Habit Strength Moderates the Effects of Daily Action Planning Prompts on Physical Activity but Not Sedentary Behavior

By: Jaclyn P. Maher, David E. Conroy

Maher, J. P. & Conroy, D.E. (2015). Habit strength moderates the effects of daily action planning prompts on physical activity but not sedentary behavior. *Journal of Sport and Exercise Psychology*. *37*(1): 97-107.

Abstract:

This study was designed to examine the moderating influence of habit strength on daily action planning effects on physical activity and sedentary behavior. A 2 by 2 design was used with experimental factors corresponding to action planning interventions for (a) engaging in physical activity and (b) limiting or interrupting sedentary behavior. At the end of each day for 1 week, university students (n = 195) completed (a) a questionnaire about their behavior during the day and behavioral intentions for the following day and (b) a planning intervention(s) corresponding to their randomly assigned experimental condition. Action planning increased physical activity in those with weak habits but decreased physical activity in those with strong habits compared with those who did not create action plans. Action planning did not impact sedentary behavior. Action planning was a useful behavior change technique for increasing physical activity in people with weak habits, but may be iatrogenic for those with strong habits.

Keywords: behavior change techniques | health behaviors | dual-process models | exercise | sitting

Article:

Despite the well-known benefits of engaging in regular physical activity (Physical Activity Guidelines Advisory Committee, 2008), nearly one third of the adults worldwide and half of the adults in the United States do not attain recommended levels of physical activity (Hallal et al., 2012). Emerging evidence suggests that excessive sedentary behavior is also detrimental to people's physical and mental health and that these health risks are independent of people's physical activity levels (Lynch, 2010; Matthews, George, et al., 2012; Proper, Singh, van Mechelen, & Chinapaw, 2011). Interventions to increase physical activity and decrease sedentary behavior often emphasize intention formation; however, many people struggle to translate their intentions into action (Rhodes & de Bruijn, 2013).

Action planning is one popular strategy to bridge this intention–behavior gap and promote behavior change (Sheeran, 2002). Action planning has been applied extensively with physical activity (Bélanger-Gravel, Godin, & Amireault, 2013; Carraro & Gaudreau, 2013) but its utility for reducing sedentary behavior is less well established. The effects of action planning may also vary as a function of habit strength for target behaviors because the act of planning can interfere with automatic motivational processes that regulate behaviors. Understanding how habit strength impacts the effects of action planning when up-regulating nonhabitual behavior (e.g., physical activity) and down-regulating habitual behavior (e.g., sedentary behavior) would inform theories of behavior change for these health behaviors. This study was designed (a) to investigate the effects of daily action planning prompts on physical activity and sedentary behavior, and (b) to determine if the effects of action planning on behavior varied as a function of habit strength.

Dual Process Theories of Health Behavior Motivation

Dual process theories propose that behavior is regulated by controlled and automatic motivational processes (e.g., Strack & Deutsch, 2004). Controlled motivational processes are reflective, conscious, and volitional whereas automatic motivational processes are reflexive, nonconscious, and unintended (Bargh & Chartrand, 1999; Evans, 2008). These two processes may operate independently or interact to regulate health behaviors (Hofmann, Schmeichel, & Baddeley, 2012; Sheeran, Gollwitzer, & Bargh, 2013).

Many theories of physical activity are social-cognitive in nature (Ajzen, 1991; Bandura, 2004; Schwarzer, 2008) and focus on the role of controlled processes in regulating behavior. A core premise of these theories is that behavior is motivated by goals, intentions, and beliefs. Unfortunately, more than one third of people intend to be active yet fail to engage in physical activity— a phenomenon known as the intention–behavior gap (Rhodes & de Bruijn, 2013).

Action Planning

Action planning has been identified as a strategy for closing the intention–behavior gap (Gollwitzer, 1999; Webb & Sheeran, 2005). Action planning involves developing a detailed plan that specifies a particular context and how one will carry out one's intentions in that particular context (e.g., "At time X, I will do Y in place Z"; Gollwitzer, 1993, 1999). Action plans shift control of goal-directed behavior from the self to contextual cues (i.e., the when and where of the plan). Over time, habits develop as consistent planning forms cue-behavior associations and a contextual cue becomes sufficient to activate the behavior automatically (Gollwitzer, 1999).

Recent meta-analyses provide evidence for the effectiveness of action planning for increasing physical activity, revealing a small to medium positive effect of experimentally manipulated action plans on subsequent physical activity (Bélanger-Gravel et al., 2013; Carraro & Gaudreau, 2013). Interventions to reduce sedentary behavior have typically included action planning as one of several intervention components and have been effective in reducing sedentary behavior. However, because action planning was bundled as part of an intervention treatment, it is unclear whether action planning was responsible for reducing sedentary behavior.

When interventions have incorporated action planning, it is usually part of a baseline session. Very few studies have allowed participants to adapt action plans over the course of the study (for exceptions, see Arbour & Martin Ginis, 2009; De Vet, Oenema, Sheeran, & Brug, 2009); however, these studies often involve adapting or selecting new action plans weekly. Given the day-to-day fluctuations in both physical activity and sedentary behavior and the motivational processes that regulate them (Conroy, Elavsky, Hyde, & Doerksen, 2011; Conroy, Maher, Elavsky, Hyde, & Doerksen, 2013), the cadence of planning doses should match the rhythm of behavior. The effect of daily action planning interventions on behavior has not been evaluated.

Individual Differences in Planning Effects on Behavior

Notwithstanding the generally positive effects of action planning across studies, this technique is not a universally effective tool for behavior change. For example, some studies have found that action planning had null, or even counterintentional, effects on behavior (e.g., Budden & Sagarin, 2007; Skår, Sniehotta, Molloy, Prestwich, & Araújo-Soares, 2011). These mixed results suggest that moderators may influence the effects of action planning on behavior. Carraro and Gaudreau (2013) investigated potential moderators and reported that planning was most effective for older adults, individuals with stronger intentions at baseline assessment, and when the time lag between action planning and assessment of physical activity was minimal.

Drawing on dual-process models of motivation, we propose that habit strength is another factor that likely moderates the effects of action planning on behavior.

Habits represent automatic regulatory processes that develop through the repeated pairing of a contextual cue with a behavior until the contextual cue becomes sufficient to automatically evoke the behavioral response (Aarts, Paulussen, & Schaalma, 1997; Ouellette & Wood, 1998; Verplanken, 2010; Verplanken & Orbell, 2003; Wood & Neal, 2007). Cues can reflect a variety of con- textual features such as a particular time of day, or even a psychological state (Wood, Quinn, & Kashy, 2002). The degree to which a contextual cue automatically elicits a behavioral response reflects the strength of the habitual behavioral response.

Individuals with weak habits for these health behaviors are likely to benefit from action planning. Action planning fosters the development of associations between the cue and behavior. Thus individuals with weak habits who develop action plans are more likely to associate a contextual cue with a particular behavior and thus execute the desired behavior (i.e., up-regulate physical activity, down-regulate sedentary behavior) (Webb, Sheeran, & Luszczynska, 2009).

For individuals with particularly strong habits for physical activity or sedentary behavior, it is unlikely that action planning has the same beneficial effects as it does for individuals with weak habits. For individuals with particularly strong physical activity habits, creating action plans to up-regulate this already habitual behavior may interfere with habitual responses, disrupt usual behavior, and result in less physical activity (Adriaanse, Gollwitzer, De Ridder, de Wit, & Kroese, 2011; Holland, Aarts, & Langendam, 2006; Webb et al., 2009; Wood & Neal, 2007). For individuals with particularly strong sedentary habits, creating action plans and the subsequent inhibition of the habitual response may deplete self-regulatory resources causing the habitual response to fully drive behavior (Webb et al., 2009; Wood & Neal, 2007). This reliance on a habitual response in those with strong habits could result in usual, or perhaps even greater, levels of sedentary behavior. Thus for individuals with strong habits, the effects of action planning will likely vary depending on whether the strong habit is for a desirable behavior (i.e., physical activity) or an undesirable behavior (i.e., sedentary behavior).

THE PRESENT STUDY

To evaluate the efficacy of daily action planning and the moderating role of habits in the association between action planning and subsequent health behaviors, we conducted a 7-day action planning intervention. The main hypotheses of the study were that (a) daily action planning to increase physical activity and limit or interrupt sedentary behavior would result in an increase and decrease in the respective behaviors, and (b) the effect of action plans on subsequent health behaviors would vary as a function of habit strength. Specifically, people with weak or moderate habits who made action plans to engage in physical activity or limit or interrupt sedentary behavior would engage in more physical activity or less sedentary behavior, compared with people with equivalent habit strength who did not make action plans. People with strong habits who made action plans to engage in physical activity or limit or interrupt sedentary behavior would engage in less physical activity or more sedentary behavior compared with people with equivalent habit strength who did not make action plans.

METHOD

Participants and Procedures

Participants were 195 undergraduate students that participated in the study as part of a class project. Of those 195 students, six students did not allow their data to be used for research purposes and two students indicated that they were not capable of performing normal physical activity. Those individuals were excluded from analysis, resulting in a final sample of 188 students (89 female, 95 male, three did not report). The average age of participants was 20.4 years. Most of the participants were Caucasian (87%). Most participants were classified as normal (61%) or overweight (32%) according to body mass index (BMI) values (M = 24.7, SD = 3.32).

Before data collection, a random sequence of experimental condition assignments was generated by a computer and participants were assigned to one of four conditions in a 2 × 2 factorial design. The two experimental factors represented whether participants created or did not create a detailed plan describing when, where, and how participants would engage in physical activity the following day (Factor 1), or when, where, and how participants would limit or interrupt an extended period sitting the following day (Factor 2). Plans for daily physical activity focused on achieving 30 min of moderate- intensity physical activity or 15 min of vigorous-intensity activity (in accordance with recommendations from the Physical Activity Guidelines Advisory Committee, 2008). Plans for limiting or interrupting sedentary time focused on standing for at least 5 min during each hour of sedentary time.

All participants attended an initial laboratory visit, during which they provided consent, were familiarized with the study procedures and completed a questionnaire. For the next 7 days, participants received an e-mail each night at 7:00 p.m. containing a link to access the questionnaire that included questions about their behavior that day and intentions for physical activity and sedentary behavior the following day and the planning intervention(s) corresponding to their randomly assigned experimental condition. Responses from the questionnaire were time stamped to ensure that participants were completing questionnaires at the end of the day. All study procedures were approved by the local Institutional Review Board.

Measures

Demographics. Demographic information including sex, age, ethnicity, year of school was self-reported by participants. Participants' height (m) and weight (kg) were measured in duplicate by a research assistant to determine BMI, and the BMI was calculated as kg/m^2.

Habit Strength. Physical activity and sedentary behavior habit strength were measured using two versions of the five-item automaticity subscale of the Self-Report Habit Index that excluded items related to behavioral frequency (Gardner, Abraham, Lally, & Bruijn, 2012; Rhodes & de Bruijn, 2010; Verplanken & Melkevik, 2008; Verplanken & Orbell, 2003). To assess physical activity habit strength, participants were prompted with definitions and examples of physical activity and asked to report their level of agreement with statements such as “Being physically active is something I do automatically” on scales ranging from 1 (*disagree completely*) to 7 (*agree completely*). Similarly, to assess sedentary behavior habit strength, participants were provided a definition and examples of sedentary behavior. Participants then reported how much they agreed with statements such as “Sitting is something I do without thinking” on scales ranging from 1 (*disagree completely*) to 7 (*agree completely*). The internal consistency for the physical activity and sedentary behavior subscales were .90 and .87, respectively. Responses for each subscale were averaged to create separate scores for physical activity and sedentary behavior habits.

Intentions. Intentions to engage in physical activity were assessed using two items: “I intend to engage in at least 30 min of moderate physical activity tomorrow” and “I intend to engage in at least 15 min of vigorous aerobic activity tomorrow.” These doses and intensities of physical activity correspond to the doses that, over 5 days, would meet current federal guidelines for weekly physical activity in the United States (i.e., 150 min of moderate aerobic activity or 75 min of vigorous aerobic activity; Physical Activity Guidelines Advisory Committee, 2008). Intentions to reduce sedentary behavior were assessed using two items: “I intend to spend no more than 75 min at a time sitting tomorrow.” and “I intend to avoid sitting for more than a total of 5 hr tomorrow.” Sitting times of no more than 75 min and 5 hr were chosen to accommodate typical class length at the university and to provide a realistic yet challenging goal for most students based on previous data describing university students' self-reported sitting time, respectively (Conroy et al., 2013). Participants rated each item on a scale ranging from 0 (*do not intend at all*) to 100 (*strongly intend*). Responses to the two intentions to engage in physical activity items were strongly correlated every day ($M_{\text{daily } r}$ = .69, range = .62–.75), as were responses to the two intentions to reduce sitting time ($M_{\text{daily } r}$ = .55, range = .47–.65). Physical activity and sedentary behavior items were averaged to produce a single intention to engage in physical activity score and a single intention to reduce sedentary behavior score for each day.

Daily Behavior. Daily physical activity and sedentary behavior were assessed using a version of the International Physical Activity Questionnaire (Booth, 2000; Sjöström et al., 2002) that we adapted to focus on daily instead of weekly physical activity and sedentary behavior. This adaptation can help to reduce reliance on heuristics and other sources of bias in self-reports (Matthews, Moore, George, Sampson, & Bowles, 2012). Participants were provided with definitions and examples of physical activities at different intensities (vigorous, moderate, walking) and sedentary behavior, and asked to report the amount of time that they spent in those physical activities for at least 10 min at a time that day as well as the total amount of time spent sitting that day. Physical activity responses were screened to recode item responses below the 10 min threshold to zero. Physical activity responses were weighted by standard metabolic equivalents (MET; vigorous physical activity = 8, moderate physical activity = 4, walking = 3.3) and summed to create a $\text{MET}\cdot\text{min}\cdot\text{day}^{-1}$ score (Sjöström et al., 2005). Sedentary behavior was operationalized as $\text{min}\cdot\text{day}^{-1}$ spent sitting.

Data Preparation

Outcome variables (i.e., daily physical activity and sedentary behavior) were screened for outliers. Outliers were considered any values more than three standard deviations away from the mean. Outliers were rescored to reflect a value exactly three standard deviations away from the mean. Based on this criteria, 25 observations were considered outliers and rescored (physical activity: $n_{\text{observations}} = 16$; sedentary behavior: $n_{\text{observations}} = 9$).

Data Analysis

Daily physical activity, sedentary behavior, and intentions were nested within people so we used multilevel models in SAS 9.3 PROC MIXED to test our hypotheses (Littell, Milliken, Stroup, & Wolfnger, 1996; Snijders & Bosker, 1999). Daily ratings of intentions for physical activity and sedentary behavior were averaged across days to estimate each person's usual intentions and daily residuals around those within-person means were calculated to represent daily intentions (Bolger, Davis, & Rafaeli, 2003; Schwartz & Stone, 1998). Effect coding was used to differentiate whether participants did (+1) or did not (–1) make action plans to engage in physical activity (or limit or interrupt sedentary behavior). Dummy variables were created to represent differences between weekday (0) and weekend (1) behavior. Between-person predictor variables, habit strength, sex, and BMI, were centered.

A lagged variable was created for daily intentions, as intentions were rated the previous evening. Behavioral data from the first day was eliminated from our analyses because lagged motivation data were not available from the preceding day, resulting in a 6-day sample of lagged motivation and behavior.

In accordance with standard multilevel modeling practice, pseudo-R^2, the additional proportion of variance explained by the predictors (e.g., daily physical activity action planning), compared with a baseline model was considered as an indicator of effect size (see Snijders & Bosker, 1999).

Model Specification. Separate models predicting daily physical activity and sedentary behavior were estimated. In both models, daily intentions and the weekend dummy variable represented within-person effects on daily physical activity and sedentary behavior. The slopes associated with the weekend dummy variable were treated as fixed effects, whereas the slopes associated with daily intentions were treated as random effects. In addition, habit strength and usual intentions, planning group, an interaction between habit strength and planning group, sex, and BMI represented between-person effects on daily physical activity and sedentary behavior.

Significant interaction coefficients were probed using the Johnson–Neyman technique (Bauer & Curran, 2005; Hayes & Matthes, 2009). This technique mathematically determines which values of the moderator closest to the mean result in significant relations between the predictor and outcome.

RESULTS

Participants provided self-report data for a total of 1,004 of the 1,122 possible person-days (89% response rate) and 59% of participants (n = 109) provided data on all study days. A small portion of available data were missing ($n_{observations}$ = 57) and treated as missing at random. The final sample consisted of 947 daily self-reports (Days 2–7) from 187 persons.

Descriptive statistics are displayed in Table 1. On average, participants reported physical activity energy expenditure equivalent to 1.5 hr of walking and moderate-intensity physical activity each day. Participants also reported sitting for, on average, slightly less than 5 hours each day. Participants' habit strength for both physical activity and sedentary behavior was moderate (M = 4.89 and 5.08, respectively, on a 1–7 scale). Daily intentions for engaging in physical activity and limiting or interrupting sedentary behavior were moderate (M = 61.90 and M = 51.95, respectively, on a 0–100 scale). Bivariate correlations in Table 1 represent between person and within-person correlations of health behaviors, motivational processes, and BMI (lower and upper diagonal, respectively). Physical activity had positive, medium-sized correlations with physical activity habit strength (r = .29) and intentions (between-person r = .33, within-person r = .35). Sedentary behavior had positive weak correlations with sedentary behavior habit strength (r = .17) but a negative medium-sized correlation with intentions (between-person r = –.33, within-person r = –.36). Physical activity and sedentary behavior were negatively and weakly correlated (between-person r = –.22, within-person r = –.18).

Table 1 Descriptive Statistics, Intraclass Correlations, and Correlations Between Health Behaviors, Habit Strength, Intentions, and BMI

		M	*SD*	1	2	3	4	5	6
1	Physical Activity (in MET·min·day^{-1})	681.05	570.85	—	–.18			.35	
2	Sedentary Behavior (in min·day^{-1})	283.28	155.88	–.22	—				–.36
3	Physical Activity Habit Strength	4.89	1.33	.29	–.20	—			
4	Sedentary Behavior Habit Strength	5.08	1.18	–.06	.17	–.23	—		
5	Physical Activity Intentions	65.90	29.61	.33	–.17	.33	–.15	—	.26
6	Sedentary Behavior Intentions	51.95	26.93	.07	–.33	.14	–.23	.26	—
7	BMI	24.47	3.32	.13	.04	.04	–.15	.02	–.02

Note. BMI = body mass index, *M* = sample-level mean, and *SD* = sample-level standard deviation. Coefficients below the diagonal are correlations across days and people. Coefficients above the diagonal represent correlations of within-person means.

Results from the multilevel model predicting daily physical activity habit strength (γ_{05}). Figure 1 depicts physical activity are presented in Table 2. Participants this moderated effect. The Johnson–Neyman technique revealed that the daily physical activity action planning intervention resulted in less physical activity for participants with strong physical activity habit strength (scores > *M* + 0.39 *SD*) compared with participants with strong habit strength who did not make physical activity action plans. Furthermore, the daily physical activity action planning intervention resulted in increased physical activity for participants with weak physical activity habit strength (scores < *M* – 1.55 *SD*) compared with participants with weak habit strength who did not make physical activity action plans. Yet, there was no effect of the daily physical activity action planning intervention for participants with moderate physical activity habit strength compared with those who did not receive the daily physical activity action planning intervention. As indicated by the pseudo-R^2, the model accounted for approximately 13% of the variance in daily physical activity, with the interaction between daily physical activity action planning and physical activity habit strength accounting for 12% of the explained variance.

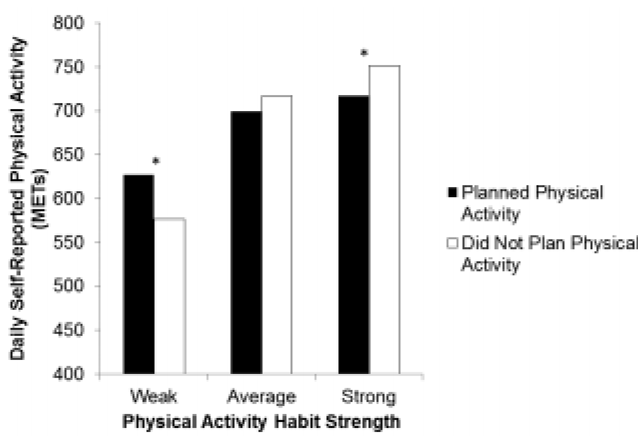

Figure 1 — The relation between physical activity action planning and self-reported physical activity in people who have weak (1.55 *SD* < *M*), average (*M*), and strong (0.39 *SD* > *M*) physical activity habit strength. METs = metabolic equivalents. *$p < .05$.

Table 2 Intraindividual Covariation in Self-Reported Physical Activity by Planning Group, Intentions, and Habit Strength

	Parameter Estimate	Standard Error
Fixed Effects		
Intercept, γ_{00}	726.45*	29.15
Physical Activity Action Planning Group, γ_{01}	–23.67	27.64
Sedentary Behavior Action Planning Group, γ_{02}	10.18	27.92
Physical Activity × Sedentary Behavior Action Planning Groups, γ_{03}	–23.32	27.69
Physical Activity Habit Strength, γ_{04}	101.95*	23.59
Physical Activity Action Planning Group × Habit Strength, γ_{05}	–49.11*	20.93
Usual Physical Activity Intentions, γ_{06}	4.13*	1.40
Daily Physical Activity Intentions, γ_{10}	4.85*	0.76
Weekend, γ_{07}	–95.43*	29.86
Sex, γ_{08}	–20.23	56.98
Body Mass Index, γ_{09}	17.40*	8.28
Random Effects		
Variance Intercept, u_{0i}	99,566	14,928
Variance Daily Physical Activity Intentions, u_{1i}	7.99	9.15
Residual	157,313	9,064.25
–2 log likelihood	13,517.1	
Akaike information criterion	13,525.1	

Note. Unstandardized estimates and standard errors. Model is based on six occasions nested within 185 participants for a total of 947 observations.
*$p < .05$.

Looking at other factors, participants whose usual intentions to engage in physical activity were stronger across days had higher levels of usual physical activity ($\gamma 06$). On days when participants had stronger physical activity intentions than usual, they reported higher levels of physical activity ($\gamma 10$). Participants tended to be less physically active on weekends ($\gamma 07$). Participants with higher BMI tended to be more active ($\gamma 09$). Sex was not associated with daily physical activity ($\gamma 08$).

Results from the multilevel model predicting daily sedentary behavior are presented in Table 3. The daily planning intervention to limit sedentary behavior ($\gamma 01$, $\gamma 02$, $\gamma 03$) was not significantly associated with daily sedentary behavior. Habit strength was a significant, positive predictor of sedentary behavior ($\gamma 03$), so that people with stronger habits for sedentary behavior engaged in more sedentary behavior. The interaction between daily planning and sedentary behavior habit strength was not a significant predictor of daily sedentary behavior ($\gamma 05$). Participants who had stronger usual intentions to limit or interrupt sedentary behavior had lower usual levels of physical activity ($\gamma 06$). On days when participants intended to limit or interrupt sitting time more than was typical for them, they reported lower levels of sedentary behavior ($\gamma 10$). Participants engaged in more sedentary behavior on weekends ($\gamma 07$). Sex ($\gamma 08$) and BMI ($\gamma 09$) were unrelated to daily sedentary behavior.

Table 3 Intraindividual Covariation in Self-Reported Sedentary Behavior by Planning Group, Intentions, and Habit Strength

	Parameter Estimate	Standard Error
Fixed Effects		
Intercept, γ_{00}	272.04	8.13
Physical Activity Action Plans, γ_{01}	–2.70	7.76
Sedentary Behavior Action Plans, γ_{02}	–11.24	7.81
Physical Activity and Sedentary Behavior Action Plans, γ_{03}	–4.44	7.79
Sedentary Behavior Habit Strength, γ_{04}	17.56*	6.97
Sedentary Behavior Action Plans × Habit Strength, γ_{05}	9.77	6.59
Usual Sedentary Behavior Intentions, γ_{06}	–1.97*	0.36
Daily Sedentary Behavior Intentions, γ_{10}	–1.47*	0.21
Weekend, γ_{07}	23.81*	7.25
Sex, γ_{08}	25.73	15.78
Body Mass Index, γ_{09}	3.43	2.34
Random Effects		
Variance Intercept, u_{0i}	8,375.38	1,167.52
Variance Daily Sedentary Behavior Intentions, u_{1i}	0.79	1.00
Residual	10,756	599.73
–2 log likelihood	11,858.6	
Akaike information criterion	11,866.6	

Note. Unstandardized estimates and standard errors. Model is based on six occasions nested within 185 participants for a total of 947 observations.
*$p < .05$.

DISCUSSION

Consistent with dual-process models of motivation and action (Strack & Deutsch, 2004), this study found that habit strength, daily intention strength, and usual intention strength each played roles in regulating daily physical activity and sedentary behavior. Daily action planning interventions had a selective effect on physical activity and no effect on sedentary behavior.

Daily action planning was an effective tool for increasing physical activity among people with weak physical activity habit strength. This finding was consistent with findings that self-regulatory interventions targeting volitional processes that bridge the gap between intentions and behavior can be useful for physical activity promotion (Bélanger-Gravel et al., 2013; Carraro & Gaudreau, 2013). It also extended those findings by showing, for the first time, that those effects are moderated by habit strength for physical activity.

Dual process theories posit that both reflective and automatic motivational processes regulate behavior and can compete in a “horse race” to determine a behavioral response, with the most quickly retrieved behavioral response being the one that is executed (Hofmann et al., 2012; Logan, 1989). Strong habits were expected to provide a behavioral default in the absence of strong intentions and plans for alternative actions (Adriaanse et al., 2011). Results supported the hypothesis that creating action plans to engage in physical activity would supersede weak habits in regulating behavior (Adriaanse et al., 2011; Hofmann et al., 2012; Wood & Neal, 2007). This finding replicates previous results from smoking cessation literature showing that for people with weak habits creating an action plan to reduce smoking subsequently leads to less smoking (Webb et al., 2009). People with weak physical activity habits who created daily action plans engaged in the equivalent of almost an additional 13 min each day of moderate-intensity physical activity compared with those with weak habits who did not make plans. Over the course of a week, this level of behavior change would account for approximately half of the recommended physical activity in national guidelines (Physical Activity Guidelines Advisory Committee, 2008).

On the other hand, when a person's physical activity was so routine that it had become associated with a particular set of cues, conscious efforts to manipulate the behavior backfired. Individuals with strong habits for physical activity who created daily action plans engaged in the equivalent of nearly 10 fewer minutes of moderate- intensity activity each day compared with those with strong physical activity habits. Of course, people who have strong physical activity habit strength are unlikely to need an action planning intervention to boost their physical activity. These findings reinforce the promise of using action planning with at-risk groups (i.e., people who have weak physical activity habits) and suggest caution is warranted before delivering this intervention with people who have strong physical activity habits already. Researchers should consider screening and excluding potential participants based on habit strength to ensure that the intervention does not have an adverse effect on this behavior.

One unusual feature of the action planning intervention in this study was that it was delivered at a higher intensity (i.e., daily) than previous interventions. This choice was made to accommodate daily fluctuations in the target behaviors as a function of the social calendar (Kozey-Keadle, Libertine, Staudenmayer, & Freedson, 2012; Sisson, McClain, & Tudor-Locke, 2008). The increased intensity may have contributed to the selective effect observed because it could have made the process of self-regulation salient to participants (Wood & Neal, 2007). It is unknown whether less-intense planning interventions would produce the same selective effect.

In addition, the effect size of the pseudo-R^2 for the interaction between daily physical activity action planning and physical activity habit strength was small (pseudo-$R^2 = .12$). Other experimental action planning studies have documented small to medium effect sizes when examining the influence of action planning on physical activity. For example, a recent meta-analysis examining the effect of physical activity action planning to other planning protocols or no planning protocols documented an effect size of .24 (based on Pearson's *r*; Carraro & Gaudreau, 2013); however, none of these studies asked participants to create *daily* action plans. The small effect size of daily action planning in this study suggests that plans should be bolstered to enhance the effectiveness of action planning. For example, participants in this study created action plans with three components (i.e., when, where, and how). However, recent evidence suggests that action plans that contain four or five components may be more effective than action plans containing two components (Carraro & Gaudreau, 2013; van Osch, Lechner, Reubsaet, & De Vries, 2010; Ziegelmann, Lippke, & Schwarzer, 2006). Further detailing plans, by including with whom participants will engage in physical activity with or the frequency, intensity, or duration of a particular activity may lead to enhanced effectiveness of daily action planning. Furthermore, combining daily physical activity action plans with other well-established behavior change techniques such as self-monitoring of behavior may help to further increase physical activity (Michie, Abraham, Whittington, McAteer, & Gupta, 2009).

In contrast to physical activity, action planning was ineffective for modifying sedentary behavior. This technique has been a component in previous sedentary behavior interventions; however, it has always been combined in a treatment package with other components (e.g., goal setting, feedback on behavior, self-monitoring, information on health consequences associated with the behavior; Fitzsimons et al., 2013; Gardiner, Eakin, Healy, & Owen, 2011). This study is the first that tested the main effects of action planning to reduce sedentary behavior. The null finding may reflect the lack of an objective out- come measure and participants' insensitivity to changes in this high-volume and often habitual behavior. In addition to objective measures, domain-specific measures of sedentary behavior may be more amendable to capturing changes in sedentary behavior as a result of action planning because specific domains of sedentary behavior may serve as a contextual cue when developing action plans and yield more valid self-reports (Clemes, David, Zhao, Han, & Brown, 2012).

Another possible explanation for this null result for sedentary behavior involves the nature of the planning prompts used in the daily intervention. Action plans are conceptually different from another common planning technique, implementation intentions (Hagger & Luszczynska, 2014). Implementation intentions are "if . . . , then . . ." plans designed to link a situation with a goal-directed behavioral response (e.g., "If I encounter situation X, then I will perform response Y"; Gollwitzer, 1999; Gollwitzer & Sheeran, 2006). Like implementation intentions, action plans are thought to initiate an automatic cue-to-action response; however, because action plans involve specifying time-related cues and/or environmental cues as well as the process through which action will occur, they may rely on conscious self-regulatory processes and decision making more than implementation intentions (Hagger & Luszczynska, 2014). Given the likely strong habitual component of sedentary behavior, the self-regulatory resources involved in developing action plans may deplete resources that would be used to enact the action plan and, therefore, be less likely to change behavior compared with implementation intentions (Bagozzi, Dholakia, & Basuroy, 2003; Luszczynska, 2006). Therefore, implementation intentions, which rely less on deliberate, conscious processes, may be particularly useful when the behavior change target is the down regulation of a highly habitual behavior, such as sedentary behavior (Hagger & Luszczynska, 2014).

Null findings may also reflect the lack of correspondence between the planned behaviors (i.e., standing and taking breaks from extended periods of sitting) and the outcome measure (i.e., daily duration of sedentary behavior). In addition, measures of habit and intentions used in this study focused on inaction (i.e., sedentary behavior) rather than action (e.g., standing). It is possible that conceptualizing sitting for an extended period of time as a behavior was challenging to participants. The term "sedentary" has most commonly been used to describe the absence of physical activity; however, recent calls have been made to use sedentary as a term that refers to activities that involve a seated or reclined position and expend little energy (Marshall & Ramirez, 2011; Pate, O'Neill, & Lobelo, 2008; Sedentary Behavior Research Network, 2012). We provided participants with a definition and examples of sedentary behavior that reflected the revised notion to help participants conceptualize the behavior that we were interested in assessing (i.e., sitting time). Future research would benefit from assessing not only sedentary behavior, but also the behaviors that dis- place sedentary behavior such as standing or other types of light-intensity physical activity as well as motivation for these different types of behaviors.

Such information would provide insights into relations between action planning, motivation, and behavior.

Regardless of the effectiveness of the action planning interventions on physical activity and sedentary behavior, results from this study support the notion that these health behaviors are regulated by both controlled and automatic motivational processes (i.e., dual-process theories of motivation; Strack & Deutsch, 2004). The findings that habit strength and daily and usual intentions all played roles in regulating daily physical activity and sedentary behavior are consistent with other studies of college students' motivation for physical activity and sedentary behavior (Conroy et al., 2011, 2013). Interventions aiming to modify physical activity, sedentary behavior, or both should target controlled and automatic motivational processes to facilitate and maintain behavior change.

The limitations of the study should be noted. The sample was a relatively homogenous one. Research with more diverse samples is necessary before these results can be generalized to broader populations. Second, the study employed self-report indices of habit strength. Given that people may not be fully aware of their habits, developing objective measures for both physical activity and sedentary behavior habits will be important for advancing this area of research. This study also used self-reported measures of physical activity and sedentary behavior. Habit strength has been shown to influence the extent to which people recall participation in health behaviors, with people with stronger habits being less accurate (Hyde, Elavsky, Doerksen, & Conroy, 2012). Objective measures of these health behaviors, or domain-specific measures that cue the context in which the behavior occurs, could reduce biases in reporting that results because of habit strength and should be incorporated into future research. Finally, this study employed daily action planning to reduce daily sedentary behavior. Due to the highly habitual nature of sitting time as well as the cognitive demands associated with executing action plans, another planning technique that relies less on deliberate, conscious processes, such as implementation intentions, may be better suited for reducing sedentary behavior. Future research should investigate the effectiveness of daily implementation intentions to reduce sedentary behavior. Future research would also benefit from exploring the effectiveness of daily action plans and implementation intentions that focus on increasing standing or other types of light-intensity physical activity as a way to displace sedentary time.

In conclusion, this study demonstrated that the effect of daily action planning on subsequent physical activity varied as a function of habit strength, and that daily action planning had no effect on sedentary behavior. Daily action planning can be used as an effective means of increasing daily physical activity for people with weak habits for physical activity; however, for those with strong habits daily action planning results in counterintentional behavior. This work informs dual-process theories of motivation and public health efforts by documenting differential effects of habit strength in the up-regulation of nonhabitual behavior and raising important questions about the down-regulation of habitual behavior through a prominent behavior change technique, action planning.

REFERENCES

Aarts, H., Paulussen, T., & Schaalma, H. (1997). Physical exercise habit: On the conceptualization and formation of habitual health behaviours. *Health Education Research, 12,* 363–374. PubMed doi:10.1093/her/12.3.363

Adriaanse, M.A., Gollwitzer, P.M., De Ridder, D.T.D., de Wit, J.B.F., & Kroese, F.M. (2011). Breaking habits with implementation intentions: a test of underlying processes. *Personality and Social Psychology Bulletin, 37*, 502–513. PubMed doi:10.1177/0146167211399102

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179–211. doi:10.1016/0749-5978(91)90020-T

Arbour, K.P., & Martin Ginis, K.A. (2009). A randomised controlled trial of the effects of implementation intentions on women's walking behaviour. *Psychology & Health, 24,* 49–65. PubMed doi:10.1080/08870440801930312

Bagozzi, R.P., Dholakia, U.M., & Basuroy, S. (2003). How effortful decisions get enacted: The motivating role of decision processes, desires, and anticipated emotions. *Journal of Behavioral Decision Making, 16,* 273–295. doi:10.1002/bdm.446

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior, 31,* 143–164. PubMed doi:10.1177/1090198104263660

Bargh, J.A., & Chartrand, T.L. (1999). The unbearable automaticity of being. *The American Psychologist*, *54*, 462–479. doi:10.1037/0003-066X.54.7.462

Bauer, D.J., & Curran, P.J. (2005). Probing interactions in fixed and multilevel regression: Inferential and graphical techniques. *Multivariate Behavioral Research, 40*, 373–400. doi:10.1207/s15327906mbr4003_5

Bélanger-Gravel, A., Godin, G., & Amireault, S. (2013). A meta- analytic review of the effect of implementation intentions on physical activity. *Health Psychology Review, 7,* 23–54. doi:10.1080/17437199.2011.560095

Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology*, *54,* 579–616. PubMed doi:10.1146/annurev.psych.54.101601.145030

Booth, M. (2000). Assessment of physical activity: An international perspective. *Research Quarterly for Exercise and Sport, 71*, S114–S120. PubMed

Budden, J.S., & Sagarin, B.J. (2007). Implementation intentions, occupational stress, and the exercise intention- behavior relationship. *Journal of Occupational Health Psychology, 12,* 391–401. PubMed doi:10.1037/1076-8998.12.4.391

Carraro, N., & Gaudreau, P. (2013). Spontaneous and experimentally induced action planning and coping planning for physical activity: A meta-analysis. *Psychology of Sport and Exercise, 14*, 228–248. doi:10.1016/j.psychs-port.2012.10.004

Clemes, S.A., David, B.M., Zhao, Y., Han, X., & Brown, W. (2012). Validity of two self-report measures of sitting time. *Journal of Physical Activity and Health, 9*, 533–539. PubMed

Conroy, D.E., Elavsky, S., Hyde, A.L., & Doerksen, S.E. (2011). The dynamic nature of physical activity intentions: A within-person perspective on intention-behavior coupling. *Journal of Sport & Exercise Psychology, 33*, 807–827. PubMed

Conroy, D.E., Maher, J.P., Elavsky, S., Hyde, A.L., & Doerksen, S.E. (2013). Sedentary behavior as a daily process regulated by habits and intentions. *Health Psychology, 32*, 1149–1157. PubMed doi:10.1037/a0031629

De Vet, E., Oenema, 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. *The International Journal of Behavioral Nutrition and Physical Activity, 6*, 11–20. PubMed doi:10.1186/1479-5868-6-11

Evans, J.S.B.T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology, 59*, 255–278. PubMed doi:10.1146/annurev.psych.59.103006.093629

Fitzsimons, C.F., Kirk, A., Baker, G., Michie, F., Kane, C., & Mutrie, N. (2013). Using an individualised consultation and activPAL feedback to reduce sedentary time in older Scottish adults: Results of a feasibility and pilot study. *Preventive Medicine, 57*, 718–720. PubMed doi:10.1016/j.ypmed.2013.07.017

Gardiner, P.A., Eakin, E.G., Healy, G.N., & Owen, N. (2011). Feasibility of reducing older adults' sedentary time. *American Journal of Preventive Medicine, 41*, 174–177. PubMed doi:10.1016/j.amepre.2011.03.020

Gardner, B., Abraham, C., Lally, P., & Bruijn, G.J. (2012). Towards parsimony in habit measurement: Testing the convergent and predictive validity of an automaticity subscale of the Self-Report Habit Index. *The International Journal of Behavioral Nutrition and Physical Activity, 9*, 102–124. PubMed doi:10.1186/1479-5868-9-102

Gollwitzer, P.M. (1993). Goal achievement: The role of intentions. *European Review of Social Psychology, 4*, 141–185. doi:10.1080/14792779343000059

Gollwitzer, P.M. (1999). Implementation intentions: Strong effects of simple plans. *The American Psychologist, 54*, 493–503. doi:10.1037/0003-066X.54.7.493

Gollwitzer, P.M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology, 38*, 69–119. doi:10.1016/S0065-2601(06)38002-1

Hagger, M.S., & Luszczynska, A. (2014). Implementation intention and action planning interventions in health contexts: State of the research and proposals for the way forward. *Applied Psychology: Health and Well-Being, 6*, 1–47. PubMed doi:10.1111/aphw.12017

Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W., & Ekelund, U. (2012). Global physical activity levels: Surveillance progress, pitfalls, and prospects. *Lancet, 380*, 247–257. PubMed doi:10.1016/S0140-6736(12)60646-1

Hayes, A.F., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior Research Methods, 41,* 924–936. PubMed doi:10.3758/BRM.41.3.924

Hofmann, W., Schmeichel, B.J., & Baddeley, A.D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences, 16*, 174–180. PubMed doi:10.1016/j. tics.2012.01.006

Holland, R.W., Aarts, H., & Langendam, D. (2006). Breaking and creating habits on the working floor: A field- experiment on the power of implementation intentions. *Journal of Experimental Social Psychology, 42*, 776–783. doi:10.1016/j.jesp.2005.11.006

Hyde, A.L., Elavsky, S., Doerksen, S.E., & Conroy, D.E. (2012). Habit strength moderates the strength of within-person relations between weekly self-reported and objectively- assessed physical activity. *Psychology of Sport and Exercise, 13*, 558–561. doi:10.1016/j.psychsport.2012.03.003

Kozey-Keadle, S., Libertine, A., Staudenmayer, J., & Freed- son, P. (2012). The feasibility of reducing and measuring sedentary time among overweight, non-exercising office workers. *Journal of Obesity, 2012,* 282303. PubMed doi:10.1155/2012/282303

Littell, R.C., Milliken, G.A., Stroup, W.W., & Wolfnger, R.D. (1996). *SAS system for mixed models*. Cary, NC: SAS Institute.

Logan, G.D. (1989). Automaticity and cognitive control. In J.S. Uleman & J.A. Bargh (Eds.), *Unintended thought* (pp. 52–74). New York, NY: Guilford Press.

Luszczynska, A. (2006). An implementation intentions intervention, the use of a planning strategy, and physical activity after myocardial infarction. *Social Science & Medicine, 62*, 900–908. PubMed doi:10.1016/j.socscimed.2005.06.043

Lynch, B.M. (2010). Sedentary behavior and cancer: A systematic review of the literature and proposed biological mechanisms. *Cancer Epidemiology, Biomarkers & Prevention, 19*, 2691–2709. PubMed doi:10.1158/1055-9965.EPI-10-0815

Marshall, S.J., & Ramirez, E. (2011). Reducing sedentary behavior: A new paradigm in physical activity promotion. *American Journal of Lifestyle Medicine, 5*, 518–530. doi:10.1177/1559827610395487

Matthews, C.E., George, S.M., Moore, S.C., Bowles, H.R., Blair, A., Park, Y., . . . Schatzkin, A. (2012). Amount of time spent in sedentary behaviors and cause-specific mortality in U.S. adults. *The American Journal of Clinical Nutrition, 95,* 437–445. PubMed doi:10.3945/ajcn.111.019620

Matthews, C.E., Moore, S.C., George, S.M., Sampson, J., & Bowles, H.R. (2012). Improving self-reports of active and sedentary behaviors in large epidemiologic studies. *Exercise and Sport Sciences Reviews, 40*, 118–126. PubMed

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. PubMed doi:10.1037/a0016136

Ouellette, J.A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin, 124,* 54–74. doi:10.1037/0033-2909.124.1.54

Pate, R.R., O'Neill, J.R., & Lobelo, F. (2008). The evolving definition of "sedentary." *Exercise and Sport Sciences Reviews, 36*, 173–178. PubMed doi:10.1097/ JES.0b013e3181877d1a

Physical Activity Guidelines Advisory Committee. (2008). *Physical Activity Guidelines Advisory Committee report*. Washington, DC: U.S. Department of Health and Human Services.

Proper, K.I., Singh, A., van Mechelen, W., & Chinapaw, M.J.M. (2011). Sedentary behaviors and health outcomes among adults: A systematic review of prospective studies. *American Journal of Preventive Medicine, 40*, 174–182. PubMed doi:10.1016/j.amepre.2010.10.015

Rhodes, R.E., & de Bruijn, G.J. (2010). Automatic and motivational correlates of physical activity: Does intensity moderate the relationship? *Behavioral Medicine (Washington, D.C.), 36*, 44–52. PubMed doi:10.1080/08964281003774901

Rhodes, R.E., & de Bruijn, G.J. (2013). How big is the physical activity intention-behaviour gap? A meta-analysis using the action control framework. *British Journal of Health Psychology, 18*, 296–309. PubMed doi:10.1111/ bjhp.12032

Schwartz, J.E., & Stone, A.A. (1998). Strategies for analyzing ecological momentary assessment data. *Health Psychology, 17*, 6–16. PubMed doi:10.1037/0278-6133.17.1.6

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology, 57*, 1–29. doi:10.1111/j.1464-0597.2007.00325.x

Sedentary Behavior Research Network. (2012). Standardized use of the terms "sedentary" and "sedentary behaviours." *Applied Physiology, Nutrition, and Metabolism, 37,* 540–542. PubMed doi:10.1139/h2012-024

Sheeran, P. (2002). Intention–behavior relations: A conceptual and empirical review. *European Review of Social Psychology, 12*, 1–36. doi:10.1080/14792772143000003

Sheeran, P., Gollwitzer, P.M., & Bargh, J.A. (2013). Non- conscious processes and health. *Health Psychology, 32*, 460–473. PubMed doi:10.1037/a0029203

Sisson, S.B., McClain, J.J., & Tudor-Locke, C. (2008). Campus walkability, pedometer-determined steps, and moderate- to-vigorous physical activity: A comparison of 2 university campuses. *Journal of American College Health, 56*, 585–592. PubMed doi:10.3200/JACH.56.5.585-592

Sjöström, M., Ainsworth, B.E., Bauman, A.E., Bull, F.C., Craig, C.L., & Sallis, J.F. (2005). *Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ) – short and long forms*. Karolinska Institute.

Sjöström, M., Ainsworth, B.E., Bauman, A.E., Bull, F., Craig, C.L., & Sallis, J.F. (2002). *International Physical Activity Questionnaire*. Karolinska Institute.

Skår, S., Sniehotta, F.F., Molloy, G.J., Prestwich, A., & Araújo- Soares, V. (2011). Do brief online planning interventions increase physical activity amongst university students? A randomised controlled trial. *Psychology & Health, 26*, 399–417. PubMed doi:10.1080/08870440903456877

Snijders, T.A.B., & Bosker, R.J. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling.* SAGE publications Ltd.

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*, 220–247. PubMed doi:10.1207/s15327957pspr0803_1

van Osch, L., Lechner, L., Reubsaet, A., & De Vries, H. (2010). From theory to practice: An explorative study into the instrumentality and specificity of implementation intentions. *Psychology & Health, 25*, 351–364. PubMed doi:10.1080/08870440802642155

Verplanken, B. (2010). By force of habit. In A. Steptoe (Ed.), *Handbook of behavioral medicine* (pp. 73–82). New York, NY: Springer. doi:10.1007/978-0-387-09488-5_6.

Verplanken, B., & Melkevik, O. (2008). Predicting habit: The case of physical exercise. *Psychology of Sport and Exercise, 9*, 15–26. doi:10.1016/j.psychsport.2007.01.002

Verplanken, B., & Orbell, S. (2003). Reflections on past behavior: A self-report index of habit strength. *Journal of Applied Social Psychology, 33*, 1313–1330. doi:10.1111/j.1559-1816.2003.tb01951.x

Webb, T.L., & Sheeran, P. (2005). Integrating concepts from goal theories to understand the achievement of personal goals. *European Journal of Social Psychology, 35*, 69–96. doi:10.1002/ejsp.233

Webb, T.L., Sheeran, P., & Luszczynska, A. (2009). Planning to break unwanted habits: Habit strength moderates implementation intention effects on behaviour change. *The British Journal of Social Psychology, 48*, 507–523. PubMed doi:10.1348/014466608X370591

Wood, W., & Neal, D.T. (2007). A new look at habits and the habit-goal interface. *Psychological Review, 114*, 843–863. PubMed doi:10.1037/0033-295X.114.4.843

Wood, W., Quinn, J.M., & Kashy, D.A. (2002). Habits in everyday life: Thought, emotion, and action. *Journal of Personality and Social Psychology, 83*, 1281–1297. PubMed doi:10.1037/0022-3514.83.6.1281

Ziegelmann, J.P., Lippke, S., & Schwarzer, R. (2006). Adoption and maintenance of physical activity: Planning interventions in young, middle-aged, and older adults. *Psychology & Health, 21*, 145–163. PubMed doi:10.1080/1476832050018891