Habits Predict Physical Activity on Days When Intentions Are Weak

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Abstract:

Physical activity is regulated by controlled processes, such as intentions, and automatic processes, such as habits. Intentions relate to physical activity more strongly for people with weak habits than for people with strong habits, but people's intentions vary day by day. Physical activity may be regulated by habits unless daily physical activity intentions are strong. University students (N = 128) self-reported their physical activity habit strength and subsequently self-reported daily physical activity intentions and wore an accelerometer for 14 days. On days when people had intentions that were weaker than typical for them, habit strength was positively related to physical activity, but on days when people had typical or stronger intentions than was typical for them, habit strength was unrelated to daily physical activity. Efforts to promote physical activity may need to account for habits and the dynamics of intentions.

Keywords: motivation | automatic regulation | dual-process model of physical activity

Article:

Physical activity lowers the risk for developing coronary heart disease, high blood pressure, bone dis- ease, stroke, type 2 diabetes, some forms of cancer, and depression, resulting in a 30% lower chance of early mortality (Physical Activity Guidelines Advisory Committee, 2008). Unfortunately, the majority of Americans are not sufficiently active enough to obtain significant health benefits. In a recent study of objectively measured physical activity, it was found that less than 10% of Americans were participating in the recommended 150 min of moderate or 75 min of vigorous weekly physical activity (Tucker, Welk, & Beyler, 2011). One way to increase the number of Americans who engage in regular physical activity is to enhance people's intentions to engage in physical activity; however intention-focused interventions have had limited success in changing behavior (Rhodes & Dickau, 2012; Webb & Sheeran, 2006). Recent proposals have called for supplementing intention-based theories of health behavior motivation with automatic regulatory constructs, such as habit (Dimmock & Banting, 2009; Marteau, Hollands, & Fletcher, 2012; Sheeran, Gollwitzer, & Bargh, 2012). At this point, however, little is known about how habits and intentions interact at a within-person level to regulate physical activity.

Dual-Process Model of Daily Physical Activity Regulation

Maintaining a physically active lifestyle involves more than a single decision or action; it requires repeated successful regulation of physical activity. According to dual-process models of behavior regulation (Chaiken & Trope, 1999; Evans, 2008, 2009; Hofmann, Schmeichel, & Baddeley, 2012), successful regulation of physical activity can be the result of rational, goal-directed *controlled* efforts (e.g., intentions), immediate, effortless *automatic* processes (e.g., habits), or a combination of both. A physically active lifestyle involves a combination of these regulatory processes on a daily basis.

Physical Activity Habit Strength. It is likely that one type of automatic process that regulates physical activ- ity is a person's *habits*—the automatic tendencies to participate in physical activity in response to certain cues or triggers such as settings, preceding events or actions (Aarts, Paulussen, & Schaalma, 1997; Verplan- ken, 2010; Verplanken & Orbell, 2003; Wood & Neal, 2007). Humans follow predictable patterns in daily life, routinely being in the same places during the same times (González, Hidalgo, & Barabási, 2008; Song, Qu, Blumm, & Barabási, 2010). For some people, these daily life routines include regular physical activity participa- tion. People with strong physical activity habits have made the decision to be physically active so often in the past that they now routinely participate in physical activity (Gardner, de Bruijn, & Lally, 2011), and this successful behavior regulation no longer requires delib- eration about the benefits of physical activity or reflection about attitudes or intentions (Ouellette & Wood, 1998). In a meta-analysis, Gardner and colleagues (2011) found a medium-strong relation between physical activity and habit strength.

Physical Activity Intentions. One controlled process that likely regulates daily physical activity is the inten- tion to participate in physical activity (Ajzen, 1991). Typically, intentions have been considered stable indi- vidual differences, and the majority of research focuses on between-person comparisons, showing that people with strong intentions to participate in physical activ- ity tend to be more physically active than those with weaker intentions (Downs & Hausenblas, 2005; Hagger, Chatzisarantis, & Biddle, 2002; McEachan, Conner, Taylor, & Lawton, 2011). In a recent review, McEachan and colleagues (2011) found a medium-to-strong relation ($\rho = 0.48$)

between intentions and prospective measures of physical activity. Intention strength can differ at a between-person level, but people's intentions can also fluctuate at a within-person level depending on daily social and physical constraints. Recent research has revealed that intentions can vary considerably over time, fluctuating on at least daily, weekly, biweekly, and monthly time scales and that these fluctuations can predict physical activity (Conroy, Doerksen, Elavsky, & Maher, 2013; Conroy, Elavsky, Hyde, & Doerksen, 2011; Scholz, Keller, & Perren, 2009; Scholz, Nagy, Schüz, & Ziegelmann, 2008). It remains unclear, however, how these daily fluctuations in intentions interact with habits to regulate daily physical activity.

Habits and Intentions Regulating Daily Physical Activity

Habits will regulate daily behavior unless a person finds himself in an unfamiliar context or other regulatory processes are strong enough to interfere with this automatic regulatory process (Neal, Wood, Wu, & Kurlander, 2011; Ouellette & Wood, 1998). Based on the consistency of human mobility patterns (González et al., 2008; Neal, Wood, & Quinn, 2006; Song et al., 2010), it may be assumed that people's contexts are relatively stable; there- fore, the current study focuses on intention strength as a means of overriding physical activity habitual behavior. Typically, people's physical activity intentions correspond with their physical activity habits. Indeed, strong physical activity habits may be developed and maintained as a result of consistently strong intentions (Neal, Wood, Labrecque, & Lally, 2012; Wood & Neal, 2007). At a between-person level, therefore, people's intentions should be positively associated with their habit strength.

Physical activity intentions can also differ from physical activity habits and create a conflict in the regulation of physical activity. For example, a person with weak physical activity habits may have strong physical activity intentions on some days. Particularly strong controlled regulatory processes can override automatic regulatory processes (Hofmann, Friese, & Strack, 2009; Hofmann et al., 2012); therefore, strong daily intentions may interfere with the habitual regulation of physical activity. In contrast, weak daily intentions likely will not interfere with habitual regulation of physical activity.

Previous research supports the theory that strong intentions can override habits. For example, it has been shown that behaviors that are repeated infrequently and in a wide variety of contexts (and therefore less likely to be habitual) are more intentionally regulated than behaviors that are repeated more frequently and consistently in the same context (Ouellette & Wood, 1998; Webb & Sheeran, 2006). In addition, it has consistently been shown that behavior is regulated more by intentions for people with weak habits than for people with strong habits (de Bruijn, Kremers, Singh, van den Putte, & van Mechelen, 2009; Ji & Wood, 2007; Knussen, Yule, MacKenzie, & Wells, 2004; Verplanken, Aarts, Knippenberg, & Moonen, 1998).

Gardner and colleagues (2011) reviewed studies that tested habit-intention moderation effects within the context of physical activity. They concluded that intentions were more strongly related to physical activity for people with weaker habits, but found some contradictory evidence as well. Some evidence suggests habits and intentions have an additive, but not interactive, effect on physical activity (Rhodes, de Bruijn, & Matheson, 2010). Beyond those covered in the review, studies have shown that the relation between exercise intentions and behavior is around three times stronger for those with weaker habits than for those with stronger habits (de Bruijn &

Rhodes, 2011) and that habits and intentions both directly predicted moderate and vigorous physical activity and had interactive effects on these behaviors (Rhodes & de Bruijn, 2010). These studies demonstrate that intentional and habitual regulation differs between types of behaviors and between people, but it remains unclear how they interact on a within-person level. Previous investigations have shown that patterns of physical activity motivation present at the between-person level do not necessarily translate to the same processes at a within-person level (e.g., Conroy et al., 2011). By investigating how these regulatory processes interact at a within-person level, more can be understood about what underlies change in physical activity behavior.

THE PRESENT STUDY

The present study used a within-person design to investigate if the link between a person's habits and physical activity varied as a function of between-person differences or within-person fluctuations in physical activity intention strength. We tested the relation of objectively measured physical activity to physical activity habit strength, a person's average daily physical activity intentions across 2 weeks, and day-to-day fluctuations in intentions. We also tested if the relation between physical activity habit strength and daily physical activity was moderated by average daily intentions or daily fluctuations in intentions. Physical activity differs between men and women (Caspersen, Pereira, & Curran, 2000; McArthur & Raedeke, 2009), between weekdays and weekends (Conroy et al., 2011; Matthews, Ainsworth, Thompson, & Bassett, 2002; Trost, Pate, Freedson, Sallis, & Taylor, 2000), and across study duration in response to self-monitoring (Motl, McAuley, Dlugonski, 2012), so we controlled for these covariates in the model. We hypothesized that habit strength and average daily intentions would positively relate to physical activity, and that both average daily physical activity intentions and daily fluctuations in physical activity intentions would moderate the relation between habit strength and physical activity. Specifically, it was expected that physical activity would be more strongly regulated by habit strength for people with weaker average intentions then for people with stronger average intentions and on days when intentions for physical activity were weaker than typical.

METHOD

Participants and Procedures

University students (N = 128, 76 women, M_{age} = 21 years) participated in the study for course credit. Participants were mostly White (95%), non-Hispanic (98%), and in their senior year at the university (80%). The study proto- col was approved by the local institutional review board. All participants gave informed consent and permission for their data to be used for research purposes.

During an initial laboratory visit, participants self-reported their physical activity habit strength and were provided with an ActiGraph accelerometer (ActiGraph, Pensacola, FL). Participants were instructed to wear the accelerometers on their right hip for all waking hours, except when coming in contact with water (e.g., showering, swimming). For the next 13 days, participants wore the accelerometers and logged in to a password-secured website between the hours of 7:00 pm and 4:00 am each night and self-reported daily intentions for physical activity (for the next day). After the 13 days, participants returned the accelerometers to the laboratory.

Measures

Physical Activity Habit Strength. The previously validated automaticity four-item subscale of the Self- Report Habit Index was used to measure physical activity habit strength during the initial laboratory visit (Gardner, Abraham, Lally, & de Bruijn, 2012; Verplanken & Melkevik, 2008; Verplanken & Orbell, 2003). Participants reported how much they agreed with the statements "Being physically active is something I do automatically, I do without thinking, I do without having to consciously remember, and I start doing before I realize I'm doing it" on scales ranging from 1 (*disagree completely*) to 7 (*agree completely*). The internal consistency for the scale was .89. Previous research has shown that this subscale is reliable, relates to prospective behavior, and moderates between-person intention- behavior relations as theorized (Gardner et al., 2012).

Physical Activity Intentions. Intentions for physical activity were assessed using two custom items that participants completed each evening in reference to the next day. Participants reported how much they "intended to engage in at least 30 min of moderate aerobic activity tomorrow," and "intended to engage in at least 15 min of vigorous physical activity tomorrow" using slider scales ranging from 0 (*do not intend at all*) to 100 (*strongly intend*). Without accounting for within-person nesting, the items were correlated .74. On average, the daily items were correlated .73 within person across the 13 days. Intentions were calculated as the average of the two scores.

Daily Physical Activity. Daily physical activity was objectively assessed as average hourly activity counts measured by the accelerometers. Days when the accelerometer was worn less than 10 hr were treated as missing. Based on conventional scoring procedures (Choi, Liu, Matthews, & Buchowski, 2011), periods of monitoring of 90 or more minutes of consecutive zero activity counts (i.e., accelerometer was not worn) were replaced with the average activity count of that individual for that day.

Data Analyses

Physical activity intentions were separated into between- and within-person components (Schwartz & Stone, 1998). The between-person level intentions variable was calculated as the person's average intentions across the 13 days. Daily intentions were calculated as the person's daily deviations from their average daily intentions. To test the study hypotheses, a hierarchical linear model was estimated. Physical activity was regressed onto average daily intentions, daily intentions, habit strength, the interaction between average daily intentions and habit strength, and the interaction between daily intentions and habit strength. We included sex (0 = female, 1 = male), a dummy code of weekend (0 = Monday–Friday, 1 = Saturday and Sunday), and study day (1–13) as covariates in the model. We tested a hierarchical linear model that optimized restricted maximum likelihood criterion in the *lmer* function of the *lme4* package in R version 2.14.1 (Bates, Maechler, & Bolker, 2011; R Development Core Team, 2011). Confidence intervals estimated from 100 posterior simulations using the *sim* function of the *arm* package in R were used to test if the model coefficient estimates significantly varied from zero (Gelman & Hill, 2006; Gelman et al., 2012). This method of significance testing accounts for predictive and inferential uncertainty in parameter estimations created by non-normal variable distributions.

The model, which consists of both within-person (Level 1) and between-person (Level 2) components, is represented by Equations 1–5.

Level 1:

$$\text{Daily Physical Activity}_{di} = \beta_{0i} + \beta_{1i}(\text{Weekend})_{di} + \beta_{2i}(\text{Study Day})_{d} + \beta_{3i}(\text{Daily Intentions})_{di} + e_{di} \quad (1)$$

Level 2:

$$\beta_{0i} = \gamma_{00} + \gamma_{01}(\text{Sex})_i + \gamma_{02}(\text{Average Daily Intentions})_i + \gamma_{03}(\text{Habit Strength})_i + \gamma_{04}(\text{Average Daily Intentions} \times \text{Habit Strength})_i + u_{0i} \quad (2)$$

$$\beta_{1i} = \gamma_{10} + u_{1i} \quad (3)$$

$$\beta_{2i} = \gamma_{20} \quad (4)$$

$$\beta_{3i} = \gamma_{30} + \gamma_{31}(\text{Habit Strength})_i + u_{3i} \quad (5)$$

The within-person component, represented by Equation 1, models each individual *i*'s physical activity on day *d* as a function of an intercept, Weekend (a binary variable), Study Day (a continuous variable 1–13), and that person's Daily Intentions for physical activity. These within-person parameters are constrained by the between-person components of the model represented in Equations 2–5, in which the $\gamma 00 – \gamma 30$ represent the fixed intercepts. Equation 2 includes the grand mean ($\gamma 00$) and tests whether Sex ($\gamma 01$), Average Daily Intentions ($\gamma 02$), and Habit Strength ($\gamma 03$) relate to Daily Physical Activity. In addition, it tests whether Average Daily Intentions moderate the relation between Habit Strength and Daily Physical Activity ($\gamma 04$). Equation 3 tests the average difference in Daily Physical Activity on weekends as opposed to weekdays ($\gamma 10$). Equation 4 tests the average relation between Study Day and Daily Physical Activity ($\gamma 20$) and this effect is fixed to be the same between people (i.e., no random effects). Equation 5 tests the average relation between Daily Intentions and Daily Physical Activity ($\gamma 30$) and the additional parameter is a cross-level interaction that tests whether the relation between Habit Strength and Daily Physical Activity (i.e., the estimate of $\beta 3i$) is moderated by Daily Intentions ($\gamma 31$). The variance in Daily Physical Activity unexplained by the model parameters are represented in Equation 1 by edi, and the variance in the within-person model coefficients unexplained by the between-person constraints are represented by u0,1, and 3i in Equations 2, 3, and 5.

Significant interaction coefficients were probed using the Johnson–Neyman technique (Bauer & Curran, 2005; Hayes & Matthes, 2009). This technique overcomes biases of other pick-a-point probing methods by mathematically determining which values of the moderator closest to the mean result in significant relations between the predictor and outcome. The test whether a Level-1 variable (daily intentions) moderates a Level-2 predictor (habit strength) is acceptable, although uncommon, for cross-level interactions in hierarchical linear modeling (Preacher, Curran, & Bauer, 2006).

RESULTS

On average, participants completed 12 of 13 possible daily intention measures. Most participants (95%) completed at least 11 daily measures, and no participants completed less than 8 daily measures. Accelerometer-derived physical activity data were available for an average of 12 days for each participant. At least 11 days of accelerometer- derived physical activity data were available for 82% of participants, but 2 participants had no physical activity data due to insufficient wear time and were not included in analyses.

Table 1 presents descriptive statistics and between- person correlations of physical activity, habit strength, and intentions (correlations were calculated using within- person means across days of intentions and physical activ- ity). Habit strength and average daily intentions showed a medium-sized positive relation ($r = .37$, $p < .01$). Physical activity showed small positive relations with average daily intentions ($r = .21$, $p = .01$) and habit strength ($r = .18$, $p = .06$). Intraclass correlations indicated that less than half of the variability in daily intentions and physical activity were attributable to between-person variability, suggesting that people's intentions and physical activity were variable across days. The average within-person relation between daily intentions and daily physical activity was not significant ($r = .01$, $p = .49$, $SD = 0.34$).

Table 1 Descriptive Statistics and Correlations of Physical Activity, Habit Strength, and Intentions

Variable		*M*	*SD*	ICC 1	2	3
1	Habit Strength	6.43	1.44	—	.37*	.18*
2	Intentions	57.61	32.18	.49	—	.21*
3	Physical Activity	28,487.96	13,896.66	.30		—

Note. Between-person correlations were calculated between the within-person mean of daily intentions and daily physical activity.

*$p < .05$.

Table 2 shows the coefficient estimates and the confidence intervals of the fixed effects from the hierarchical linear model testing the study hypotheses. People with stronger average daily physical activity intentions participated in more physical activity than people with weaker average daily intentions (γ_{02}), but habit strength was not significantly related to physical activity (γ_{03}). Average daily intentions did not significantly moderate the relation between habit strength and physical activity (γ_{04}), daily physical activity intentions were not significantly related to daily physical activity (γ_{30}), but daily intentions significantly moderated the relation between habit strength and daily physical activity (γ_{31}). Figure 1 depicts the relation between habit strength and physical activity on days when intentions were weaker than typical (1 *SD* below *M*), typical (*M*), and stronger than typical (1 *SD* above *M*).The Johnson–Neyman technique used to probe the significant moderating effect (Bauer & Curran, 2005; Hayes & Matthes, 2009) revealed that on days when people's intentions were typical (*M*) or stronger than typical (scores $> M$) habit strength was unrelated to daily physical activity, but on days when people's intentions were weaker than typical (scores $< M - 0.55\ SD$), habit strength was positively related to physical activity.

Table 2 Coefficient Estimates of Fixed Effects of Hierarchical Linear Model Testing the Moderating Influence of Physical Activity Intentions on Relations Between Physical Activity Habit Strength and Daily Physical Activity

Fixed Effects	Coefficient	*SE*	95% Confidence Intervals		
Intercept, γ_{00}	28,283.79*	1,214.85	26,556.06	–	30,805.31
Sex, γ_{01}	2,007.57	1,416.82	–814.83	–	4,529.32
Average Daily Intentions, γ_{02}	102.84*	31.48	34.44	–	159.46
Habit Strength, γ_{03}	810.75	520.42	–186.30	–	1,879.01
Average Daily Intentions × Habit Strength, γ_{04}	–11.07	20.63	–52.89	–	28.46
Weekend, γ_{10}	–2,342.09*	802.14	–4,186.42	–	–332.43
Study Day, γ_{20}	–29.46	84.37	–195.52	–	144.58
Daily Intentions, γ_{30}	–17.39	16.42	–47.31	–	12.89
Habit Strength × Daily Intentions, γ_{31}	–19.68*	10.34	–37.23	–	–1.60

Note. Confidence intervals based on 100 posterior simulations.
$^*p < .05$.

The coefficients of the covariates in the model revealed that there were no sex differences in physical activity after accounting for the other predictors in the model ($\gamma 01$), people tended to be more physically active on weekdays than weekends ($\gamma 10$), and study day did not impact physical activity ($\gamma 20$). There was significant variability in the amount of daily physical activity that was unexplained by the model (e_{di} = 134,623,586, *SD* = 12,266.19), the relation between daily intentions and daily physical activity (u_{2i} = 3,837, *SD* = 61.86), and the difference between weekday and weekend physical activity (u_{1i} = 6,093,565, *SD* = 2,468.51).

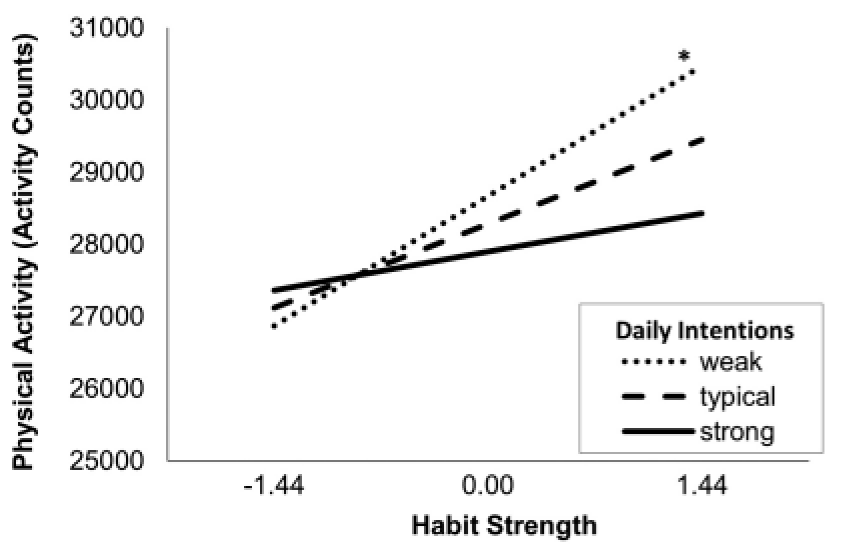

Figure 1 — Slopes of the relations between habit strength and physical activity on days of weaker than typical (1 *SD* < *M*), typical (*M*), and stronger than typical (1 *SD* > *M*) fluctuations in physical activity intentions with significant slope marked with an asterisk.

DISCUSSION

This study investigated the habitual and intentional regulation of physical activity on a daily, within-person level. When tested simultaneously, a person's average daily physical activity intentions, but not habit strength, positively related to physical activity. Although average daily physical activity intentions did not significantly moderate the relation between physical activity habit strength and physical activity, daily intentions were found to moderate the relation between habit strength and physical activity. Physical activity was regulated by people's habit strength when daily physical activity intentions were weaker than usual. These results suggest that the ongoing regulation of physical activity is a combination of controlled and automatic processes.

Habits and Intentions Regulating Daily Physical Activity

Previous research has shown that people with stronger physical activity habits are more physically active than people with weaker habits (Gardner et al., 2011; Rhodes & de Bruijn, 2010), but this between-person effect was not replicated in this study. In previous research, habit was measured using the entire Self-Report Habit Index, including items assessing frequency of physical activity participation. This may have led to an overestimation of the influence of habit on physical activity, given that other regulatory processes influence past and future frequency of behavior (Ajzen, 2002; Gardner et al., 2012). The present study used a subscale of the index that excluded frequency-related items; therefore, variability shared between past and future behavior unrelated to automaticity was not represented. Importantly, the null main effect is not necessarily an indication of a lack of correspondence between habit strength and physical activity. People with strong physical activity habits tended to also have strong physical activity intentions, suggesting that people with strong physical activity habits have chronically activated physical activity goals, consistent with the habit-goal interface outlined by Wood & Neal (2007). There is correspondence between the automatic regulatory process of habits and the controlled regulatory process of intentions; however, it seems that the influence of the automatic component of physical activity habits does not generally extend beyond that of between-person differences in physical activity intentions.

There is a strong research base suggesting that people's physical activity is linked to their intentions to engage in physical activity (Hagger et al., 2002; McEachan et al., 2011), so the present result that people with stronger intentions were more physically active than people with weaker intentions was not unexpected. Repeated behaviors are not necessarily habits (Aarts & Dijksterhuis, 2000; Ajzen, 2002; Wood & Neal, 2007), so it may be that some people's regular participation in physical activity is the result of controlled regulatory processes, such as intentions. It has also been shown that intentions can be inferred from behavior (e.g., I participate in physical activity regularly; therefore, I must have strong intentions to do so; Banks & Isham, 2009; Eagleman, 2004; Wegner & Wheatley, 1999), so physical activity may also lead to stronger physical activity intentions. Although the direction of the effect could not be extrapolated from this observational design, the current study replicated the well-established link between intentions and physical activity and extended beyond these previous studies by investigating the interactive regulation of intentions and habits at both between- and within-person levels.

Average daily intentions and habit strength were not found to interact to regulate physical activity. This result is similar to the findings of a previous study (Rhodes et al., 2010), but contrasts with research that showed that behavior was regulated more by intentions for people with weaker habits than for people with strong habits (de Bruijn et al., 2009; de Bruijn &

Rhodes, 2011; Gardner et al., 2011; Ji & Wood, 2007; Knussen et al., 2004; Verplanken et al., 1998). It may be that the difference in findings between this and the previous studies is partially due to how between-person level physical activity intentions were defined. Physical activity intentions are typically measured as general intentions across the next several weeks (e.g., de Bruijn et al., 2009; de Bruijn & Rhodes, 2011), but in this study, intentions were defined at a between-person level as the trend of a person's daily physical activity intentions across 2 weeks (see Fleeson, 2001, 2004). The ability to self-regulate fluctuates on a daily basis (Baumeister & Heatherton, 1996; Baumeister, Muraven, & Tice, 2000; Conroy et al., 2011), and the findings of the current study demonstrate that the habitual regulation of physical activity interacts with daily fluctuations in physical activity intentions, but not trends in a person's daily intentions across 2 weeks.

Habit strength only predicted physical activity on days when people had weak intentions. As proposed by dual process theories (Evans, 2008, 2009), these results suggest that physical activity is regulated by both automatic and controlled processes that interact on a daily level. These results support Hoffmann and colleagues' (2009, 2012) postulation that self-regulation must be especially strong to override automatic tendencies.

Implications for Physical Activity Motivation Theories and Interventions

Most contemporary physical activity motivation theories focus on controlled regulatory processes such as intentions, goals, values, and beliefs (Biddle & Mutrie, 2008). Based on the results of this and other studies of automatic regulation of physical activity (e.g., Conroy, Hyde, Doerksen, & Ribeiro, 2010; Dimmock & Banting, 2009; Gardner et al., 2011; Sheeran et al., 2012), it is becoming increasingly clear that automatic regulatory processes merit roles in our conceptualizations of physical activity motivation. In addition to strengthening people's physical activity intentions, physical activity motivation interventions may also benefit from enhancing automatic regulatory processes, such as habits, to compensate for when physical activity intentions are weak.

Interventions with education components have been shown to be effective in increasing intentions, but to be less effective at changing behavior (Rhodes & Dickau, 2012; Webb & Sheeran, 2006). These interventions do not address automatic regulatory processes, such as habits. Enhancements of physical activity habit strength may be possible through changes in the environment or the introduction of habit development techniques, such as implementation intentions—a form of behavior planning that specifies the context cues that will cue specific behavioral responses (Gollwitzer, 1999; Marteau et al., 2012; Sheeran & Orbell, 1999; Verplanken & Faes, 1999). Future investigations of intervention techniques for targeting automatic regulation of physical activity will help broaden the scope of physical activity interventions, potentially improving the effectiveness of such efforts.

Strengths, Limitations and Future Directions

Strengths of this study include the within-person study design, the objective measurement of physical activity, and the high completion rate of the repeated physical activity intentions and behavior assessments. These aspects of the study strengthen our confidence in the conclusions of the study, but further research is needed to address limitations of this study to increase the generalizability of the conclusions. Our study sampled mostly White, high-functioning young adults. Physical activity has been shown to differ as a function of sociodemographic characteristics (Trost, Owen, Bauman, Sallis, & Brown, 2002), so studies with more heterogeneous samples in terms of age, race, ethnicity, and functional ability are necessary before these results can be generalized to a broader population. Although objective measurement of physical activity reduces the risk for reporting biases such as social desirability, the accelerometers that were used also have limitations. For example, the devices are not waterproof and therefore could not account for water-based physical activity, such as swimming.

Participants may have been reactive to the monitoring of their intentions (Chandon, Morwitz, & Reinartz, 2005) and behavior (Motl et al., 2012), so it is important to note that the levels reported in this study may not represent those present in the absence of monitoring. This study investigated physical activity intentions and habits, but other controlled and automatic processes are also likely to play instrumental roles in regulating physical activity (e.g., self-efficacy, outcome expectancies, automatic evaluations, automatic self-schemas). Future research investigating the interaction between these processes will also be important for clarifying how these dual processes simultaneously regulate physical activity.

In sum, this study revealed that physical activity is regulated by a person’s habits when they have weak physical activity intentions for that day. Future research and physical activity promotion efforts that attend to habit development as well as to the time-varying nature of intentions may enhance the effectiveness of those interventions over time (via increased behavioral maintenance), increase the number of people who engage in regular physical activity, and reduce the health burden of physical inactivity.

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