A Daily Process Analysis of Intentions and Physical Activity in College Students

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Abstract:

Social-cognitive theories, such as the theory of planned behavior, posit intentions as proximal influences on physical activity (PA). This paper extends those theories by examining within-person variation in intentions and moderate-to-vigorous physical activity (MVPA) as a function of the unfolding constraints in people's daily lives (e.g., perceived time availability, fatigue, soreness, weather, overeating). College students (N = 63) completed a 14-day diary study over the Internet that rated daily motivation, contextual constraints, and MVPA. Key findings from multilevel analyses were that (1) between-person differences represented 46% and 33% of the variability in daily MVPA intentions and behavior, respectively; (2) attitudes, injunctive norms, self-efficacy, perceptions of limited time availability, and weekend status predicted daily changes in intention strength; and (3) daily changes in intentions, perceptions of limited time availability, and weekend status predicted day-to-day changes in MVPA. Embedding future motivation and PA research in the context of people's daily lives will advance understanding of individual PA change processes.

Keywords: self-regulation | planned behavior | intraindividual

Article:

Intentions are a core construct used to explain physical activity (PA) in social-cognitive theories, such as the theory of planned behavior. These theories emphasize the influence of social-cognitive factors, such as attitudes and subjective norms toward a behavior, to explain why some people form stronger intentions than others. Theorists have largely been silent on how the constraints that people encounter in the context of their daily lives might influence daily PA intentions. Furthermore, it is not clear whether acute changes in the strength of daily PA intentions are associated with corresponding changes in daily PA. These within-person processes may aid in understanding individual patterns of PA and subsequently developing effective tailored interventions for individual behavior change. In light of the potential for motivational and behavioral processes to vary over time, we aimed to (a) establish how much daily intentions and PA vary between people over time, (b) evaluate social-cognitive and contextual factors proposed to change daily PA intentions, and (c) link daily intentions and contextual constraints on intentions with subsequent changes in PA.

Extending the Theory of Planned Behavior via Disaggregation

The *theory of planned behavior* is a social-cognitive theory that posits intentions as a direct influence on behavior. This proposition has received consistent support in research on physical activity although the effects are stronger in nonexperimental than in experimental studies (Hagger, Chatzisarantis, & Biddle, 2002; McEachan, Conner, Taylor, & Lawton, 2011; Rhodes & Dickau, 2012). In the theory of planned behavior, intentions are produced by favorable evaluations of a behavior (attitudes), perceptions that the behavior is expected by others (subjective norms), and beliefs that the behavior is within the person's control (perceived behavioral control; Ajzen, 1991). Attitude- and control-based differences between people who form strong and weak intentions are well established, whereas the subjective norm–based influences are less consistent (Hagger et al., 2002; McEachan et al., 2011).

Notwithstanding the success of initial validation efforts with the theory of planned behavior, calls have been made to augment this theory by adding explanatory constructs that enhance its ability to predict PA (Rhodes & Nigg, 2011). In addition to the originally posited beliefs about perceived behavioral control (i.e., that one has control over external influences on behavior), self-efficacy beliefs (i.e., that one has the internal resources to produce the desired behavior) have consistently predicted unique variance in PA intentions and behavior, and have even tended to be stronger predictors of PA than perceived behavioral control (Hagger et al., 2002; Rodgers, Conner, & Murray, 2008).

Another approach to extending the theory involves disaggregating motivation and behavior to predict why a given person tends to be more motivated or physically active on some days than on others (i.e., within-person differences) because those factors may or may not be the same as those that explain between-person differences. Theoretically, antecedents originating in between-person differences inform us about more general or dispositional qualities of people that are associated with intention formation and behavior, whereas within-person antecedents shed light on the processes associated with unfolding changes in people's motivation and behavior. Theories focused on explaining relations between a person's typical (i.e., aggregated) motivation and their typical (i.e., aggregated) behavior are inherently limited because "typical" motivation or behavior over a period of time is a statistical construction that may not resemble motivation or behavior at

any single point in time. For example, daily variability in PA is sufficient that researchers must collect multiple samples of daily activity (including measures on weekday and weekend days) to generate valid estimates of between-person differences in weekly PA (Tudor-Locke et al., 2005). To the extent that motivational processes change over time, the ability of those processes to regulate behavior also may change (Conroy, Elavsky, Hyde, & Doerksen, 2011). Self-regulation of behavior occurs on an ongoing basis and likely varies with regular depletion and replenishment of self-control resources (e.g., Shmueli & Prochaska, 2012). Only by treating time as a meaningful dimension of motivation and behavior and disaggregating these constructs over time can we understand these dynamic phenomena and sharpen the focus of interventions to enhance individual motivation and, ultimately, behavior.

Within-Person Processes That Motivate Daily Physical Activity

Both motivation and PA vary over time. Roughly half of the variability in PA intentions sampled on weekly to monthly timescales lies between people with the remaining variation attributed to within-person fluctuations (and measurement error; Conroy et al., 2011; Scholz, Keller, & Perren, 2009; Scholz, Nagy, Schüz, & Ziegelmann, 2008). In those studies, within-person fluctuations in intentions corresponded with fluctuations in weekly and monthly PA, and between-person differences in the aver- age strength of intentions corresponded with people's overall level of PA. What is missing from the literature is research on daily variation in intentions and their association with PA.

This gap in the literature is striking because the day is a natural and fundamental period of human life, defined physically by light–dark cycles and behaviorally by sleep–wake cycles, around which people self-regulate and restore self-regulatory resources. The changing con texts of people's daily lives should also influence daily motivation and PA. Skeptics might even argue that daily contextual factors influence motivation and behavior more than the social-cognitive antecedents proposed in the theory of planned behavior. For example, college students tend to be more physically active on weekdays than on weekends, possibly because walking is a common mode of transportation between classes and not because college students are necessarily more motivated during the week than on weekends (Behrens & Dinger, 2003, 2005; Sisson, McClain, & Tudor-Locke, 2008). A number of other daily contextual constraints are likely to influence PA intentions and PA, including prior PA, perceptions of time availability, physical depletion (e.g., fatigue, sore- ness), weather, and overeating (Bauman, Sallis, Dzewaltowski, & Owen, 2002; Seefeldt, Malina, & Clark, 2002; Sherwood & Jeffery, 2000). Whether daily intentions predict day-to-day changes in PA after controlling for changes in these daily contextual constraints is an open empirical question that must be answered to advance our understanding of within-person changes in PA and ultimately develop more effective, tailored interventions for individual behavior change.

THE PRESENT STUDY

This study was designed with three objectives in mind. First, we sought to characterize the proportion of between- and within-person variability in daily PA intentions. Based on previous research, we expected that between-person variation would not exceed half of the total variation in daily ratings of motivation. Second, we sought to evaluate within-person influences on daily

PA intentions. We hypothesized that people would have stronger PA intentions on days when they had (1) more positive attitudes and greater self-efficacy than usual and (2) fewer contextual constraints (i.e., when they had not been active the previous day, perceived that they had time available, were not physically depleted, expected good weather, and had not overeaten). The influences of the social-cognitive antecedents (i.e., attitudes, self-efficacy) were expected to be robust in the face of the daily con- textual constraints on motivation. Finally, we sought to evaluate prospective, within-person links between daily PA intentions and subsequent PA. We hypothesized that people's daily PA intentions would be positively associated with their subsequent PA. In this analysis, we con- trolled for changes in the daily context of people's lives. We designed a 14-day ecological momentary assessment study to accomplish these objectives. We focused on moderate-to-vigorous physical activity (MVPA), as opposed to light-intensity PA or activities of daily living, because of its relevance for health benefits (Physical Activity Guidelines Advisory Committee, 2008). College students were the focus of this study because (a) most college students do not attain recommended levels of MVPA, (b) MVPA decreases from adolescence to adulthood, and (c) the increased autonomy and identity exploration during this time have important implications for motivation in adulthood (Arnett, 2000; Bray & Born, 2004). The transition into adulthood—which involves college attendance for approximately two-thirds of American youth (U.S. Department of Labor, Bureau of Labor Statistics, 2013)—represents a valuable point for interventions to promote adult MVPA, particularly if we can enhance our understanding of the processes that regulate motivation and behavior within-people over time.

METHODS

Participants and Procedures

A total of 63 college students (37 women, 25 men; 1 did not report sex) participated in this study as a part of a required class project in two upper-level kinesiology courses. The sample comprised predominantly White (87%) students who were not Hispanic or Latino (97%) and had no limitations that prevented them from normal PA. Body mass index scores indicated that most participants were in the normal and overweight range (men: M = 27.1 kg/m^2, SD = 4.3, range = 20.4–39.3; women: M = 25.0 kg/m^2, SD = 4.4, range = 19.3–37.1). All students provided permission for their data to be used for research purposes. In an initial laboratory visit, participants pro- vided informed consent and received training on study procedures; a research assistant measured their height and weight. Beginning that night and continuing for 13 days, participants completed a brief web-based questionnaire about their motivation and MVPA (available every night between 7 pm and 4 am and accessed via an individual URL distributed via e-mail). All procedures were approved by the local institutional review board.

Measures

Daily PA intentions were assessed using two items: "I intend to engage in at least 30 minutes of moderate aerobic activity tomorrow" and "I intend to engage in at least 15 minutes of vigorous aerobic activity tomorrow." These doses and intensities of MVPA correspond to the doses that, over 5 days, would satisfy current federal guidelines for weekly MVPA in the United States (i.e., 150 min of moderate aerobic activity or 75 min of vigorous aerobic activity; Physical Activity

Guidelines Advisory Commit- tee, 2008). Based on conventional criteria for interpreting correlation magnitudes (Cohen, 1992), responses were strongly correlated every day ($M_{\text{daily } r}$ = .77), so we averaged them to produce a single intentions score for each day (α = .86).

Theory of planned behavior constructs were assessed daily using items selected from an established measure and modified to specify a temporal frame of reference (Rhodes, Blanchard, Matheson, & Coble, 2006). *Attitudes* were assessed with a pair of items that sampled affective and instrumental attitudes: "Exercising tomorrow would be fun" and "Exercising tomorrow would be useful." Responses were strongly correlated (Mdaily r = .59), so we averaged them to produce a single attitude score (α = .71). *Descriptive and injunctive subjective norms* were assessed separately with the single items, "I saw a lot of people exercising today" and "Other people expect me to exercise tomorrow," respectively. *Perceived behavioral control* was assessed using a single item, "It is up to me whether I exercise tomorrow." Participants rated these items on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

Daily PA self-efficacy beliefs were assessed using two items: "I believe I can accumulate at least 30 min of moderate aerobic activity tomorrow" and "I believe I can accumulate at least 15 min of vigorous aerobic activity tomorrow." Participants rated each item on a scale ranging from 1 (*not at all confident*) to 5 (*completely confident*). Responses were strongly correlated every day ($M_{\text{daily } r}$ = .83), so we averaged them to produce a single MVPA self-efficacy score for each day (α = .90).

Daily constraints on PA motivation were assessed in terms of both present-oriented cognitions (e.g., having overeaten ["I ate too much today"], feeling fatigued ["I feel very fatigued today"], feeling sore ["I feel very sore today"]) and future-oriented cognitions (e.g., anticipated lack of time availability ["I will not have time for exercise tomorrow"], anticipated weather ["Tomorrow's weather should be excellent for exercising"]). Participants rated these items on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

Daily PA was assessed using the International Physical Activity Questionnaire, which was modified to focus on daily instead of weekly PA (Sjöström et al., 2002). Participants reported the amount of time that they spent in different intensity physical activities (vigorous, moderate, walking) for at least 10 min at a time that day. Responses were screened using standard procedures for this measure, weighted by standard metabolic equivalents (METs), and summed to create a total PA MET·minutes/ day score (Sjöström et al., 2005). In this scoring model, walking is weighted by a factor of 3.3 METs and the minimum MET value for moderate-intensity PA is 3.0, so we included responses to the walking item in the MVPA score. Self-reported MVPA was significantly skewed (skewness = 2.56, *SE* = .09). To normalize the distribution, the variable was anchored at 1 and a range of Box– Cox transformations were examined (Osborne, 2010). The optimal transformation (λ = 0.3) produced a largely normal distribution (M = 17.23, SD = 5.64, skewness = –0.20) but 16 observations (< 1%) were greater than ±3 SD. Those observations were Winsorized to values equivalent to ±3 SD (Aguinis, Gottfredson, & Joo, 2013).

Data Analysis

Daily reports of motivation and PA were nested within people, so we tested our hypotheses using the multi- level modeling features of Mplus version 5.2 (Muthén & Muthén, 1998). Within-

person means of the daily constraints, social-cognitive, and MVPA variables were calculated to represent differences in people's overall tendencies (Schwartz & Stone, 1998). Dummy variables were created to represent whether intentions referred to weekend MVPA (i.e., intentions rated on Friday/Saturday [coded as 1] or another day [coded as 0]) and whether MVPA ratings corresponded to Saturday/Sunday (coded as 1) or weekday (coded as 0) activity levels. Single-day lag variables for intentions and MVPA were created and data from the first day of data collection (Day 1) was only used to provide the lagged estimates of motivation and MVPA for Day 2. With the exception of dummy variables, all within-person (daily) scores were person centered.

Separate multilevel models were estimated to predict motivation and MVPA. In the Level-1 (within-person) model, daily intentions were regressed on previous-day intentions, daily social-cognitive antecedents of intentions (e.g., attitudes, subjective norms, perceived control, self-efficacy), and daily constraints on motivation (e.g., weekend status, previous-day MVPA, anticipated time availability, expected weather, overeating, fatigue, soreness). Random effects in this model included the Level-1 intercept and slopes for previous-day intentions, social-cognitive constructs, weekend status, and previous-day MVPA. Slopes for the remaining contextual constraints were treated as fixed effects. In the Level-2 (between-person) model, intercepts for daily intentions were regressed on sex, BMI, overall levels of the social cognitive antecedents, and overall levels of the daily contextual constraints. Level-2 slopes were unconditional.

A similar model was used to predict daily MVPA scores. In the Level-1 (within-person) model, daily MVPA was regressed on previous-day MVPA, previous- day intentions, and daily constraints on motivation (e.g., weekend status, anticipated time availability, expected weather, overeating, fatigue, soreness). Random effects in this model included the Level-1 intercept and slopes for previous-day MVPA, previous-day intentions, and weekend status. Slopes for the remaining contextual constraints were treated as fixed effects. In the Level-2 (between-person) model, intercepts for daily MVPA were regressed on sex, BMI, overall intention strength, and overall levels of the daily contextual constraints. Level-2 slopes were unconditional.

RESULTS

Based on daily MVPA reports, participants achieved the national guidelines' level of MVPA on 46% of the days in the study (i.e., 30 min of moderate PA, 15 min of vigorous PA, or an equivalent combination thereof). Descriptive statistics for key study variables are presented in Table 1. Score distributions spanned a wide range of the possible response scales. Variance decomposition analyses revealed that most variables had moderate between-person variation over the 13 days, with intraclass correlation coefficients ranging from .25 (overeating) to .54 (attitudes and perceived behavioral control). Daily intentions and MVPA exhibited 46% and 33% between-person variability, respectively. Between-person differences in motivation and behavior are of well-established interest (e.g., Hagger et al., 2002; McEachan et al., 2011) and these estimates suggest even more variation exists within person that between person, so we proceeded by testing our hypotheses at both the between- and within- person levels of analysis.

Table 1 Descriptive Statistics

	M	*SD*	Range	ICC
Physical Activity (MET·min/day, transformed)	17.22	5.88	0.32–34.13	.33
Physical Activity Intentions	4.66	1.71	1.00–7.00	.46
Attitudes	5.78	1.13	1.00–7.00	.55
Subjective Norms—Descriptive	4.10	1.98	1.00–7.00	.38
Subjective Norms—Injunctive	4.00	1.79	1.00–7.00	.53
Perceived Behavioral Control	5.75	1.54	1.00–7.00	.56
Self-Efficacy	2.95	1.28	1.00–5.00	.49
Anticipated Lack of Time Availability	3.69	2.00	1.00–7.00	.42
Expected Weather	3.80	1.47	1.00–7.00	.31
Overeating	3.34	1.55	1.00–7.00	.25
Fatigue	3.78	1.77	1.00–7.00	.29
Soreness	2.78	1.70	1.00–7.00	.38

Note. Descriptive statistics were based on scores from Days 2–14. ICC = intraclass correlation coefficient.

For descriptive purposes, Table 2 presents two types of associations between self-report variables. The matrix above the diagonal presents correlations between each person's mean scores; these between-person correlations are insensitive to within-person variability in scores. The matrix below the diagonal presents correlations between daily responses across occasions and people; these within- person correlations are insensitive to the nesting of daily ratings within people. We interpreted these correlations descriptively but refrained from drawing inferences about their statistical significance because of the clear within-person variation and dependencies among ratings people made over the course of the study. The patterns of between- and within-person correlations were generally similar, although estimates were slightly stronger for the former than the latter. In both matrices, MVPA intentions were strongly associated with self-efficacy beliefs, expecting time for exercise to be available the following day, and subjective norms for exercise. Although not quite as strong as the aforementioned correlates, people's attitudes toward exercise, expectations regarding the weather, and MVPA levels also were associated with stronger intentions to be physically active. Daily MVPA was strongly associated with people's self-efficacy, and moderately associated with people's intentions to be active, subjective norms for exercise, and expecting time for exercise to be available the following day. Note that these correlations are based on same-day and not lagged ratings (e.g., MVPA during a day and self-efficacy at the end of that day).

Participants provided 7,836 out of 9,053 possible data points on Days 2–14 (86.5% complete data; individual data ranged from 85.1% to 87.1% complete)—the equivalent of over 11 out of 13 possible days/participant. The proportion of missing data for any single variable (missingness) was not correlated with the within-person mean for that variable or any other variables ($p > .01$). Thus, missing data were treated as missing at random and coefficients were estimated using the full information maximum likelihood algorithm. Listwise deletion was used for cases with missing Level-2 data.

Table 2 Correlations Between Physical Activity Intentions, Physical Activity, Social-Cognitive Antecedents, and Contextual Constraints

		1	2	3	4	5	6	7	8	9	10	11	12
1	Physical Activity		.47	.05	.32	.31	–.01	.55	–.28	.18	.11	.08	.13
2	Physical Activity Intentions	.24		.38	.50	.52	.14	.91	–.61	.51	.26	–.11	.11
3	Attitudes	.05	.36		.53	.24	.46	.37	–.17	.40	.07	–.24	–.19
4	Subjective Norms—Descriptive	.33	.31	.34		.63	.30	.48	–.31	.47	.04	–.14	.11
5	Subjective Norms—Injunctive	.18	.48	.26	.46		.00	.47	–.53	.36	.10	–.10	.11
6	Perceived Behavioral Control	–.01	.15	.39	.12	.03		.18	–.10	.39	–.07	–.19	–.16
7	Self-Efficacy	.27	.83	.36	.33	.47	.17		–.59	.46	.27	–.13	.08
8	Anticipated Lack of Time	–.12	–.52	–.19	–.13	–.36	–.15	–.51		–.32	.05	.50	.14
9	Expected Weather	.12	.31	.26	.31	.29	.22	.29	–.22		.08	–.26	.01
10	Overeating	.00	.10	.01	–.04	.07	–.04	.11	.08	.03		.12	.24
11	Fatigue	–.04	–.07	–.17	–.12	–.06	–.06	–.09	.23	–.13	.19		.62
12	Soreness	.05	.06	–.13	.11	.08	–.09	.04	.09	.05	.17	.45	

Note. Between- and within-person correlations are presented above and below the diagonal, respectively.

Predicting Daily Moderate-to-Vigorous Physical Activity Intentions

Table 3 presents coefficients from the model of daily MVPA intentions. In this model, intentions did not differ for men and women or as a function of BMI. Intentions also were not associated with previous-day intentions and this coefficient did not vary significantly between people; however, including this predictor in the model permitted us to interpret the remaining variables in terms of their association with residualized change in daily intentions (and reduced the threat of regression to the mean).

From a social-cognitive standpoint, intentions were stronger on days when people had more positive attitudes, injunctive (but not descriptive) subjective norms, or self- efficacy beliefs than usual; none of those within-person associations varied significantly between people. People's attitudinal tendencies and injunctive norms were associated with their overall intention strength but people who had stronger efficacy beliefs formed stronger intentions on average. Neither descriptive nor injunctive subjective norms were associated with intentions at the between-person level of analysis.

With respect to contextual constraints, people formed the strongest intentions for MVPA on weekdays and days when they anticipated having more time available. People who were more fatigued overall also formed stronger intentions (on average) than people who were less fatigued overall. Daily MVPA intentions were not associated with any other daily contextual constraints at either the between- or within-person level of analysis (e.g., previous-day MVPA, expected weather, overeating, soreness).

Table 3 Multilevel Model Coefficients Predicting Daily Physical Activity Intentions

Predictor	Between-Person Coefficient (*SE*)	Within-Person Coefficient (*SE*)
Intercept	—	4.03 (0.41)**
Sex	0.20 (0.14)	—
BMI	0.01 (0.02)	—
Previous day intention	—	0.02 (0.03)
Variance in previous-day intention slopes	—	0.01 (0.01)
Attitude	0.01 (0.08)	0.13 (0.05)*
Variance in attitude slopes	—	0.00 (0.01)
Descriptive norms	0.02 (0.08)	–0.04 (0.03)
Variance in descriptive norm slopes	—	0.01 (0.01)
Injunctive norm	0.03 (0.06)	0.14 (0.06)*
Variance in injunctive norm slopes	—	0.05 (0.04)
Perceived behavioral control	–0.13 (0.06)*	–0.01 (0.04)
Variance in perceived behavioral control slopes	—	0.02 (0.02)
Self-efficacy	1.11 (0.21)**	0.76 (0.07)**
Variance in self-efficacy slopes	—	0.05 (0.04)
Weekend	—	–0.34 (0.11)**
Variance in weekend slopes	—	0.17 (0.11)
Previous-day physical activity	–0.02 (0.02)	0.01 (0.01)
Variance in previous-day physical activity slopes	—	0.00 (0.00)
Anticipated lack of time availability	–0.12 (0.08)	–0.10 (0.03)**
Expected weather	0.14 (0.08)	0.03 (0.03)
Overeating	0.00 (0.07)	0.02 (0.02)
Fatigue	0.19 (0.10)*	0.01 (0.02)
Soreness	–0.11 (0.08)	0.00 (0.03)
Residual variance	0.01 (0.07)	0.47 (0.09)**

Note. All coefficients are unstandardized estimates. The model is based on 13 occasions nested with 62 participants for a total of 571 observations.

**$p \leq .01$; *$p < .05$.

Predicting Daily Moderate-to-Vigorous Physical Activity

Table 4 presents coefficients from the model of daily MVPA. In this model, self-reported MVPA did not differ for men and women or as a function of BMI. Daily MVPA was positively associated with previous-day MVPA; including this predictor in the model permitted us to interpret the remaining variables in terms of their association with residualized change in daily MVPA (and reduced the threat of regression to the mean).

From a social-cognitive standpoint, intentions were associated with daily MVPA at the within-person level of analysis (intentions were marginally but positively associated at the between-person level, $p = .054$). On evenings when people formed stronger intentions than usual, they increased their MVPA the following day; this within-person coefficient did not vary significantly between people.

Table 4 Multilevel Model Coefficients Predicting Daily Physical Activity

Predictor	Between-Person Coefficient (*SE*)	Within-Person Coefficient (*SE*)
Intercept	—	8.33 (4.53)
Sex	1.15 (0.69)	—
BMI	–0.03 (0.10)	—
Previous-day physical activity	—	0.08 (0.04)*
Variance in previous-day physical activity slopes	—	0.00 (0.00)
Previous day intention	0.84 (0.44)	0.44 (0.21)*
Variance in previous-day intention slopes	—	0.07 (0.09)
Weekend	—	–1.26 (0.57)*
Variance in weekend slopes	—	6.23 (3.27)
Previous-day anticipated lack of time availability	0.41 (0.40)	–0.31 (0.13)*
Previous-day weather expectation	–0.04 (0.49)	0.08 (0.16)
Previous-day overeating	–0.32 (0.45)	0.12 (0.15)
Previous-day fatigue	0.66 (0.69)	–0.15 (0.14)
Previous-day soreness	–0.25 (0.56)	–0.13 (0.14)
Residual variance	2.42 (2.50)	17.73 (2.72)**

Note. All coefficients are unstandardized estimates. The model is based on 13 occasions nested with 61 participants for a total of 575 observations. $^{**}p < .01$; $^{*}p < .05$.

With respect to contextual constraints, participants were more active on weekdays than weekends (and that association did not vary between-people). People significantly decreased their MVPA following evenings when they anticipated having less time available than usual but this effect was not significant at the between- person level. No other daily contextual constraints were significantly associated with MVPA at the within- or between-person levels (e.g., expected weather, overeating, fatigue, soreness).

DISCUSSION

In this study, we examined naturalistic daily variation in MVPA intentions and their role in regulating daily MVPA. Three main findings emerged: (1) MVPA intentions varied considerably from day to day, (2) social- cognitive factors accounted for fluctuations in intentions better than contextual constraints, and (3) fluctuations in intentions predicted daily variation in MVPA even after controlling for the unfolding contextual constraints in participants' lives. It is worth noting that, in these analyses, motivation ratings for moderate and vigorous intensity activities were combined to create general intention and self-efficacy scores. Consistent with Rhodes, de Bruijn, and Matheson (2010), the large correlation between ratings at those intensities suggests that these items were capturing motivational processes for a very intentional form of PA, namely, exercise.

The Ebb and Flow of Physical Activity Intentions

Longitudinal studies of motivation and PA are becoming more common but the time scales for sampling these phenomena remain relatively slow, often separated by weeks or months. In this daily study, less than half of the variability in MVPA intentions could be attributed to between-

person differences. This estimate fits within the low end of the range of between-person variability established in studies of weekly and monthly intentions (Conroy et al., 2011; Scholz et al., 2009, 2008). It is, to the best of our knowledge, the first reported estimate of daily variability in MVPA intention strength because the only other known study of daily PA motivation did not report the proportion of between-person variation in intention strength (Payne, Jones, & Harris, 2010). Taken in concert with the daily variation in MVPA, these findings reinforce the need to treat motivation and behavior as dynamic processes that fluctuate over time (even as quickly as from one day to the next).

Important insights into why one person's motivation might differ from that of another person can be gained from cross-sectional studies but it is clear that those differences represent only half of the story when it comes to people's daily intentions and MVPA. The principle of aggregation has served its purpose well by implicating social-cognitive constructs in behavior (Ajzen, 1991), but this principle invokes the unnecessary assumption that temporal fluctuations in motivation and behavior are noise. In fact, the observed daily covariation of daily motivational processes and MVPA in this study suggests that those fluctuations are the signal (i.e., useful information about the phenomenon) that we seek in our work. Whether the daily time scale is optimal for studying and intervening with these phenomena will be determined in future research, but we believe it warrants further investigation because people deplete and replenish self-regulatory resources on a daily basis and both motivation and MVPA fluctuate in coordination with daily fluctuations in the social calendar.

Social-Cognitive Regulation of Motivation and Physical Activity

As expected, intentions were associated with daily fluctuations in people's attitudes toward exercise. These attitudes fluctuated considerably within people and it was these daily fluctuations, rather than general attitudinal tendencies, that predicted intention strength. This finding was consistent with assertions that outcome proximity is a key moderator of attitude effects on intentions (Williams, Anderson, & Winett, 2005). This interpretation also helps to explain why persuasive communications used to change attitudes at the outset of a study have had small effects on intentions assessed weeks later (e.g., Chatzisarantis & Hagger, 2005). Instead, repeated persuasive communications over time may be necessary to stimulate the attitudinal fluctuations required to strengthen intentions consistently.

Subjective norms had mixed associations with intention strength at the within-person level: injunctive, but not descriptive, norms were associated with daily intention strength. These results may help to explain why, when these norms are combined, results suggest a very weak association between subjective norms and intention strength (Hagger et al., 2002). Daily perceptions of unusually high or low social support or pressure (i.e., injunctive norms) may be coupled with acute fluctuations in intentions; however, this association is short lived and does not appear to generalize to differences between people with relatively controlled regulations for exercise. Descriptive norms, on the other hand, appeared to be entirely disconnected from daily intentions. Recent work has shown that messages that promote descriptive norms do not modify PA (Priebe & Spink, 2012). Normative messaging interventions to promote college students' MVPA may only be effective when they focus on injunctive norms and, even then, the effects are likely to be indirect (i.e., changes in intentions may lead to changes in behavior). Rather than

phasing out or deemphasizing the role of subjective norms in MVPA research, as some have suggested (Rhodes & Nigg, 2011), it may be enough to focus specifically on injunctive rather than descriptive or undifferentiated subjective norms.

People with stronger efficacy beliefs—both in general as well as on a given day—were more likely to form stronger intentions for MVPA. Self-efficacy has previously been linked directly with PA (e.g., McAuley & Blissmer, 2000; Schwarzer, Luszczynska, Ziegelmann, Scholz, & Lippke, 2008; Schwarzer, 1992) and, to the best of our knowledge, our study was the first to extend that association to the daily level of analysis. The magnitude of the association likely reflects the direct link between constructs posited in social-cognitive theory as well as the rapid sampling time scale, although it may also be inflated by common measurement error. Despite the unusually large bivariate association between self- efficacy and intentions, significant residual variance at the within-person level indicated that these variables were not isomorphic when the nested nature of observations was taken into account. One likely consequence of this strong association was the unexpected negative between- person association between perceptions of behavioral control and intentions in the multilevel model. Although efficacy beliefs and perceptions of control are both rooted in beliefs about control, beliefs about internal agency (i.e., efficacy) have emerged as superior predictors of intentions relative to beliefs about external influences on control when both are modeled simultaneously (Hagger et al., 2002; Rodgers et al., 2008). In light of this previous work and the composition of the model in this study, we suspect that the observed negative association between perceived control and intentions is spurious.

We concluded that social-cognitive constructs—such as attitudes, injunctive norms, and efficacy beliefs— accounted for some of the factors that (a) differentiate people who generally form stronger MVPA intentions from those who generally form weaker MVPA intentions and (b) lead people to form stronger MVPA intentions on some days than on others. The social-cognitive factors that differentiate between people who adopt strong or weak MVPA intentions (and between active or inactive people) are not necessarily the same as those that determine why a person adopts stronger intentions (or is more active on some days than on others). Overall, the theory of planned behavior functioned reasonably as an explanatory tool for predicting within-person variation in intentions and behaviors; however, contrary to the theory, descriptive norms and perceived behavioral control had questionable value for predicting intentions in this study. These results also raise the question of whether self-efficacy is sufficient for explaining between-person differences in MVPA intentions without the additional explanatory constructs posited by the theory of planned behavior (or related theories).

With respect to the effects of changing intentions, medium-to-large changes in intention strength lead to small-to-medium changes in behaviors including PA (Rhodes & Dickau, 2012; Webb & Sheeran, 2006). The intention–behavior association appears to be stronger in studies with a shorter period between the intention manipulation and behavioral assessment (Webb & Sheeran, 2006). Given the daily fluctuations in intention strength, we can speculate that periodic—possibly even daily—booster interventions to maintain strong intentions may be useful for increasing the association between intentions and MVPA. Experimental research would be especially valuable for testing this hypothesis because of the need to establish the causal influence of the booster interventions.

Daily Contextual Constraints on Motivation and Physical Activity

The aforementioned social-cognitive influences were examined against the backdrop of changing constraints on people's daily motivation and MVPA. Of all the daily constraints assessed in this study, the perceived unavailability of time was negatively associated with both daily intentions and daily MVPA. A lack of time frequently emerges as a barrier to PA (Bauman et al., 2002), and our findings point to the importance of attending to perceived time limitations on a daily basis for enhancing both intentions and MVPA. Although weather was not a significant constraint on intentions or MVPA in this study, the daily timescale of the current study was too fast to capture the seasonal variation implicated in previous studies on weather and MVPA (Tucker & Gilliland, 2007).

Limitations

Some limitations of this study require attention. First, the sample was fairly homogeneous with respect to age, race, ethnicity, education, and physical ability. The sample size also limited statistical power for detecting between-person associations. On a related note, although the effective *n* for within-person analyses was relatively large, extremely small within-person associations may not have been detected. Second, we relied on single-item or extremely brief measures, which narrowed the content representativeness of our assessments, and, based on the Spearman–Brown prophecy formula, likely reduced the reliability of scores and inflated the apparent proportion of within-person variation. In the context of intensive assessments such as daily diaries, researchers must balance concerns about participant burden and fatigue against content representativeness. Motivation is undoubtedly constrained by environmental and social factors, which we did not assess, and we look forward to research that incorporates objectively measured (e.g., diet diaries, weather) as well as construed daily contextual constraints from different domains of daily life. Third, we assessed MVPA using self-reports, which are vulnerable to over-reporting. Fourth, these findings are specific to MVPA and may not generalize to conceptually related phenomena such as activities of daily living or sedentary behavior. Finally, the present data were collected in a nonexperimental context, so strong causal inferences are not possible.

CONCLUSIONS

In conclusion, intentions to engage in public-health doses of MVPA and people's reported MVPA varied considerably from day to day. Social-cognitive motivational processes are relevant for predicting people's intentions and MVPA (even at the daily level, which would be most vulnerable to the influence of contextual constraints). The unfolding constraints on people's daily intentions offer additional value when predicting MVPA. Sensitivity to the daily motivational fluctuations and shifting constraints imposed by perceived time availability narrowed but did not altogether close the intention–behavior gap for MVPA. Disaggregating motivation and behavior over time and treating time as a meaningful theoretical dimension would be valuable in future research on motivation and MVPA.

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