definition where *all* behavioral outcomes were required to show statistically significant between-groups differences in favor of the intervention group at end-of-intervention *and* at follow-up. For the combined physical activity and diet interventions this criterion required all behavioral outcomes for *both* behaviors to meet the maintenance definition.

Data Analysis

We established how frequently maintenance was achieved, using both the lenient and conservative maintenance definitions. Due to the small number of studies, and the infrequent occurrence of some characteristics, we did not perform statistical comparisons. To examine how commonly specific sample, methodologic, and intervention characteristics occurred among trials that achieved maintenance, we report characteristics as more or less common among studies, if the differences met a threshold of $\geq 10\%$. Continuous characteristics (e.g., intervention duration, length of follow-up) are reported as being higher or lower for studies achieving maintenance if the difference in means (normally distributed

data) or medians (non-normally distributed data) was $\geq 10\%$. We also examined frequency of achievement of maintenance among trials based on dichotomized continuous characteristics ($>$ or \leq median). Sample, methodologic or intervention characteristics of low frequency (i.e., < 5 studies with the characteristic) were not reported because of the bias in interpretation based on proportions resulting from small groupings of studies (including objective measures of behavioral outcomes [3/29]; missing data imputation method [3/29]).

Results

Search Outcomes

The search of the four databases resulted in 349 unique publications being assessed for eligibility. Of these publications, 319 were excluded (see Figure 2). Twenty-nine trials were included in the review and are summarized in Table 1 (full details of included trials are available as online supplementary material). Included trials evaluated interventions targeting physical activity only ($n = 15$), diet only ($n = 7$), or both physical activity and diet ($n = 7$). The length of postintervention follow-up differed for physical activity only interventions (median 6 months, range 3–24 months), diet only interventions (median 12 months, range 3–12 months), and combined interventions (median 8 months, range 3–12 months). There were three studies that included more than one postintervention follow-up at least 3 months after intervention completion (Study No. 16, 18, 21). In these three studies use of the behavioral outcomes for the shorter follow-up assessment resulted in the same interpretation as the longer follow-up outcomes, thus as previously stated, the longest follow-up was used.

Research Question 1: How Frequently Did Trials Report on Maintenance of Behavior Change?

To answer this question, we examined the 157 publications that directly reported on behavioral outcomes of a physical activity and/or diet intervention (see Figure 2). Of these 157 trials, 55 (35%) included a postintervention follow-up of 3 months or longer. When the additional criterion of including a comparison group was considered, this proportion dropped to 18% (29/157).

Research Question 2: How Frequently Did Interventions Achieve Maintenance of Behavior Change?

Of the 29 trials that met all inclusion criteria, 26 (90%) reported significant positive, between-groups differences at the end-of-intervention for at least one behavioral outcome, and 21 (72%) also reported significant between-groups differences at follow-up for at least one outcome, thus meeting the lenient definition (maintenance in one or more behavioral outcomes; Figure 3). Eleven of the 29 trials (38%) met the conservative definition (maintenance on all outcomes). Of note, an additional two trials (Study No. 11, 13) reported significant between-groups behavior change at follow-up, in the absence of significant between-groups end-of-intervention effects (based on the lenient definition).

For physical activity intervention trials, 12 of the 15 trials reported significant between-groups differences at end-of-

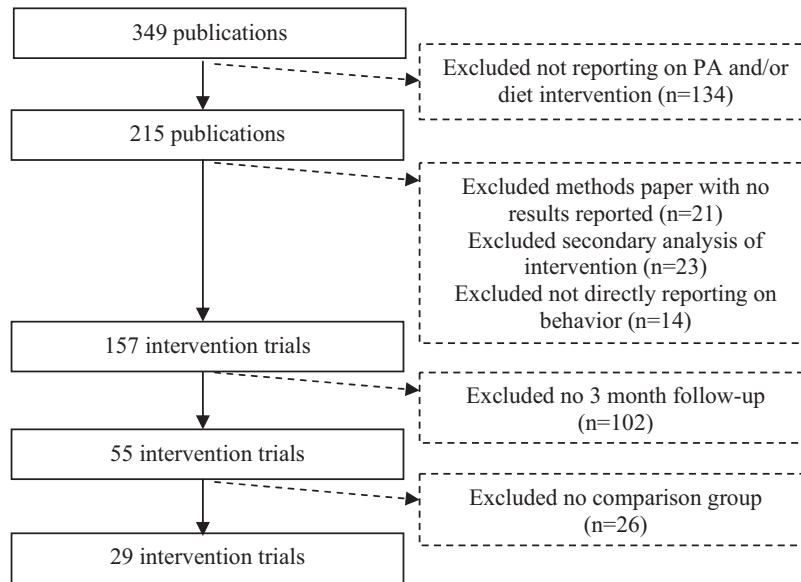


Figure 2. Reasons for exclusion of publications resulting from database search ($n = 349$).

intervention in at least one behavioral outcome, nine of these trials maintained significant between-groups differences at follow-up, and four achieved this for all physical activity variables reported (see Figure 3). For the dietary intervention trials, all seven reported significant between-groups differences at end-of-intervention in one or more outcome, six maintained significant between-groups differences at follow-up, and five achieved this for all dietary outcomes (see Figure 3). All seven studies intervening on both physical activity and diet reported significant between-groups effects at end-of-intervention for at least one physical activity or dietary outcome, and six maintained significant between-groups differences in at least one physical activity or dietary outcome at follow-up (see Figure 3). Of the six trials that maintained behavior change at follow-up in at least one outcome, only two maintained change at follow-up for all behavioral outcomes measured (i.e., all physical activity *and* dietary outcomes).

Research Question 3: What Sample, Methodological or Intervention Characteristics Were Common in Interventions Achieving Maintenance of Behavior Change?

Sample characteristics. The proportion of trials meeting the lenient maintenance definition did not differ between trials targeting healthy participants (primary prevention) and those targeting at-risk or diagnosed participants (secondary prevention; Table 2), nor between trials that did and did not target older adults. Studies that only targeted women were less likely to achieve maintenance, but importantly, seven of these eight studies targeted women with chronic conditions.

Methodology characteristics. The mean length of postintervention follow-up was 9 months ($SD\ 4.5$) among trials that met the lenient maintenance definition and seven months ($SD\ 3.4$) among

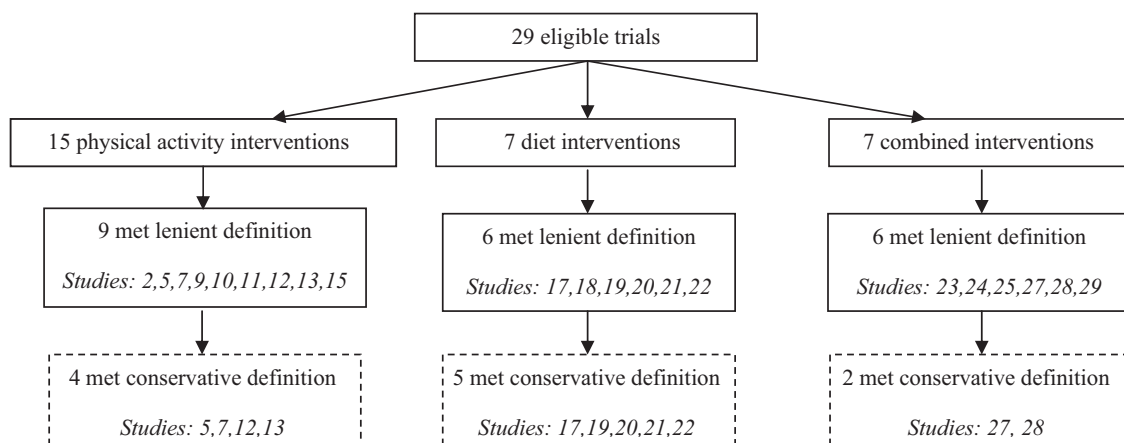


Figure 3. Number of trials in each category meeting the lenient and conservative maintenance definitions, and the corresponding study numbers (listed in Table 1).

Table 2
Sample, Methodology, and Intervention Characteristics of Trials Achieving Maintenance of Behavior Change (Based on Lenient Definition)

	<i>n</i>	Achieved maintenance <i>n</i> (%)
<i>Sample characteristics</i>		
Targeted healthy participants (primary prevention focus)		
yes	14	10 (71)
no	15	11 (73)
Targeted older adults		
yes	5	4 (80)
no	24	17 (71)
Targeted women only		
yes	8	5 (63)
no	21	16 (76)
<i>Methodology characteristics</i>		
Length of post-intervention follow-up ≥ 12 months		
yes	8	6 (75)
no	21	15 (71)
Retained at least 70% of randomized participants at follow-up		
yes	21	13 (62)
no	8	8 (100)
Adequate handling of missing data at follow-up		
yes	16	12 (75)
no	13	9 (69)
Pre-trial screening based on behavioral criteria		
yes	11	9 (82)
no	18	12 (67)
More than assessment contact with control group participants		
yes	16	11 (69)
no	13	10 (77)
<i>Intervention characteristics</i>		
Intervention duration > 24 weeks		
yes	10	8 (80)
no	19	13 (68)
Ratio of intervention contact frequency: intervention duration (wks) > 1		
yes	11	8 (73)
no	18	13 (72)
Intervention delivery includes face-to-face contact		
yes	18	15 (83)
no	11	6 (55)
More than six intervention strategies employed		
yes	15	13 (87)
no	14	8 (57)
Intervention strategies included relapse prevention		
yes	5	4 (80)
no	24	17 (71)
Intervention strategies included follow-up prompts		
yes	8	7 (88)
no	21	14 (66)
Intervention strategies included self-monitoring		
yes	10	7 (70)
no	19	14 (74)

trials that did not. Achievement of maintenance was similarly common among trials that did and did not have a postintervention follow-up of 12 months or more, and those that did and did not handle missing data adequately (see Table 2). The median methodological quality scores were the same across trials that did and did not meet the maintenance definition (median 4, range 2–5). Trials with adequate retention rates ($>70\%$) less commonly achieved maintenance than those with lower retention rates. Studies that used pretrial screening to exclude potential participants who met behavioral targets more com-

monly achieved maintenance than those that did not. Achievement of maintenance was similarly common among trials that did and did not include comparison groups that received brief intervention (e.g., advice only, standard print materials).

Intervention characteristics. Trials that met the lenient definition of maintenance had a mean intervention duration of 21 weeks (SD 17), whereas trials that did not were on average shorter (mean 12 weeks, SD 8). Interventions that lasted more than 24 weeks were more likely to achieve maintenance than those that did

not (see Table 2). Trials achieving maintenance had a higher number of intervention contacts (mean 13, *SD* 16), than trials not achieving maintenance (mean 7, *SD* 9). Given the likelihood of correlation between intervention duration and number of contacts, a ratio of contacts to duration was calculated; there was no difference in the proportions achieving maintenance between trials with higher ratios of intervention contact and those with lower ratios of contact (see Table 2). Trials achieving maintenance more commonly included face-to-face contact during the intervention than those that did not include any face-to-face contact.

The median number of behavior change strategies employed was 6.0 (range 4–14) among interventions meeting the maintenance definition and 4.5 (range 1–12) among those not meeting the definition. Interventions that employed more than six intervention strategies were more successful at achieving maintenance than those that did not (Table 2). The proportion of trials achieving maintenance was higher among trials that employed follow-up prompts as an intervention strategy compared to those that did not. However, achievement of maintenance was similarly common among trials that did and did not include self-monitoring or relapse prevention as intervention strategies. The most common strategies employed among trials that met the maintenance definition were providing instruction on how to achieve behavior change (17/21, 81%); prompting intention formation (15/21, 71%); prompting barrier identification (15/21, 71%); and providing opportunity for social comparison (14/21, 67%).

Categorization of the sample, methodologic, and intervention characteristics within trials meeting the conservative definition of maintenance was not possible due to the smaller number of trials meeting the conservative definition (11/29).

Discussion

Approximately one third of physical activity and/or dietary intervention trials published since 2000 reported on maintenance of behavioral outcomes (at least 3 months subsequent to the completion of the intervention), and this proportion fell to less than one fifth, when only randomized controlled trials were considered. Of the trials that met our inclusion criteria, less than one third included a follow-up assessment of 12 months or longer. Thus, the issue of maintenance of behavior change following interventions is not receiving the attention it should, and not in the context of rigorous experimental designs. This finding is of particular note given that the sampling frame used in this review was limited to trials including the keywords “follow-up” or “maintenance,” and the required follow-up period (3 months or longer) was relatively short, which would have positively inflated the findings. The lack of published findings on maintenance of behavior change may be due to a lack of research attention, or to a publication bias toward successful interventions, which has been previously suggested for physical activity and dietary interventions published between 1990 and 2008 (Michie et al., 2009). Another potential explanation for the lack of published results of maintenance of behavior change is that the available funding for intervention research often does not allow sufficient resources or time to conduct extended postintervention follow-up assessments.

This was a complex review, with no precedent or consensus on how to define maintenance of behavior change. Thus, we examined and reported on two definitions of behavioral maintenance, one that was purposefully lenient and the other, more conservative.

Among the trials that reported on maintenance, nearly three-quarters achieved the lenient definition (one or more outcomes) for maintenance and 38% met the more conservative definition (all outcomes). Therefore, the studies reviewed provide some evidence for the ability to achieve maintenance of behavior change in the context of diet, physical activity, and combined interventions. However, using a more conservative definition suggests that there remains much to be done to better understand how to promote maintenance of multiple health behaviors, and whether different intervention approaches for diet versus physical activity might be required.

Dietary behavior interventions achieved maintenance more often than physical activity interventions, regardless of which maintenance definition was applied. This finding is supported by previous literature reviews of intervention outcomes (Eakin et al., 2007; Goldstein et al., 2004; Kroeze, Werkman, & Brug, 2006). A high proportion of combined interventions also achieved behavioral maintenance, although this was not the case when the conservative definition was used (noting the challenge of achieving maintenance on all dietary and physical activity outcomes reported). Findings from previous interventions targeting physical activity and diet suggest that dietary behaviors may be more amenable to change than physical activity behaviors (Eakin et al., 2009; Emmons et al., 2005). A number of potential explanations have been offered for the greater maintenance seen for diet than physical activity, including: differences in how well powered the studies were for each outcome, due to differences in responsiveness of the measures; contextual differences in behaviors; and, consistency of intervention approaches between the behaviors. These will be important to explore in future research.

The ability to achieve maintenance did not seem to be impacted by sample characteristics such as health status or age, but was related to gender. Maintenance was less likely to be achieved in studies targeting women, however, the majority of these studies targeted women with chronic conditions, suggesting a possible interaction between gender and health status. Maintenance was also affected by a number of methodological and intervention characteristics. Lower participant retention (<70%) was common among trials achieving maintenance, which is likely due to increased attrition among intervention participants who do not attain their behavioral goals, thus inflating maintenance outcomes. A related issue is the manner in which missing follow-up data are handled. While this review found that there was no difference in achieving maintenance between trials that adequately and inadequately dealt with missing data, only half of the studies reported on methods for dealing with missing data at follow-up, with only a few imputing values for missing data (carrying forward either the last known value or baseline value). The imputation of missing data is a relevant methodological consideration for this review, as an assumption of no change from an end-of-intervention assessment can inappropriately inflate the maintenance effect, while an assumption of no change from baseline may underestimate the effect. As noted in a recent review of published RCTs of health care interventions (Toerien et al., 2009), it is important that authors report on the amount of missing data at all follow-up assessments and the methods employed to adequately deal with missing data.

Pretrial screening based on behavioral criteria, which occurred in approximately half of all trials reviewed, was common among trials achieving maintenance. In addition to directing intervention to those most in need, pretrial behavioral screening may also result in a sample

with more potential to achieve and maintain behavior change by reducing ceiling effects. However, in the health behavior intervention literature, mixed findings have been reported on the effects of pretrial behavioral screening on intervention outcomes (De Cocker, De Bourdeaudhuij, Brown, & Cardon, 2009; Delahanty, Conroy, & Nathan, 2006; Steptoe, Rink, & Kerry, 2000; Wilcox et al., 2009) and its effects require further empirical investigation.

Interventions were more likely to achieve maintenance if they: were conducted over a longer period (>24 weeks); included some face-to-face contact; used multiple intervention strategies (>6); and included follow-up prompts (i.e., brief contacts that occurred after the main part of the intervention to reinforce previous intervention content). The total number of intervention contacts was related to maintenance, but consideration of the number of contacts as a ratio of the duration of intervention attenuated the finding, which highlights the importance of prolonged intervention contact rather than high frequency contact. Previous reviews have found some of these factors to be related to initial physical activity and dietary behavior change, in particular, longer duration intervention contact (Eakin et al., 2007; Neville et al., 2009a, 2009b; Vandelandotte, Spathonis, Eakin, & Owen, 2007). Two recent meta-analyses of health behavior interventions, both employing the taxonomy of strategies used in this review, offer mixed support for the importance of employing more intervention strategies, with one reporting similar results (Webb, Joseph, Yardley, & Michie) and the other not (Michie et al., 2009), however, neither meta-analysis was specific to postintervention maintenance outcomes. The more extensive body of findings on maintenance of weight loss and smoking cessation also suggests that longer duration interventions that incorporate some face-to-face contact are more successful at producing sustained effects (Jeffery et al., 2000; Lombard, Deeks, & Teede, 2009; Ockene et al., 2000).

A key finding of this review is the importance of follow-up prompts to achieving maintenance. This suggests that brief contact, beyond the end of the main part of the intervention, may be necessary to promote maintenance of behavior change. While there is limited experimental evidence to draw upon, this finding is consistent with the more recent trend toward multiyear interventions that include brief follow-up contacts in subsequent years, which have been implemented in a number of large-scale health behavior intervention trials (Diabetes Prevention Program Research, 2002; Ryan et al., 2003). Research is needed to establish whether follow-up prompts after cessation of an intensive intervention may provide an effective and cost-effective alternative to longer interventions in achieving maintenance of behavior change. Surprisingly, our review did not support self-monitoring as an intervention strategy to promote maintenance of behavior change. This finding is unlike what has been reported in the weight loss maintenance literature (Butryn, Phelan, Hill, & Wing, 2007; Wing & Phelan, 2005), and more recently, by Michie and colleagues who found improved effect sizes in physical activity and diet interventions that employed self-monitoring (Michie et al., 2009).

Overall there is limited evidence to suggest which intervention strategies support maintenance and whether these differ to those known to support behavioral initiation (Nigg, Borelli, Maddock, & Dishman, 2008; Rothman, 2000; Rothman, Sheeran, & Wood, 2009). Rothman and colleagues (2009) propose a theoretical analysis of how the determinants of initiation of dietary behavior change (attitudes, social norms, self-efficacy, behavioral primes)

should differ from the determinants of maintenance of dietary change (satisfaction with behavior change, habits), but cite only modest experimental evidence to support this proposed distinction. They also suggest that it is necessary to explore the impact of these distinct behavioral determinants on initiation and maintenance separately for physical activity and dietary behaviors (Rothman et al., 2009), a suggestion which is supported by the differential findings for dietary versus physical activity interventions in our review. Evidence from intervention trials that have evaluated factors related to behavioral initiation and maintenance within the same study suggests that the determinants of physical activity (Boutelle, Jeffery, & French, 2004; Sallis, Hovell, & Hofstetter, 1992; Williams et al., 2008) and dietary behaviors (Tinker et al., 2007; Urban, White, Anderson, Curry, & Kristal, 1992) are different for initiation and maintenance of behavior change. For example, physical activity initiation was predicted by different determinants (e.g., home access to physical activity equipment) than those related to maintenance of physical activity change (e.g., self efficacy, perceived satisfaction; (Williams et al., 2008). Similarly, initial dietary behavior change was predicted by different determinants (e.g., attendance at intervention sessions), than those associated with maintenance of dietary behavior change (e.g., lower cost and burden associated with diet, development of distaste of fat; (Urban et al., 1992).

In general, there was minimal description of intervention content reported in the studies in this review. Reporting on intervention content has been improved through the wide adoption of the CONSORT (Moher et al., 2001) and TREND statements (Des Jarlais, Lyles, & Crepaz, 2004). In addition, Davidson and colleagues specified a checklist of features to be reported for behavioral interventions, including intervention content (Davidson et al., 2003). However, based on the findings of the current review, this level of detailed reporting is still not common among physical activity and dietary behavior change intervention trials, making it difficult to systematically evaluate the impact of intervention strategies on maintenance of behavior change. This problem needs to be addressed collaboratively by both those reporting on the results of intervention trials and by the peer-review bodies, and journal editing boards that assess intervention articles.

Limitations

Compliance with either maintenance definition may have still allowed for a decrease in behavior between end-of-intervention and follow-up, assuming there was still a between-groups difference in favor of the intervention group. While this is a limitation, it was the only way to consistently apply a definition across the heterogeneous behavioral outcomes reported in trials. Our inclusion criteria may have excluded interventions evaluated in community-based settings, such as trials that were ongoing and therefore lacked a maintenance period without intervention contact (e.g., Ryan et al., 2003) or trials that lacked a comparison group (e.g., Giacomantonio & Firth, 2007; Gould & Anderson, 2000). Exclusion of effectiveness trials in systematic reviews has been raised previously (Glasgow et al., 2003; Green, 2008) and has implications for informing dissemination of public health interventions. We were not able to systematically assess intervention fidelity in the trials reviewed, therefore it cannot be assumed that reporting more intervention strategies equates to higher quality

intervention implementation. In the context of this review, it was not possible to determine if the characteristics examined were independently related to meeting the maintenance criteria or whether they were dependent on interactions with other factors. Finally, due to the sampling frame of this review, it was not possible to examine whether factors related to maintenance of behavior change differed from those associated with initiation.

Recommendations

Since the publication of the health behavior maintenance supplement in *Health Psychology* in 2000, the field has made progress in improving our conceptual understanding of maintenance of physical activity and dietary behavior change and how it can be achieved in the context of interventions. Based on the findings of this review, the following recommendations for future research are offered:

1) Intervention trials should include evaluation of maintenance of behavioral outcomes following the end of intervention (optimally 12 months or longer).

2) Studies are needed that experimentally evaluate intervention strategies targeting maintenance of behavior change (see Calfas et al., 2000; Glasgow, Toobert, Hampson, & Strycker, 2002, as examples), and that also examine differences in determinants of behavior change initiation and maintenance.

3) Evaluation of interventions of longer duration (>24 weeks) is required, with consideration of the use of follow-up prompts, which could be implemented via mediated delivery modalities (i.e., telephone, Internet, text messaging) to maintain long-term contact with participants while reducing burden and increasing cost-effectiveness (Eakin et al., 2007; Fjeldsoe, Marshall, & Miller, 2009; Vandelandotte et al., 2007).

4) More detailed reporting of intervention content is needed (based on the checklist developed by Davidson et al., 2003), and should employ the standardized vocabulary offered for behavior change techniques (Abraham & Michie, 2008).

5) More detailed reporting of maintenance outcomes is needed, with respect to the magnitude of between-groups differences at follow-up (often only *p* values were reported); and, the direction and magnitude of change between end-of-intervention and follow-up (see Eakin, Reeves, Winkler, Lawler, & Owen, 2010, as example).

6) Methods for handling missing data should be reported, with attention to the potential impact of imputing missing data on maintenance outcomes.

7) Finally, peer-review bodies that critique manuscript submissions and funding applications should consider the critical importance of follow-up assessments in research designs and publications, regardless of the favorability of the initial behavior change outcomes that are reported.

References

- * indicates a paper included in this systematic review
- Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology, 27*, 379–387.
- Ammerman, A. S., Lindquist, C. H., Lohr, K. N., & Hersey, J. (2002). The efficacy of behavioral interventions to modify dietary fat and fruit and vegetable intake: A review of the evidence. *Preventive Medicine, 35*, 25–41.
- Australian Institute of Health and Welfare. (2008). *Australia's health 2008. Cat. no. AUS 99*. Canberra: AIHW.
- *Basler, H.-D., Bertalanffy, H., Quint, S., Wilke, A., & Wolf, U. (2007). TTM-based counselling in physiotherapy does not contribute to an increase of adherence to activity recommendations in older adults with chronic low back pain—A randomised controlled trial. *European Journal of Pain, 11*, 31–37.
- *Bock, B. C., Marcus, B. H., Pinto, B. M., & Forsyth, L. H. (2001). Maintenance of physical activity following an individualized motivationally tailored intervention. *Annals of Behavioral Medicine, 23*, 79–87.
- Boutelle, K. N., Jeffery, R. W., & French, S. A. (2004). Predictors of vigorous exercise adoption and maintenance over four years in a community sample. *International Journal of Behavioral Nutrition and Physical Activity, 1*, 13.
- Brown, T., Avenell, A., Edmunds, L. D., Moore, H., Whittaker, V., Avery, L., & Summerbell, C. (2009). Systematic review of long-term lifestyle interventions to prevent weight gain and morbidity in adults. *Obesity Reviews, 10*, 627–638.
- *Burke, V., Giangulio, N., Gillam, H. F., Beilin, L. J., & Houghton, S. (2003). Physical activity and nutrition programs for couples: A randomized controlled trial. *Journal of Clinical Epidemiology, 56*, 421–432.
- Butryn, M. L., Phelan, S., Hill, J. O., & Wing, R. R. (2007). Consistent self-monitoring of weight: A key component of successful weight loss maintenance. *Obesity (Silver Spring), 15*, 3091–3096.
- Calfas, K. J., Sallis, J. F., Nichols, J. F., Sarkin, J. A., Johnson, M. F., Caparosa, S., . . . Alcaraz, J. (2000). Project GRAD: Two-year outcomes of a randomized controlled physical activity intervention among young adults. Graduate Ready for Activity Daily. *American Journal of Preventive Medicine, 18*, 28–37.
- Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, L. A., Izzo, J. L., Jr., . . . Roccella, E. (2003). The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 report. *Journal of the American Medical Association, 289*, 2560–2572.
- *Clark, M., Hampson, S. E., Avery, L., & Simpson, R. (2004). Effects of a tailored lifestyle self-management intervention in patients with Type 2 diabetes. *British Journal of Health Psychology, 9*, 365–379.
- *Connell, C. M., & Janevic, M. R. (2009). Effects of a telephone-based exercise intervention for dementia caregiving wives a randomized controlled trial. *Journal of Applied Gerontology, 28*, 171–194.
- Curioni, C. C., & Lourenco, P. M. (2005). Long-term weight loss after diet and exercise: A systematic review. *International Journal of Obesity, 29*, 1168–1174.
- Davidson, K. W., Goldstein, M., Kaplan, R. M., Kaufmann, P. G., Knatterud, G. L., Orleans, C. T., . . . Whitlock, E. P. (2003). Evidence-based behavioral medicine: What is it and how do we achieve it? *Annals of Behavioral Medicine, 26*, 161–171.
- De Cocker, K., De Bourdeaudhuij, I., Brown, W., & Cardon, G. (2009). Moderators and mediators of pedometer use and step count increase in the “10,000 Steps Ghent” intervention. *International Journal of Behavioral Nutrition and Physical Activity, 6*, 3.
- Delahanty, L. M., Conroy, M. B., & Nathan, D. M. (2006). Psychological predictors of physical activity in the diabetes prevention program. *Journal of the American Dietetic Association, 106*, 698–705.
- Des Jarlais, D. C., Lyles, C., & Crepaz, N. (2004). Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: The TREND statement. *American Journal of Public Health, 94*, 361–366.
- *De Vet, E., O. A., Sheeran, P., & Brug, J. (2009). Should implementation intentions interventions be implemented in obesity prevention: The impact of if-then plans on daily physical activity in Dutch adults. *International Journal of Behavioral Nutrition and Physical Activity, 6*, 11.
- Diabetes Prevention Program Research, G. (2002). The Diabetes Prevention Program (DPP): description of lifestyle intervention. *Diabetes Care, 25*, 2165–2171.
- Eakin, E., Reeves, M., Lawler, S., Graves, N., Oldenburg, B., Del Mar, C., . . .

- Barnett, A. (2009). Telephone counseling for physical activity & diet in primary care patients. *American Journal of Preventive Medicine*, 36, 142–149.
- Eakin, E., Reeves, M., Winkler, E., Lawler, S., & Owen, N. (2010). Maintenance of physical activity and dietary change following a telephone-delivered intervention. *Health Psychology*, 29, 566–573.
- Eakin, E. G., Lawler, S. P., Vandelanotte, C., & Owen, N. (2007). Telephone interventions for physical activity and dietary behavior change: A systematic review. *American Journal of Preventive Medicine*, 32, 419–434.
- *Elder, J. P., Ayala, G. X., Campbell, N. R., Arredondo, E. M., Slymen, D. J., Baquero, B., . . . Engelberg, M. (2006). Long-term effects of a communication intervention for Spanish-dominant Latinas. *American Journal of Preventive Medicine*, 31, 159–166.
- *Elder, J. P., Candelaria, J. I., Woodruff, S. I., Criqui, M. H., Talavera, G. A., & Rupp, J. W. (2000). Results of Language for Health: Cardiovascular disease nutrition education for Latino English-as-a-second-language students. *Health Education & Behavior*, 27, 50–63.
- Emmons, K. M., Stoddard, A. M., Fletcher, R., Gutheil, C., Suarez, E., Gonzalez, L., . . . Bigby, J. A. (2005). Cancer prevention among working class, multiethnic adults: Results of the Healthy Directions-Health Centers Study. *American Journal of Public Health*, 95, 1200–1205.
- Eyre, H., Kahn, R., & Robertson, R. M. (2004). Preventing cancer, cardiovascular disease, and diabetes. *Circulation*, 109, 3244–3255.
- Fjeldsoe, B. S., Marshall, A. L., & Miller, Y. D. (2009). Behavior change interventions delivered by mobile telephone short-message service. *American Journal of Preventive Medicine*, 36, 165–173.
- Franz, M. J., VanWormer, J. J., Crain, A. L., Boucher, J. L., Histon, T., Caplan, W., . . . Pronk, N. P. (2007). Weight-loss outcomes: A systematic review and meta-analysis of weight-loss clinical trials with a minimum 1-year follow-up. *Journal of the American Dietetic Association*, 107, 1755–1767.
- *Fries, E., Edinboro, P., McClish, D., Manion, L., Bowen, D., Beresford, S. A. A., & Ripley, J. (2005). Randomized trial of a low-intensity dietary intervention in rural residents—The Rural Physician Cancer Prevention Project. *American Journal of Preventive Medicine*, 28, 162–168.
- Giacomantonio, N., & Firth, W. (2007). Integrating multi disciplinary community heart health program with family physicians: An innovative model for vascular health. *New Horizons in Coronary Artery Disease*, 233–240.
- Glasgow, R. E., Goldstein, M. G., Ockene, J. K., & Pronk, N. P. (2004). Translating what we have learned into practice: Principles and hypotheses for interventions addressing multiple behaviors in primary care. *American Journal of Preventive Medicine*, 27, 88–101.
- Glasgow, R. E., Lichtenstein, E., & Marcus, A. C. (2003). Why don't we see more translation of health promotion research to practice? Rethinking the efficacy-to effectiveness transition. *American Journal of Public Health*, 93, 1261–1267.
- Glasgow, R. E., Toobert, D. J., Hampson, S. E., & Strycker, L. A. (2002). Implementation, generalization and long-term results of the "choosing well" diabetes self-management intervention. *Patient Education and Counseling*, 48, 115–122.
- Goldstein, M. G., Whitlock, E. P., & DePue, J. (2004). Multiple behavioral risk factor interventions in primary care: Summary of research evidence. *American Journal of Preventive Medicine*, 27, 61–79.
- Gould, S. M., & Anderson, J. (2000). Using interactive multimedia nutrition education to reach low-income persons: An effectiveness evaluation. *Journal of Nutrition Education*, 32, 204–213.
- *Greaney, M. L., Riebe, D., Garber, C. E., Rossi, J. S., Lees, F. D., Burbank, P. A., . . . Clark, P. G. (2008). Long-term effects of a stage-based intervention for changing exercise intentions and behavior in older adults. *Gerontologist*, 48, 358–367.
- Green, L. W. (2008). Making research relevant: If it is an evidence-based practice, where's the practice-based evidence? *Family Practice*, 25, i20–i24.
- Hajek, P., Stead, L. F., West, R., Jarvis, M., & Lancaster, T. (2009). Relapse prevention interventions for smoking cessation. *Cochrane Database of Systematic Reviews* 1, CD003999.
- *Hughes, S. L., Seymour, R. B., Campbell, R. T., Huber, G., Pollak, N., Sharma, L., & Desai, P. (2006). Long-term impact of Fit and Strong! on older adults with osteoarthritis. *Gerontologist*, 46, 801–814.
- Jeffery, R. W., Drewnowski, A., Epstein, L. H., Stunkard, A. J., Wilson, G. T., Wing, R. R., & Hill, D. R. (2000). Long-term maintenance of weight loss: Current status. *Health Psychology*, 19, 5–16.
- *Jimmy, G., & Martin, B. W. (2005). Implementation and effectiveness of a primary care based physical activity counselling scheme. *Patient Education and Counseling*, 56, 323–331.
- Kahn, E. B., Ramsay, L. T., Brownson, R. C., Heath, G. W., Howze, E. H., Powell, K. E., . . . Corso, P. (2002). The effectiveness of interventions to increase physical activity: A systematic review. *American Journal of Preventive Medicine*, 22, 73–107.
- *Kirk, A. F., Mutrie, N., MacIntyre, P. D., & Fisher, M. B. (2004). Promoting and maintaining physical activity in people with type 2 diabetes. *American Journal of Preventive Medicine*, 27, 289–296.
- Kroeze, W., Werkman, A., & Brug, J. (2006). A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Annals of Behavioral Medicine*, 31, 205–223.
- Kumanyika, S. K., Van Horn, L., Bowen, D., Perri, M. G., Rolls, B. J., Czajkowski, S. M., & Schron, E. (2000). Maintenance of dietary behavior change. *Health Psychology*, 19, 42–56.
- Lancaster, T., Hajek, P., Stead, L. F., West, R., & Jarvis, M. J. (2006). Prevention of relapse after quitting smoking: A systematic review of trials. *Archives of Internal Medicine*, 166, 828–835.
- Le Foll, B., Aubin, H. J., & Lagrue, G. (2002). Behavioral and cognitive therapy to break the smoking habit. Review of the literature. *Annales de Medecine Interne*, 153, 1S32–1S40.
- *Lindsay, S., Smith, S., Bellaby, P., & Baker, R. (2009). The health impact of an online heart disease support group: A comparison of moderated versus unmoderated support. *Health Education Research*, 24, 646–654.
- Lombard, C. B., Deeks, A. A., & Teede, H. J. (2009). A systematic review of interventions aimed at the prevention of weight gain in adults. *Public Health Nutrition*, 12, 2236–2246.
- Marcus, B. H., Dubbert, P. M., Forsyth, L. H., McKenzie, T. L., Stone, E. J., Dunn, A. L., & Blair, S. N. (2000). Physical activity behavior change: Issues in adoption and maintenance. *Health Psychology*, 19, 32–41.
- *Marshall, A. L., Bauman, A. E., Owen, N., Booth, M. L., Crawford, D., & Marcus, B. H. (2003). Population-based randomized controlled trial of a stage-targeted physical activity intervention. *Annals of Behavioral Medicine*, 25, 194–202.
- Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology*, 28, 690–701.
- Moher, D., Schulz, K. F., & Altman, D. G. (2001). The CONSORT statement: Revised recommendations for improving the quality of reports of parallel-group randomized trials. *Annals of Internal Medicine*, 134, 657–662.
- *Moore, S. M., Charvat, J. M., Gordon, N. H., Pashkow, F., Ribisl, P., Roberts, B. L., & Rocco, M. (2006). Effects of a CHANGE intervention to increase exercise maintenance following cardiac events. *Annals of Behavioral Medicine*, 31, 53–62.
- Neville, L. M., O'Hara, B., & Milat, A. J. (2009b). Computer-tailored physical activity behavior change interventions targeting adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 6, 30.
- Neville, L. M., O'Hara, B., & Milat, A. J. (2009a). Computer-tailored dietary behaviour change interventions: A systematic review. *Health Education Research*, 24, 699–720.
- Nigg, C. R., Borelli, B., Maddock, J., & Dishman, R. K. (2008). A theory

- of physical activity maintenance. *Applied Psychology: An International Review*, 57, 544–560.
- *Nour, K., Laforest, S., Gauvin, L., & Gignac, M. (2007). Long-term maintenance of increased exercise involvement following a self-management intervention for housebound older adults with arthritis. *International Journal of Behavioral Nutrition and Physical Activity*, 4.
- Ockene, J., Mermeistein, R., Bonollo, D., K. E., Perkins, K., Voorhees, C., & Hollis, J. F. (2000). Relapse and maintenance issues for smoking cessation. *Health Psychology*, 19, s17–s31.
- Orleans, C. T. (2000). Promoting the maintenance of health behavior change: Recommendations for the next generation of research and practice. *Health Psychology*, 19, 76–83.
- Ory, M. G., Jordan, P. J., & Bazzarre, T. (2002). The Behavior Change Consortium: Setting the stage for a new century of health behavior-change research. *Health Education Research*, 17, 500–511.
- Owen, N., Glanz, K., Sallis, J., & Kelder, S. (2006). Evidence-based approaches to dissemination and diffusion of physical activity interventions. *American Journal of Preventive Medicine*, 31, S35–S44.
- *Pinto, B. M., Rabin, C., Papandonatos, G. D., Frierson, G. M., Trunzo, J. J., & Marcus, B. H. (2008). Maintenance of effects of a home-based physical activity program among breast cancer survivors. *Supportive Care in Cancer*, 16, 1279–1289.
- Prochaska, J. J., Velicer, W. F., Nigg, C. R., & Prochaska, J. O. (2008). Methods of quantifying change in multiple risk factor interventions. *Preventive Medicine*, 46, 260–265.
- *Prochaska, J. O., Velicer, W. F., Redding, C., Rossi, J., Goldstein, M., DePue, J., . . . Plummer, B. A. (2005). Stage-based expert systems to guide a population of primary care patients to quit smoking, eat healthier, prevent skin cancer, and receive regular mammograms. *Preventive Medicine*, 41, 406–416.
- *Prochaska, J. O., Velicer, W. F., Rossi, J. S., Redding, C. A., Greene, G. W., Rossi, S. R., . . . Plummer, B. A. (2004). Multiple risk expert systems interventions: Impact of simultaneous stage-matched expert system interventions for smoking, high-fat diet, and sun exposure in a population of parents. *Health Psychology*, 23, 503–516.
- *Rejeski, W. J., Marsh, A. P., Chmelo, E., Prescott, A. J., Dobrosielski, M., Walkup, M. P., . . . Kritchevsky, S. (2009). The Lifestyle Interventions and Independence for Elders Pilot (LIFE-P): 2-year follow-up. *Journal of Gerontology: Medical Sciences*, 64, 462–467.
- *Rogers, L. Q., Hopkins-Price, P., Vicari, S., Markwell, S., Pamentier, R., Courneya, K. S., . . . Verhulst, S. (2009). Physical activity and health outcomes three months after completing a physical activity behavior change intervention: Persistent and delayed effects. *Cancer Epidemiology Biomarkers & Prevention*, 18, 1410–1418.
- Rothman, A. J. (2000). Toward a theory-based analysis of behavioral maintenance. *Health Psychology*, 19, 64–69.
- Rothman, A. J., Sheeran, P., & Wood, W. (2009). Reflective and automatic processes in the initiation and maintenance of dietary change. *Annals of Behavioral Medicine*, 38, S4–S17.
- Ryan, D. H., Espeland, M. A., Foster, G. D., Haffner, S. M., Hubbard, V. S., Johnson, K. C., . . . Yanovski, S. (2003). Look AHEAD (Action for Health in Diabetes): Design and methods for a clinical trial of weight loss for the prevention of cardiovascular disease in type 2 diabetes. *Controlled Clinical Trials*, 24, 610–628.
- Sallis, J. F., Hovell, M. F., & Hofstetter, C. R. (1992). Predictors of adoption and maintenance of vigorous physical activity in men and women. *Preventive Medicine*, 21, 237–251.
- *Sallit, J., Ciccazzo, M., & Dixon, Z. (2009). A cognitive-behavioral weight control program improves eating and smoking behaviors in weight-concerned female smokers. *Journal of the American Dietetic Association*, 109, 1398–1405.
- Sigal, R. J., Kenny, G. P., Wasserman, D. H., Castaneda-Sceppa, C., & White, R. D. (2006). Physical activity/exercise and type 2 diabetes: A consensus statement from the American Diabetes Association. *Diabetes Care*, 29, 1433–1438.
- Stephens, A., Rink, E., & Kerry, S. (2000). Psychosocial predictors of changes in physical activity in overweight sedentary adults following counseling in primary care. *Preventive Medicine*, 31, 183–194.
- *Sternfeld, B., Block, C., Quesenberry, C. P., Block, T. J., Husson, G., Norris, J. C., . . . Block, G. (2009). Improving diet and physical activity with ALIVE a worksite randomized trial. *American Journal of Preventive Medicine*, 36, 475–483.
- *Stevens, V. J., Glasgow, R. E., Toobert, D. J., Karanja, N., & Smith, K. S. (2003). One-year results from a brief, computer-assisted intervention to decrease consumption of fat and increase consumption of fruits and vegetables. *Preventive Medicine*, 36, 594–600.
- *Thoolen, B. J., de Ridder, D., Bensing, J., Gorter, K., & Rutten, G. (2009). Beyond good intentions: The role of proactive coping in achieving sustained behavioural change in the context of diabetes management. *Psychology & Health*, 24, 237–254.
- Tinker, L. F., Rosal, M. C., Young, A. F., Perri, M. G., Patterson, R. E., Van Horn, L., . . . Wu, L. (2007). Predictors of dietary change and maintenance in the Women's Health Initiative Dietary Modification Trial. *Journal of American Dietetics Association*, 107, 1155–1166.
- Toerien, M., Brookes, S., Metcalfe, C., de Salis, I., Tomlin, Z., Peters, T., . . . Donovan, J. L. (2009). A review of reporting of participant recruitment and retention in RCTs in six major journals. *BMC Trials*, 10, 52.
- U.S. Preventive Services Taskforce. (1996). *Guide to clinical preventive services*. Baltimore: Williams & Wilkins.
- Urban, N., White, E., Anderson, G. L., Curry, S., & Kristal, A. R. (1992). Correlates of maintenance of a low-fat diet among women in the Women's Health Trial. *Preventive Medicine*, 21, 279–291.
- U. S. Department of Health and Human Services. (2000). *Healthy people 2010* (2nd ed.). Washington DC: U.S. Government Printing Office.
- *Vallance, J. K., Courneya, K. S., Plotnikoff, R. C., Dinu, I., & Mackey, J. R. (2008). Maintenance of physical activity in breast cancer survivors after a randomized trial. *Medicine and Science in Sports and Exercise*, 40, 173–180.
- Vandelanotte, C., Spathonis, K. M., Eakin, E. G., & Owen, N. (2007). Website-delivered physical activity interventions: A systematic review. *American Journal of Preventive Medicine*, 33, 54–64.
- *Van der Ploeg, H. P., Streppel, K. R. M., Van der Beek, A. J., Van der Woude, L. H. V., Vollenbroek-Hutten, M. M. R., Van Harten, W. H., & Van Mechelen, W. (2006). Counselling increases physical activity behavior nine weeks after rehabilitation. *British Journal of Sports Medicine*, 40, 223–229.
- *von Gruenigen, V. E., Coumeya, K. S., Gibbons, H. E., Kavanagh, M. B., Waggoner, S. E., & Lemer, E. (2008). Feasibility and effectiveness of a lifestyle intervention program in obese endometrial cancer patients: A randomized trial. *Gynecologic Oncology*, 109, 19–26.
- Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the internet to promote health behavior change: A systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, 12, e4.
- Wilcox, S., Dowda, M., Dunn, A., Ory, M. G., Rheume, C., & King, A. C. (2009). Predictors of increased physical activity in the Active for Life program. *Preventing Chronic Disease*, 6, A25.
- Williams, D. M., Lewis, B. A., Dunsiger, S., Whiteley, J. A., Papandonatos, G. D., Napolitano, M. A., . . . Marcus, B. H. (2008). Comparing psychosocial predictors of physical activity adoption and maintenance. *Annals of Behavioral Medicine*, 36, 186–194.
- Wing, R. R., & Phelan, S. (2005). Long-term weight loss maintenance. *American Journal of Clinical Nutrition*, 82, 222S–225S.