# Sedentary behavior as a daily process regulated by habits and intentions

By: David E. Conroy, Jaclyn P. Maher, Steriani Elavsky, Amanda L. Hyde, Shawna E. Doerksen

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*(11):1149-57.



## Abstract:

**Objective:** Sedentary behavior is a health risk but little is known about the motivational processes that regulate daily sedentary behavior. This study was designed to test a dual-process model of daily sedentary behavior, with an emphasis on the role of intentions and habits in regulating daily sedentary behavior. **Method:** College students (N = 128) self-reported on their habit strength for sitting and completed a 14-day ecological momentary assessment study that combined daily diaries for reporting motivation and behavior with ambulatory monitoring of sedentary behavior using accelerometers. **Results:** Less than half of the variance in daily sedentary behavior was attributable to between-person differences. People with stronger sedentary habits reported more sedentary behavior on average. People whose intentions for limiting sedentary behavior were stronger, on average, exhibited less self-reported sedentary behavior (and marginally less monitored sedentary behavior). Daily deviations in those intentions were negatively associated with changes in daily sedentary behavior (i.e., stronger than usual intentions to limit sedentary behavior were associated with reduced sedentary behavior). Sedentary behavior also varied within people as a function of concurrent physical activity, the day of week, and the day in the sequence of the monitoring period. **Conclusions:** Sedentary behavior was regulated by both automatic and controlled motivational processes. Interventions should target both of these motivational processes to facilitate and maintain behavior change. Links between sedentary behavior and daily deviations in intentions also indicate the need for ongoing efforts to support controlled motivational processes on a daily basis.

**Keywords:** sitting | inactivity | goal | perception–behavior link

## Article:

**Supplemental materials: http://dx.doi.org/10.1037/a0031629.supp**

Excessive sedentary behavior has emerged as a major health threat. Although often confused with low levels of physical activity, sedentary behavior is best defined as the amount of time that people spend sitting because most seated activities require minimal energy expenditure (Marshall & Ramirez, 2011; Owen, Sparling, Healy, Dunstan, & Matthews, 2010; Pate, O'Neill, & Lobelo, 2008). National data indicate that American adults spend an average of 7.7 hr/day engaged in sedentary behavior (Matthews et al., 2008). Excessive sitting has been linked with increased risk for all-cause mortality and noncommunicable diseases such as cancer, cardiovascular disease, and Type 2 diabetes (Lynch, 2010; Proper, Singh, van Mechelen, & Chinapaw, 2011). These health risks are often independent of people's physical activity, so reducing sedentary behavior is an important public health goal in and of itself.

Although there have been many efforts to modify children's sedentary behavior (for a review, see Biddle, O'Connell, & Braithwaite, 2011), we are only aware of a few, relatively recent efforts to reduce sedentary behavior in adults (e.g., Gardiner, Eakin, Healy, & Owen, 2011; Kozey-Keadle, Libertine, Staudenmayer, & Freedson, 2012; Otten, Jones, Littenberg, & Harvey-Berino, 2009; Wilmot et al., 2011). One barrier to effective intervention development may be the absence of basic research on the motivational processes underlying sedentary behavior. In this study, we sought to fill that gap by applying a dual-process theory of motivation to sedentary behavior. We report results from a 14-day ecological momentary assessment study that we conducted to test hypotheses based on that theory.

## A MOTIVATIONAL THEORY FOR SEDENTARY BEHAVIOR

*Motivation* refers to the processes that initiate, orient, and regulate behavior over time. Some of the most exciting recent motivation discoveries are reflected in the proliferation of dual-process theories that distinguish between automatic (i.e., impulsive) and controlled (i.e., reflective) motivational processes (e.g., Gawronski & Bodenhausen, 2006; Hofmann, Friese, & Wiers, 2008; Smith & DeCoster, 2000; Strack & Deutsch, 2004). *Automatic motivational processes* are nonconscious, effortless, fast, and unintended, whereas *controlled motivational processes* are conscious, effortful, slow, and volitional (Bargh & Chartrand, 1999). We propose that automatic and controlled motivational processes will each exert a unique influence on sedentary behavior.

An automatic perceptual mechanism is central in theories of habits that emphasize the role of contextual cues in activating a behavior (Wood & Neal, 2007). As people pursue goals in a stable context, behavioral habits develop through a process of automatically associating that context with a particular behavioral response. Thus, habits are characterized by both high behavioral frequency and automatic regulation (Aarts & Dijksterhuis, 2000; Ouellette & Wood, 1998). We believe that a great deal of sedentary behavior will be habitual because, over time, people develop associations between sitting and common activities or contexts in their daily lives (e.g., working at the office while sitting, watching TV while sitting in a favorite armchair; Neal, Wood, & Quinn, 2006). This habitual component of sedentary behavior has been demonstrated in children, but we are not aware of any evidence related to adult sedentary behavior being habitual (Kremers & Brug, 2008; Kremers, van der Horst, & Brug, 2007). We hypothesized that people with stronger sedentary habits would engage in more sedentary behavior.

Intentions (i.e., goals) are at the center of theories that emphasize controlled motivational processes (e.g., Ajzen, 1991; Bandura, 1989; Schwarzer, Lippke, & Luszczynska, 2011). Intentions orient people's actions toward or away from specific behaviors and have a consistent positive association with physical activity (McEachan, Conner, Taylor, & Lawton, 2011). In the case of sedentary behavior, it seems unlikely that many people form intentions to engage in sedentary behavior; however, they may form intentions to limit their sedentary behavior. Such intentions to limit sedentary behavior should reduce daily sitting time (i.e., stronger intentions would lead to less sitting time). Intentions to limit and interrupt sedentary behavior are a common feature of existing interventions that set goals such as limiting oneself to 30 min of uninterrupted sitting or prompt participants to set personal goals for their sedentary behavior (e.g., Gardiner et al., 2011; Wilmot et al., 2011); however, we are not aware of any studies that have examined natural daily variation in such intentions. Given that intentions for related behaviors, such as physical activity, can vary considerably over time (Conroy, Elavsky, Hyde, & Doerksen, 2011; Conroy, Elavsky, Maher, & Doerksen, 2012; Scholz, Keller, & Perren, 2009), intentions for limiting sedentary behavior also may vary over time. In this case, it is important to distinguish *between-person processes* (i.e., those that differentiate people who engage in more vs. less sedentary behavior overall) from *within-person processes* (i.e., those that differentiate days when people engage in more vs. less sedentary behavior) when testing intention–behavior relations. We hypothesized that (1) people who had stronger overall intentions to limit their sedentary behavior would engage in less sedentary behavior (a between-person hypothesis), and (2) on days when people had stronger intentions to limit their sedentary behavior than was typical for them, they would engage in less sedentary behavior (a within-person hypothesis).

The automatic and controlled processes that regulate sedentary behavior are expected to have separate mechanisms of behavioral regulation (i.e., perceptual cuing of behavior vs. intentional regulation); however, these systems are inevitably intertwined as they regulate behavior. For example, controlled processes, such as intention formation, may be used to interrupt habitual sedentary behavior (Wood & Neal, 2007) but, absent such deliberate efforts, habitual sedentary behavior should unfold automatically when people encounter the relevant contextual cue(s) for that behavior. Accordingly, we expected that habits and intentions would have unique simultaneous associations with daily sedentary behavior. In the context of food choice, intentions and habits have been proposed as keys to the initiation and maintenance of behavior change, respectively (Rothman, Sheeran, & Wood, 2009). It is possible that similar predictions could apply to sedentary behavior; however, at this early stage of research, we first need to evaluate whether these processes are simultaneously associated with sedentary behavior.

Of course, there are a number of other possible influences on both motivation and sedentary behavior that could confound conclusions about the dual-process theory of sedentary behavior motivation. For example, sedentary behavior is incompatible with physical activity (Epstein, Saelens, & O'Brien, 1995), so the amount of overall activity that people accrue each day should displace (i.e., be inversely associated with) sedentary behavior that day. Alternatively, sedentary behavior may be regulated around a set point such that perturbations in sedentary behavior on one day may lead to compensation on the next day (e.g., increasing sedentary behavior following a day with unusually low sedentary time). For college students and adults, the social calendar also has been associated with differences in both physical activity and sedentary behavior (i.e., greater physical activity and sedentary behavior on weekdays than weekends; Behrens & Dinger, 2003, 2005; Kozey-Keadle et al., 2012; Sisson, McClain, & Tudor-Locke, 2008). We expected that daily variation in class schedules, extracurricular activities, and other features of the social calendar would impact sedentary behavior in our study population of college students. Finally, in the context of an ecological momentary assessment study, reactivity to study procedures, such as self-monitoring or activity monitoring, may impact people's sedentary behavior (e.g., Motl, McAuley, & Dlugonski, 2012). Given the possible influence of these variables, we sought to control them statistically when evaluating associations between automatic and controlled motivational processes and daily sedentary behavior. In total, we controlled for potential threats presented by behavioral displacement (i.e., concurrent physical activity), compensatory regulation from one day to the next (i.e., previous-day sedentary behavior), the social calendar (i.e., day of the week), and reactivity to study procedures (i.e., position of the day in the sequence of the study).

## THE PRESENT STUDY

To test the dual-process theory of sedentary behavior outlined above, we conducted a 14-day ecological momentary assessment study employing both daily diary and ambulatory monitoring techniques. We selected a daily sampling schedule because the day is the most fundamental period of human activity, defined physically by light–dark cycles and behaviorally by wake–sleep cycles. We included both self-report and direct measures of sedentary behavior in recognition of the complexity of sedentary behavior and the limits of each assessment technique. We assumed that habit strength would be relatively stable over a 14-day monitoring period and treated this construct as a between-person source of variation in sitting time. Based on findings that intentions for physical activity vary considerably over time (Conroy et al., 2011, 2012; Scholz et al., 2009), we examined both between-person and within-person associations between intentions and sedentary behavior. Our model statistically controlled for a number of potential confounds, including behavioral displacement, compensatory regulatory processes, the social calendar, and reactivity to study procedures. Our primary hypotheses were that (1) sedentary habit strength would be positively associated with the average level of self-reported and directly monitored sedentary behavior, and (2) daily intentions would be negatively associated with self-reported and directly monitored sedentary behavior at both the between-person and within-person levels of analysis.

## METHOD

### *Participants*

A convenience sample of participants was recruited from advanced undergraduate courses ($N$ = 130); they completed this study as part of required class projects from late September to early October 2011 (48%) and from late January to early February 2012 (52%). One student did not grant explicit permission to use his data for research purposes and one participant indicated that she was unable to perform normal physical activity at the time. We present data from the remaining 128 participants in this article. This sample included 53 men and 75 women with a mean age of 21.3 years ($SD$ = 1.1). Most participants were White (89%; 5% Asian American; 5% African American, 2% two or more races) and not Hispanic or Latino (98%; 2% Hispanic or

Latino). Based on World Health Organization (2000) cutoffs for body mass index (BMI), participants were mostly normal weight (60%: $18.5 \leq \text{BMI} < 24.9$) or overweight (32%: $25.0 \leq \text{BMI} < 29.9$; $M = 24.7$, $SD = 3.8$, range = 18.0–44.4).

### *Measures*

The Self-Report Habit Index (Verplanken & Orbell, 2003) was modified to assess sedentary behavior habits. Previous adaptations of this measure have been used to assess habits for a variety of behaviors including physical activity, beverage consumption, dietary behavior, food safety practices, cigarette smoking, flossing, Internet use, and social behavior (Gardner, Bruijn, & Lally, 2011; Orbell & Verplanken, 2010; Verplanken, 2010; Verplanken & Melkevik, 2008). The 12-item measure samples content related to behavioral frequency (e.g., “Sitting is something I do frequently [e.g., in cars/buses, at school/work/home]”) and automaticity (e.g., “Sitting is something I start doing before I realize I’m doing it [e.g., in cars/buses, at school/work/home]”). Participants rated each item on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). This measure has been criticized on the grounds that the frequency-related items may be confounded by nonautomatic behavioral repetition, and others have used a five-item subset of items focused on automaticity (i.e., efficiency and lack of awareness) to mitigate this criticism (Rhodes & de Bruijn, 2010). Given this concern, we report results based on the five-item score; however, we ran analyses with both the 12- and five-item versions, and our conclusions were equivalent regardless of which version was used. Responses to the five-item scale were internally consistent ($\alpha = .91$), and the score is reported as a mean response to those items.

Intentions were assessed using two items: “I intend to spend no more than 75 minutes at a time sitting tomorrow (e.g., in cars/buses, at school/work/home)” and “I intend to avoid sitting for more than a total of 5 hours tomorrow (e.g., in cars/buses, at school/work/home).” These durations were selected because (a) no standard durations could be identified from the literature, (b) few classes at the university where we collected data lasted longer than 75 min, and (c) pilot work indicated that 5 hr would be a challenging but realistic goal for college students (and therefore reduce the likelihood of ceiling or floor effects in responses). These items were strongly correlated ($r = .63$, $p < .01$), so we combined them into a single score.

Physical activity and sedentary behavior were assessed using direct and self-report methods. During the day, participants wore an ActiGraph GT3X accelerometer (ActiGraph, Pensacola, FL) on the midline of their right hip. We examined two common sets of cutoff values that classified activity within 60-s epochs as sedentary if the monitors recorded fewer than 100 or 250 counts$\cdot$ $\text{min}^{-1}$ (Freedson, Melanson, & Sirard, 1998; Matthew, 2005). The two criteria yielded highly correlated scores ($r = .79$), and results from our analyses were equivalent with the two measures. We report findings based on the more conservative 100 counts$\cdot$ $\text{min}^{-1}$ standard because of its superior sensitivity and specificity (Kozey-Keadle, Libertine, Lyden, Staudenmayer, & Freedson, 2011). The percentage of sedentary time each day and the average daily activity counts$\cdot$ $\text{hr}^{-1}$ (adjusted for valid wear time) served as our measures of daily sedentary time and physical activity, respectively. A valid day of recording consisted of $\geq$10 valid wear time hours with every period of 90 consecutive minutes of zero being considered nonwear.

At the end of each day, participants also completed the short form of the International Physical Activity Questionnaire (Booth, 2000; Sjöström et al., 2002). This four-item measure included questions about the duration of time spent engaged in vigorous physical activity, moderate physical activity, walking, and sitting that day. Although originally developed as a 7-day recall measure, this daily adaptation reduces the threat of retrospective bias and has been used successfully in our previous research (Maher et al., in press). Following established data management protocols, we calculated physical activity scores by (a) weighting each activity duration by constants reflecting estimated energy expenditure (i.e., vigorous physical activity = 8 metabolic equivalents [METs], moderate physical activity = 4 METs, walking = 3.3 METs), and (b) summing those products (Sjöström et al., 2005). Scores represented estimated daily energy expenditure through physical activity (MET· min· day$^{-1}$). Sedentary behavior scores were expressed as the number of minutes that a participant spent sitting each day.

### *Procedure*

In an initial laboratory visit, a research assistant described the study to participants and answered any questions about the procedures. Participants provided written informed consent. A research assistant recorded the height and weight of each participant twice. A third measure was taken if differences between these two measures exceeded our criteria (i.e., ± 0.3 kg or ± 0.4 cm). Every participant was given an activity monitor, instructed on how and where to wear it, and asked to wear it at all times except when they were bathing/showering, swimming, or engaging in other water activities. At night, participants were asked to move the activity monitor from their hip to their wrist (for assessment of sleep, which was filtered out of the activity data used in this study) and then to move it back to their hip on waking in the morning. Every participant received a paper log on which they were asked to record the times when they woke up, put the monitor on their hip, moved the monitor to their wrist, went to bed, and any other times when they removed the monitor. Starting that evening and continuing for 14 days, participants were sent an automated e-mail at 7 p.m. with a reminder to complete an online questionnaire and a link to that questionnaire. Participants who had not completed their daily report by 9 a.m. received a second reminder e-mail and had an opportunity to complete the daily report until 1 p.m. Reports submitted after 1 p.m. were discarded. After 2 weeks, participants returned their activity monitors and log books to the laboratory.

### *Data Analysis*

When descriptive statistics indicated significant skew in a variable, we evaluated a range of power-law transformations using the Box–Cox method to normalize the distribution (Box & Cox, 1964; Osborne, 2010). Transformed values were used to calculate correlations and estimate parameters in multilevel models. Bivariate correlations were calculated using two methods. First, they were calculated using the full series of data points without regard to the nested design in which each participant had multiple data points. Second, within-person means were estimated for each variable and relations between those means were examined. These correlations were interpreted descriptively rather than inferentially because of the limitations inherent in each estimate (i.e., neglecting dependencies within people or within-person variation across occasions).

Daily data on motivation and behavior were nested within people in this study, so we used multilevel modeling to test our hypotheses about between-person and within-person associations (Snijders & Bosker, 1999). Models were estimated using Mplus 5.2 (Muthén & Muthén, 1998). Two multilevel models were estimated: one using self-report measures of sedentary behavior and a second using the direct measure of sedentary behavior. In preliminary analyses, there were no differences in daily sedentary behavior between the two semesters of data collection, so we dropped this variable from subsequent analyses.

***Multilevel data preparation***

Several steps were taken to prepare data for analyses. First, a single-day lagged motivation variable was created for daily intentions to reflect that intentions rated at the end of day *d* – 1 corresponded to intended behavior on day *d*. Next, we separated each daily motivation and behavior score into two components: a person-level average across days (between-person variable) and a person-centered daily score (within-person variable; Schwartz & Stone, 1998). The person-level (between-person) score represented a person's average level of motivation or behavior over the monitoring period (e.g.,

$$\textit{Overall Physical Activity}_i = \frac{1}{d}\sum\nolimits_{d=1}^{d} \textit{Physical Activity}_{id},$$

where person *i*'s overall physical activity is the average of her daily physical activity across the *d* days). The daily (within-person) score represented daily deviations from that average level (e.g.,

$$\textit{Daily Physical Activity}_{di} = \textit{Physical Activity}_{id} - \textit{Overall Physical Activity}_i,$$

where person *i*'s deviation in physical activity on day *d* is the difference between her physical activity on day *d* and her overall physical activity across the *d* days). With the exception of sex (female coded as 1, male coded as 2), all between-person predictor variables were centered prior to the analysis.

Six dummy variables representing the day of the week were created as within-person variables. Saturday served as the reference category because it had low levels of sedentary time in both the self-report and direct measures. To control for the possibility that sedentary behavior changed as a function of participating in the study (i.e., reactivity), we created another within-person variable to represent the position of the day in the sequence of the study.

***Multilevel model specifications***

In the Level-1 model shown in Equation 1, daily sedentary behavior was regressed on a series of within-person predictor variables that included the dummy variables representing the day of the week (β1–6), the day number of the protocol (β7), previous-day sedentary behavior (β8), concurrent physical activity (β9), and lagged intentions for limiting sedentary behavior (i.e., intentions rated the previous evening [day *d* – 1] concerning day *d* behavior; β10). The inclusion of previous-day sedentary behavior in the model permitted us to interpret the remaining within-person model coefficients as predictors of residualized change in daily sedentary behavior.

Level-1 model:

$$\begin{aligned}Sedentary_{id} &= \beta_0 + \beta_1(Sunday_{id}) + \beta_2(Monday_{id}) + \beta_3(Tuesday_{id}) \\ &+ \beta_4(Wednesday_{id}) + \beta_5(Thursday_{id}) + \beta_6(Friday_{id}) \\ &+ \beta_7(Day\ in\ Sequence_{id}) + \beta_8(Previous\ Day\ Sedentary_{i(d-1)}) \\ &+ \beta_9(Daily\ Physical\ Activity_{di}) + \beta_{10}(Intentions_{i(d-1)}) + \varepsilon_{id}. \quad (1)\end{aligned}$$

In the Level-2 model shown in Equation 2, the intercept for sedentary behavior (β0) was regressed on overall physical activity, overall intention strength, habit strength for sedentary behavior, sex, and BMI. As seen in Equation 3, the Level-1 slope coefficients for the day-of-week and day-in-sequence variables were treated as unconditional fixed effects in the Level-2 model (γ(1–7)0) to reduce model complexity in the absence of specific expectations that these coefficients would vary between people. The Level-1 slopes for previous-day sedentary behavior (γ80), concurrent physical activity (γ90), and daily intentions (γ100) were treated as unconditional random effects as shown in Equation 4.

$$\begin{aligned}\beta_0 &= \gamma_{00} + \gamma_{01}(Overall\ Physical\ Activity_i) \\ &+ \gamma_{02}(Overall\ Intentions_i) + \gamma_{03}(Habit\ Strength_i) + \gamma_{04}(Sex_i) \\ &+ \gamma_{05}(BMI_i) + \mu_{0i}, \quad (2)\end{aligned}$$

$$\beta_{1-7} = \gamma_{(1-7)0}. \quad (3)$$

$$\beta_{8-10} = \gamma_{(8-10)0} + \mu_{(8-10)i}. \quad (4)$$

## RESULTS

Participants provided 1,541 of 1,664 possible daily self-reports concerning motivation (Days 1–13) and behavior (Days 2–14; 93% compliance overall), and had 1,429 of 1,664 possible days with valid accelerometer data (i.e., ≥ 10 valid wear time hours; 86%). In total, participants provided both valid self-report and accelerometer data on 1,340 days (81%), valid accelerometer data (but missing self-report data) on 201 days (12%), valid self-report data (but missing accelerometer data) on 89 days (5%), and no valid data at all on 34 days (2%). The overall proportion of missing data on each variable was not significantly associated with any between-person scores for any of the variables ($p > .01$). To evaluate the within-person odds of missing data as a function of the day of week or sequence in the study, we estimated a multilevel logistic regression. Sunday had the highest proportion of missing data for both self-report and accelerometer data, so it was used as the reference category for this model. Self-report data were significantly less likely to be missing from Monday through Friday than on Sunday (odds ratios ranged from 0.08 to 0.26; *p*s < .01); Saturday and Sunday odds of missingness did not differ ($p >$ .01). Accelerometer data were significantly less likely to be missing from Tuesday through Friday than on Sunday (odds ratios ranged from 0.15 to 0.24; *p*s < .01); Saturday and Monday odds did not differ from those on Sunday ($p > .01$). The position of the day in the sequence of the study was not significantly associated with the odds of missingness ($p > .01$); however, we included both the day of the week and day in sequence as control variables in our subsequent analyses.

Descriptive statistics appear in online Supplementary Table 1. Participants reported an average of approximately 6 hr of sitting time/day (within-person range: 0–16 hr; between-person range: 2.43–11.09 hr) and the accelerometers indicated that 67% of waking hours were classified as sedentary (within-person range: 26.5–99.6%; between-person range: 52.6–82.5%). Assuming 16 waking hours/day, the 100 count· $min^{-1}$ criterion implies that people engaged in an average of nearly 11 hr of sedentary behavior each day. These self-reported and directly monitored values likely under- and overestimate sedentary behavior, respectively, because people may not be aware of or recall all of their daily sitting time and the activity monitors cannot differentiate standing still from actual sedentary behavior.

Scores for both sedentary behavior and physical activity were significantly skewed, so we identified optimal power-law transformations to normalize the distributions for self-reported sedentary behavior ($\lambda = 0.60$), monitored sedentary behavior ($\lambda = 1.90$), self-reported physical activity ($\lambda = 0.40$), and monitored physical activity ($\lambda = 0.30$). These transformed values were used to estimate subsequent correlations as well as in the multilevel models.

The intraclass correlation coefficients shown along the diagonal of the matrix in online Supplementary Table 1 indicated that approximately half of the variance in self-reported behavior and one quarter of the variance in monitored behavior existed between people. Slightly more than half of the variance in daily intentions to limit sedentary behavior was between people. The remaining variance in these scores represented within-person variation or measurement error. People who exhibited the greatest day-to-day variation in intention ratings—as indicated by their within-person standard deviation for those ratings—tended to report stronger intentions on average ($r = .18$, $p = .04$) but did not differ in their sex, habit strength, or the amount of physical activity or sedentary behavior ($p > .05$).

The patterns in both sets of bivariate correlations were similar for self-reports and direct measures of behavior and for between-person and within-person correlations (upper and lower diagonals of online Supplementary Table 1, respectively). Habit strength for sedentary behavior was positively associated with sedentary behavior (*r*s = .20, .36) and unassociated with physical activity (*r*s = −.03, −.06). People with stronger sedentary habits reported, on average, weaker intentions to limit their sedentary behavior ($r = -.25$). Intentions to limit sedentary behavior were associated with less sedentary behavior (*r*s ranged from −.23 to −.56) and more physical activity (*r*s ranged from .18 to .30). Sedentary behavior and physical activity exhibited moderate to strong negative correlations (*r*s ranged from −.22 to −.59). Next, separate multilevel models were tested for self-reported and directly monitored sedentary behavior to evaluate the simultaneous associations of controlled and automatic motivation while controlling for a variety of confounds in the nested data structure.

### *Self-Reported Sedentary Behavior*

Online Supplementary Table 2 presents the final coefficients from our multilevel model of self-reported sedentary behavior. Consistent with our within-person hypothesis, daily deviations in intentions were significantly associated with decreased self-reported sitting time ($\gamma_{100} = -0.09$, $p < .001$; i.e., people who reported stronger intentions to limit their sitting time subsequently reported sitting less); this association varied significantly between people ($\sigma^2_{\gamma 100} = 0.01, p = .04$). Consistent with our between-person hypothesis, both the overall strength of intentions to limit sitting time ($\gamma_{02} = -0.22$, $p < .001$) and sedentary habit strength ($\gamma_{03} = 2.13$, $p < .001$) were significantly associated with self-reported sitting time (in opposite directions as expected).

In this model, self-reported sedentary behavior also was significantly associated with the day of the week and the position of the day in the monitoring period. Relative to Saturdays, participants reported sitting more on Mondays ($\gamma_{20} = 3.31$, $p = .001$), Tuesdays ($\gamma_{30} = 3.15$, $p < .001$), Wednesdays ($\gamma_{40} = 3.31$, $p < .001$), and Thursdays ($\gamma_{50} = 2.46$, $p = .005$); there were no differences on Sundays ($\gamma_{10} = -0.66$, $p = .50$) or Fridays ($\gamma_{60} = 0.64$, $p = .53$). Participants increased their reported sitting time over the course of the 13 days of the study ($\gamma_{70} = 0.37$, $p < .001$). Sedentary behavior was not associated with previous-day sedentary behavior ($\gamma_{80} = 0.03$, $p = .26$); however, this within-person association varied significantly between people ($\sigma^2_{\gamma 80}$ = 0.05, $p = .04$). People reported decreasing their sedentary behavior on days when they reported more physical activity ($\gamma_{90} = -0.49$, $p < .001$), and this within-person association also varied between-people ($\sigma^2_{\gamma 90} = .05$, $p = .04$). Overall physical activity levels across the 13 days were not associated with overall sedentary time ($\gamma 01 = -0.22$, $p = .08$). Self-reported sedentary behavior was not associated with sex ($\gamma 04 = 0.60$, $p = .70$) or BMI ($\gamma 05 = -0.16$, $p = .38$).

***Directly Monitored Sedentary Behavior***

Consistent with our within-person hypothesis, online Supplementary Table 3 shows that daily deviations in intentions to limit sedentary behavior were associated with decreased sedentary behavior ($\gamma_{100} = -1.40$, $p = .003$); this association varied marginally between people ($\sigma^2_{\gamma 100} = 6.12, p = .05$). he overall strength of intentions was only marginally associated with sedentary behavior ($\gamma_{02} = -1.25$, $p = .05$). Consistent with our between-person hypothesis, habit strength was associated with greater sedentary behavior ($\gamma_{03} = 23.97$, $p = .04$).

Directly monitored sedentary behavior also differed as a function of the day of the week. Relative to Saturdays, participants exhibited more sedentary time on Tuesdays ($\gamma_{30} = 153.46$, $p < .001$), Wednesdays ($\gamma_{40} = 238.91$, $p < .001$), Thursdays ($\gamma_{50} = 125.52$, $p < .001$), and Fridays ($\gamma_{60} = 168.98$, $p < .001$), and less sedentary time on Sundays ($\gamma_{10} = -85.12$, $p = .004$) and Mondays ($\gamma_{20} = -72.63$, $p < .001$). Sedentary behavior increased marginally over the course of the monitoring period ($\gamma_{70} = 3.95$, $p = .06$) and was negatively associated with previous-day sedentary behavior ($\gamma_{80} = -2.69$, $p = .003$); the latter association did not vary between people ($\sigma^2_{\gamma 80} = 0.92, p = .94$). People also decreased their sedentary time on days when they exhibited more physical activity ($\gamma_{90} = -24.95$, $p < .001$); this association varied significantly between people ($\sigma^2_{\gamma 90} = 35.65, p = .006$). Monitored sedentary time was not associated with sex ($\gamma_{04} = -49.68$, $p = .14$) or BMI ($\gamma 05 = -6.57$ $p = .24$). On average, people who engaged in more physical activity ($\gamma_{01} = -17.33$, $p < .001$) engaged in less sedentary behavior than people who engaged in less physical activity.

## DISCUSSION

This study tested and provided support for a dual-process theory of daily sedentary behavior motivation. Directly monitoring sedentary behavior in this sample revealed that participants sat for almost two thirds of their waking hours per day (e.g., 11 hr/16 waking hours). Matthews et al. (2008) recently examined directly measured sitting time across the life span as part of National Health and Nutrition Examination Survey 2003–2004 data and found that young adults (ages 20–29) sat for approximately 55% of their waking hours. Accelerometer-derived activity counts and the distribution of time spent in light, lifestyle, moderate, vigorous, and very vigorous activities in our sample were similar to those of national averages reported by Troiano et al. (2008) using the same epidemiological data set. It should be noted that the validity of these comparisons is limited somewhat by the lack of standardized procedures to adjust accelerometer data for valid wear time.

Intentions to limit sedentary behavior—reflecting a controlled motivational process—were consistent predictors of sedentary behavior at the within-person level of analysis for both self-reported and directly monitored sedentary behavior. Intentions also predicted between-person differences in sedentary behavior, although less consistently than they did at the within-person level. Individual differences in habit strength—reflecting a between-person, automated motivational process—were positively associated with both self-reported and directly monitored sedentary behavior. These findings extend arguments that dual-process theories can be useful for explaining health behaviors (Hofmann et al., 2008) and, to the best of our knowledge, provide the first evidence that emerging adults' sedentary behavior is regulated by both automatic and controlled motivational processes.

Our finding that intentions regulated sedentary behavior indicates a clear role for controlled motivational processes in regulating daily sedentary behavior. Although we did not examine the sources of daily variation in intentions, this question warrants attention in future research and answers should inform future intervention development efforts. Our findings reinforce the value of including an intention formation component in interventions to reduce sedentary behavior (Gardiner et al., 2011; Wilmot et al., 2011), albeit with an important caveat. Although relatively few studies have attended to the temporal ebb and flow of motivation, intentions in this study were quite variable from day to day—a finding that mirrored observations from studies of intensively measured physical activity intentions (e.g., Conroy et al., 2011, 2012). This daily variation implies that intentions formed at the outset of a behavior-change program may not remain as consistent as one might expect over the days and weeks that follow initial intervention delivery. Interventions that are sensitive to this daily motivational variation may be more effective at reducing daily sedentary behavior. Accordingly, future interventions that involve setting an initial goal for limiting sedentary behavior may benefit from the inclusion of daily booster interventions to shield those intentions from unwanted variation that could decouple motivation from behavior (see Conroy et al., 2011). Daily booster interventions of this nature may be most useful on weekdays when people engage in the greatest amount of sedentary behavior.

Intentions represent only one form of controlled motivational processing, and it would be valuable to examine the contribution of related processes such as self-efficacy or action planning (e.g., Adams, 2012). Given the pervasiveness of sedentary behavior in people's daily activities, it may also help to contextualize motivation with respect to activities that are completed while sedentary (e.g., intentions to limit TV watching while sedentary, intentions to limit uninterrupted sedentary time at one's desk). This connection between motivation, context, and action over time is the foundation of habits.

Habits pervade our daily lives (Wood, Quinn, & Kashy, 2002), so it was unsurprising that habit strength had some of the strongest bivariate correlations with sedentary behavior. This association was robust in both multilevel models of sedentary behavior and leads to the conclusion that between-person differences in sedentary behavior are at least partly rooted in people's habit strength for sedentary behavior.

The Self-Report Habit Index that we used in this study has been used successfully to assess a variety of behavioral habits (Gardner et al., 2011; Verplanken, 2010). The construct validity of this measure has been criticized on the grounds that it conflates behavioral repetition with habits (Sniehotta & Presseau, 2012). We excised items with content based on behavioral frequency to address this problem (see also Rhodes & de Bruijn, 2010), but it is still not clear that people are capable of providing valid self-reports on automatic processes that may lie outside of their awareness. Another concern with this measure is the insensitivity of its original items to the stability of contexts in which people engage in sedentary behavior. We provided examples of common contexts for sedentary behavior at the end of each item (i.e., "in cars/buses, at school/work/home") in an attempt to cue relevant context–behavior linkages when participants responded. Nevertheless, alternative measures of habit strength that capture both the frequency of sedentary behavior and the stability of the contexts in which people engage in sedentary behavior would be welcome in future research (e.g., Wood, Tam, & Witt, 2005).

It would also be fruitful to explore other automatic motivational pathways that may play a role in regulating sedentary behavior. For example, automatic evaluations have proven to be valuable for predicting physical activity (Conroy, Hyde, Doerksen, & Ribeiro, 2010). Automatic evaluations of sedentary behavior may help to explain why people slip into sedentary behaviors so frequently and effortlessly. It is also possible that the landscape of everyday life contains cues that prime nonconscious goals for sitting. In pursuing this work, it will be important to consider the possibility that some mechanisms of automatic motivation are more relevant for initiating behavior change whereas others are more relevant for maintaining those changes (Rothman et al., 2009). Although we have much to learn about the specific automatic and controlled motivational processes that regulate sedentary behavior, findings from the present study recommend further consideration of dual-process models of sedentary behavior in future basic and translational research efforts.

Most previous research on sedentary behavior has focused on differences between people over a fixed period of time. This study provided novel insight into within-person daily variation in sedentary behavior and that insight complements findings on hourly differences in sedentary behavior (Gardiner et al., 2011). These results indicate that between-person variation only scratches the surface of people's sedentary behavior. The social calendar (indicated by the day of the week in this study) was one source of daily variation, with people generally exhibiting more sedentary behavior during weekdays than on weekends (Kozey-Keadle et al., 2012). This finding presumably reflects college students' coursework and extracurricular activities. Taken in combination with research on physical activity (Behrens & Dinger, 2003, 2005; Conroy et al., 2011), college students' weekdays appear to be characterized by both extreme activity and extreme inactivity relative to the weekends. As such, there may be more potential for interventions to reduce sedentary behavior on weekdays and to increase physical activity on weekends.

Another source of within-person variation in sedentary behavior may have been reactivity to study procedures (Motl et al., 2012). Participants in this study increased their sedentary behavior with every day that they monitored their behavior. Research on the question–behavior effect has shown that self-monitoring undesirable behaviors can lead to paradoxical increases in those behaviors (Williams, Block, & Fitzsimons, 2006), so self-monitoring may be an undesirable, or even iatrogenic, component of interventions to reduce sedentary behavior. This research on the question–behavior effect contrasts with research demonstrating that self-monitoring is a key component of effective interventions to promote physical activity (Michie, Abraham, Whittington, McAteer, & Gupta, 2009), and may indicate a key difference in the strategies needed to change these health behaviors. Our design was not experimental, so it is not possible to draw causal conclusions about the effects of self-monitoring on sedentary behavior. Nevertheless, these findings are suggestive and warrant further investigation.

A final within-person influence on daily sedentary behavior was the amount of concurrent physical activity obtained by a person. This association was present at both between- person and within-person levels of analysis. Previous work has established that children and adolescents can substitute sedentary behaviors and physical activity for each other (e.g., Epstein, Saelens, Myers, & Vito, 1997). Our findings suggest that a similar process may exist in college students, but experimental work that manipulates one behavior to observe changes in the other will be necessary before strong conclusions can be drawn. It is also worth noting that, in the present study, sedentary behavior was measured in terms of duration, whereas physical activity was measured in terms of overall volume. This lack of correspondence may have impacted these results. It is also possible that participants interpreted the question about sitting time as a lack of physical activity.

Several limitations of this study have been addressed. This young and well-educated sample was quite homogeneous with respect to race and ethnicity. Conclusions may not generalize to children and adolescents, the "forgotten half" of emerging adults who are not enrolled in college, adults at other points in the life span, or members of more diverse racial and ethnic groups. Automatic and controlled motivation processes were sampled selectively to evaluate the general propositions of a dual-process theory; conclusions may not generalize to all automatic and controlled motivation processes. These processes also may have different implications depending on whether participants were attempting to initiate behavior change or maintain their established behavioral pattern (Rothman et al., 2009); we did not assess participants' stage of change. The intention items were also based on pilot work with this population and may not be appropriate for other groups with different constraints on their sedentary time. In the multilevel model, slopes were assumed to be simple linear relations, and we did not explore the possibility of curvilinear or nonlinear relations between motivation and behavior. Likewise, these models assumed that the day of week and day in sequence had uniform associations with sedentary behavior for all people. The research design was nonexperimental, so conclusions about causality must also be tempered despite the longitudinal design that controlled for prior levels of sedentary behavior.

Although there is some controversy about the best cutoff values for inferring sedentary behavior, concerns about our cutoff value were mitigated by the equivalence of our findings using both the 100 and 250 counts· $min^{-1}$ cutoff values proposed by Freedson et al. (1998) and Matthews (2005), respectively. Those two criteria selectively underestimate (100 counts· $min^{-1}$) and overestimate (250 counts· $min^{-1}$) sedentary time (Kozey-Keadle et al., 2011), so the consistency of our results across cutoff values increases confidence in the validity of our conclusions. It is possible that the absence of inclinometer data confounded our direct measure of sedentary behavior, but the criterion that we used has previously demonstrated adequate sensitivity and specificity in relation to dual accelerometers/inclinometers (Kozey-Keadle et al., 2012). Another measurement limitation associated with the accelerometer was that some sedentary behavior may not have been recorded because participants were not wearing the activity monitor. We assumed that any effects of nonwear time on estimates of sedentary behavior were distributed randomly across participants in our model.

In conclusion, this study demonstrated that college students' daily sedentary behavior varies in motivationally meaningful ways. Sensitivity to this within-person variation can provide insight into processes that regulate sedentary behavior and lead to more effective behavior-change interventions. Controlled motivational processes, represented by intentions in this study, play a role in differentiating sedentary behavior within people from one day to the next as well as—albeit to a lesser extent—between people. Automatic motivational processes, represented by habit strength in this study, can differentiate people based on their average level of sedentary behavior. These basic findings about the motivational processes that underlie sedentary behavior provide a theoretically based and empirically supported basis for elaborating dual-process models of motivation for sedentary behavior. Understanding these motivational processes will be instrumental for promoting standing and developing other interventions to reduce sedentary behavior. These efforts hold promise for improving health and reducing all-cause mortality by reducing risk for noncommunicable diseases such as diabetes, cardiovascular disease, and selected cancers (Lynch, 2010; Proper et al., 2011).

## FOOTNOTES

[1] Our use of the term *controlled* to describe these motivational processes is specific to reflective motivational processes that are slow, voluntary, and effortful. Other theories have used this term to describe the quality of people's motivation and their reasons for engaging in a behavior (e.g., self-determination theory); we make no assumptions about the quality of people's motivation in this study.

## REFERENCES

Aarts, H., & Dijksterhuis, A. (2000). Habits as knowledge structures: Automaticity in goal-directed behavior. *Journal of Personality and Social Psychology*, *78*, 53–63. doi:10.1037/0022-3514.78.1.53

Adams, M. M. (2012). *On our feet: Feasibility trial of an intervention to reduce sedentary behavior and increase physical activity* (Unpublished doctoral dissertation). University of North Carolina at Greensboro.

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

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, *44*, 1175–1184. doi:10.1037/0003-066X.44.9.1175

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

Behrens, T. K., & Dinger, M. K. (2003). A preliminary investigation of college students' physical activity patterns. *American Journal of Health Studies*, *18*, 169–172.

Behrens, T. K., & Dinger, M. K. (2005). Ambulatory physical activity patterns of college students. *American Journal of Health Education*, *36*, 221–227.

Biddle, S. J., O'Connell, S., & Braithwaite, R. E. (2011). Sedentary behaviour interventions in young people: A meta-analysis. *British Journal of Sports Medicine*, *45*, 937–942. doi:10.1136/bjsports-2011-090205

Booth, M. (2000). Assessment of physical activity: An international perspective. *Research Quarterly for Exercise and Sport*, *71*(2 Suppl.), S114–S120.

Box, G. E. P., & Cox, D. R. (1964). An analysis of transformations. *Journal of the Royal Statistical Society Series B (Methodological)*, *26*, 211–252.

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.

Conroy, D. E., Elavsky, S., Maher, J. P., & Doerksen, S. E. (2012). *A daily process analysis of intentions and physical activity in emerging adults*. Unpublished manuscript, University Park, PA.

Conroy, D. E., Hyde, A. L., Doerksen, S. E., & Ribeiro, N. F. (2010). Implicit attitudes and explicit motivation prospectively predict physical activity. *Annals of Behavioral Medicine*, *39*, 112–118. doi:10.1007/s12160-010-9161-0

Epstein, L. H., Saelens, B. E., Myers, M. D., & Vito, D. (1997). Effects of decreasing sedentary behaviors on activity choice in obese children. *Health Psychology*, *16*, 107–113.

Epstein, L. H., Saelens, B. E., & O'Brien, J. G. (1995). Effects of reinforcing increases in active behavior versus decreases in sedentary behavior for obese children. *International Journal of Behavioral Medicine*, *2*, 41–50. doi:10.1207/s15327558ijbm0201_4

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine and Science in Sports and Exercise*, *30*, 777–781.

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. doi:10.1016/j.amepre.2011.03.020

Gardner, B., Bruijn, G.-J., & Lally, P. (2011). A systematic review and meta-analysis of applications of the Self-Report Habit Index to nutrition and physical activity behaviours. *Annals of Behavioral Medicine*, *42*, 174–187. doi:10.1007/s12160-011-9282-0

Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: An integrative review of implicit and explicit attitude change. *Psychological Bulletin*, *132*, 692–731. doi:10.1037/0033-2909.132.5.692

Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: A theoretical framework and empirical review. *Health PsychologyReview*, *2*, 111–137. doi:10.1080/17437190802617668

Kozey-Keadle, S., Libertine, A., Lyden, K., Staudenmayer, J., & Freedson, P. S. (2011). Validation of wearable monitors for assessing sedentary behavior. *Medicine and Science in Sports and Exercise*, *43*, 1561–1567. doi:10.1249/MSS.0b013e31820ce174

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

Kremers, S. P. J., & Brug, J. (2008). Habit strength of physical activity and sedentary behavior among children and adolescents. *Pediatric Exercise Science*, *20*, 5–14.

Kremers, S. P. J., van der Horst, K., & Brug, J. (2007). Adolescent screen-viewing behaviour is associated with consumption of sugar-sweetened beverages: The role of habit strength and perceived parental norms. *Appetite*, *48*, 345–350. doi:10.1016/j.appet.2006.10.002

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. doi:10.1158/1055-9965.EPI-10-0815

Maher, J. P., Doerksen, S. E., Elavsky, S., Hyde, A. L., Pincus, A. L., Ram, N., & Conroy, D. E. (in press). A daily analysis of physical activity and satisfaction with life in emerging adults. *Health Psychology*.

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

Matthew, C. E. (2005). Calibration of accelerometer output for adults. *Medicine and Science in Sports and Exercise*, *37*(11 Suppl.), S512–S522.

Matthews, C. E., Chen, K. Y., Freedson, P. S., Buchowski, M. S., Beech, B. M., Pate, R. R., & Troiano, R. P. (2008). Amount of time spent in sedentary behaviors in the United States, 2003–2004. *American Journal of Epidemiology*, *167*, 875–881. doi:10.1093/aje/kwm390

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review*, *5*, 97–144. doi:10.1080/17437199.2010.521684

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. doi:10.1037/a0016136

Motl, R. W., McAuley, E., & Dlugonski, D. (2012). Reactivity in baseline accelerometer data from a physical activity behavioral intervention. *Health Psychology*, *31*, 172–175. doi:10.1037/a0025965

Muthén, L. K., & Muthén, B. O. (1998). *Mplus user's guide* (4th ed.). Los Angeles, CA: Author.

Neal, D. T., Wood, W., & Quinn, J. M. (2006). Habits—A repeat performance. *Current Directions in Psychological Science*, *15*, 198–202. doi:10.1111/j.1467-8721.2006.00435.x

Orbell, S., & Verplanken, B. (2010). The automatic component of habit in health behavior: Habit as cue-contingent automaticity. *Health Psychology*, *29*, 374–383. doi:10.1037/a0019596

Osborne, J. (2010). Improving your data transformations: Applying the Box–Cox transformation. *Practical Assessment, Research & Evaluation*, *15*, 1–9.

Otten, J. J., Jones, K. E., Littenberg, B., & Harvey-Berino, J. (2009). Effects of television viewing reduction on energy intake and expenditure in overweight and obese adults: A randomized controlled trial. *Archives of Internal Medicine*, *169*, 2109–2115. doi:10.1001/archinternmed.2009.430

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

Owen, N., Sparling, P. B., Healy, G. N., Dunstan, D. W., & Matthews, C. E. (2010). Sedentary behavior: Emerging evidence for a new health risk. *Mayo Clinic Proceedings*, *85*, 1138–1141. doi:10.4065/mcp.2010.0444

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

Proper, K. I., Singh, A. S., 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. 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*, *36*, 44–52. doi:10.1080/08964281003774901

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*(Suppl. 1), S4–S17. doi:10.1007/s12160-009-9118-3

Scholz, U., Keller, R., & Perren, S. (2009). Predicting behavioral intentions and physical exercise: A test of the health action process approach at the intrapersonal level. *Health Psychology*, *28,* 702–708. doi:10.1037/a0016088

Schwartz, J. E., & Stone, A. A. (1998). Strategies for analyzing ecological momentary assessment data. *Health Psychology*, *17*, 6–16.

Schwarzer, R., Lippke, S., & Luszczynska, A. (2011). Mechanisms of health behavior change in persons with chronic illness or disability: The health action process approach (HAPA). *Rehabilitation Psychology*, *56*, 161–170. doi:10.1037/a0024509

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. *American Journal of College Health*, *56,* 585–592.

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

Sjöström, M., Ainsworth, B., Bauman, A., Bull, F., Craig, C., & Sallis, J. (2005). *Guidelines for data processing and analysis of the Intentional Physical Activity Questionnaire (IPAQ)—Short and long forms*. Solna, Sweden: Karolinska Institute.

Smith, E. R., & DeCoster, J. (2000). Dual-process models in social and cognitive psychology: Conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review*, *4*, 108–131. doi:10.1207/S15327957PSPR0402_01

Sniehotta, F. F., & Presseau, J. (2012). The habitual use of the Self-Report Habit Index. *Annals of Behavioral Medicine*, *43*, 139–140. doi:10.1007/s12160-011-9305-x

Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Thousand Oaks, CA: Sage.

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

Troiano, R. P., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise*, *40,* 181–188. doi:10.1249/mss.0b013e31815a51b3

Verplanken, B. (2010). By force of habit. In A.Steptoe (Ed.), *Handbook of behavioral medicine* (pp. 73–82). New York, NY: Springer. Retrieved from http://www.springerlink.com/content/w2q218484mt71232/abstract/

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

Williams, P., Block, L. G., & Fitzsimons, G. J. (2006). Simply asking questions about health behaviors increases both healthy and unhealthy behaviors. *Social Influence*, *1*, 117–127. doi:10.1080/15534510600630850

Wilmot, E. G., Davies, M. J., Edwardson, C. L., Gorely, T., Khunti, K., Nimmo, M., . . .Biddle, S. J. H. (2011). Rationale and study design for a randomised controlled trial to reduce sedentary time in adults at risk of Type 2 diabetes mellitus: Project STAND (Sedentary Time ANd Diabetes). *BMC Public Health*, *11*, 908. doi: 10.1186/1471-2458-11-908

Wood, W., & Neal, D. T. (2007). A new look at habits and the habit–goal interface. *Psychological Review*, *114*, 843–863. 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. doi:10.1037/0022-3514.83.6.1281

Wood, W., Tam, L., & Witt, M. G. (2005). Changing circumstances, disrupting habits. *Journal of Personality and Social Psychology*, *88*, 918–933. doi:10.1037/0022-3514.88.6.918

World Health Organization. (2000). *Obesity: Preventing and managing the global epidemic* (WHO Tech. Series Rep. No. 894). Geneva, Switzerland: Author.

*Submitted:* April 11, 2012 *Revised:* July 11, 2012 *Accepted:* September 17, 2012