

Self-Regulation and Implicit Attitudes Toward Physical Activity Influence Exercise Behavior

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Dual-process models of health behavior posit that implicit and explicit attitudes independently drive healthy behaviors. Prior evidence indicates that implicit attitudes may be related to weekly physical activity (PA) levels, but the extent to which self-regulation attenuates this link remains unknown. This study examined the associations between implicit attitudes and self-reported PA during leisure time among 150 highly active young adults and evaluated the extent to which effortful control (one aspect of self-regulation) moderated this relationship. Results indicated that implicit attitudes toward exercise were unrelated to average workout length among individuals with higher effortful control. However, those with lower effortful control and more negative implicit attitudes reported shorter average exercise sessions compared with those with more positive attitudes. Implicit and explicit attitudes were unrelated to total weekly PA. A combination of poorer self-regulation and negative implicit attitudes may leave individuals vulnerable to mental and physical health consequences of low PA.

Keywords: effortful control, inhibitory control, psychology, self-regulatory capacity

Regular exercise promotes physical and mental health; however, fewer than 25% of Americans meet national physical activity (PA) guidelines (Centers for Disease Control, 2014). Understanding the factors that influence exercise behavior is crucial for improving regular exercise adherence. Self-reported attitudes about exercise influence whether people decide to engage in PA or avoid it (Rhodes, Fiala, & Conner, 2009). However, attitudes alone do not determine exercise behavior, and interventions targeting self-reported exercise attitudes do not typically result in long-term increases in PA (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003; Callahan, 2013; Ogden, Karim, Choudry, & Brown, 2007). Accordingly, consideration of other pathways through which attitudes influence exercise initiation and adherence is necessary. Implicit attitudes may play a role in whether and for how long individuals choose to exercise.

Implicit Attitudes and PA

Implicit attitudes are automatic, emotional responses to stimuli (Gawronski & Bodenhausen, 2006). Researchers

have examined these automatic attitudes in response to a variety of targets such as political candidates, feared animals like spiders, or racially diverse people. These attitudes cannot be self-reported, as they are outside of a person's awareness (although some researchers contend implicit attitudes may be consciously accessible to some degree; see Hahn & Gawronski, 2014). Implicit attitudes are believed to be the result of prior direct or indirect experience with the target object or activity, and may differ in magnitude and direction from an individual's explicit attitude. People who exercise more frequently tend to have more positive implicit attitudes about exercise (Markland, Hall, Duncan, & Simatovic, 2015). In one study, individuals whose attitudes toward PA improved over 1 week became more physically active throughout the week compared with those whose attitudes worsened or remained the same (Hyde, Elavsky, Doerksen, & Conroy, 2012).

Furthermore, results from prospective studies provide evidence that implicit attitudes about exercise predict subsequent PA, even after controlling for explicit attitudes. In one study, participants completed measures of implicit attitudes and explicit motivation toward exercise and wore a pedometer for 1 week (Conroy, Hyde, Doerksen, & Ribeiro, 2010). Implicit attitudes predicted daily step count after controlling for explicit processes such as motivation, perceived control, and exercise self-efficacy. In a more recent study, participants wore an accelerometer for 2 weeks after completing tests of implicit and explicit attitudes toward PA (Rebar, Ram, & Conroy, 2015). Individuals with more favorable implicit attitudes exercised more on average

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than those with unfavorable attitudes, even after controlling for forms of explicit attitudes such as affective and instrumental attitudes.

Self-Regulation and Implicit Attitudes

Effortful control, an important component of self-regulatory capacity, is the ability to control impulses to engage in an alternative behavior, as well as to develop and execute plans (Rothbart, Ellis, Rueda, & Posner, 2003). Effortful control is a personality trait consisting of three aspects: attentional control, activation control, and inhibitory control (Muris & Meesters, 2009; Verstraeten, Vasey, Claes, & Bijttebier, 2010). Attentional control is the ability to focus and shift one's attention when necessary. Activation control is the ability to initiate a behavior despite low motivation or a desire to avoid the behavior. Inhibitory control refers to the ability to suppress a dominant approach behavior when the behavior is inappropriate. Prior research has not investigated the relationship between these facets of effortful control and average workout duration.

Effortful control may influence PA by equipping individuals to overcome negative implicit attitudes toward exercise to achieve the longer-term goal of improved health or weight loss. Indeed, authors of the Systems of Evaluation Model (SEM; McConnell & Rydell, 2014; Rydell & McConnell, 2006) posit that although both explicit and implicit processes guide behavior, goal-directed health behaviors may be more strongly governed by nonconscious processes than conscious thought among individuals with poor self-regulatory capacity. Therefore, it is reasonable to expect that individuals with low self-regulatory capacity are more likely to act in line with their implicit attitudes about PA, whether positive or negative. Among those with negative implicit attitudes, low self-regulatory capacity would ultimately make it more difficult to exercise for the sake of a desirable goal, such as improved physical health.

Although past studies have not applied this self-regulation theory to exercise, research on eating behavior provides some support for the theory. For example, in one study, researchers manipulated participants' self-regulatory capacity in the moment by asking them to engage in a demanding memory task (Friese, Hofmann, & Wänke, 2008). Participants with more favorable implicit attitudes toward chocolate consumed more chocolate following the memory task compared with those with less favorable attitudes; however, there was no association between implicit attitudes and consumption among those who did not complete the memory task. Hofmann and Friese (2008) reported similar findings from another study in which self-regulatory capacity was depleted through alcohol consumption: Individuals who consumed alcohol were less able to overcome their positive implicit attitudes toward food and consumed more chocolate on average than those in the control condition. These data suggest that implicit

attitudes are more strongly related to unhealthy choices when self-regulatory capacity is diminished.

Research in substance and alcohol use has provided further evidence that the association between implicit attitudes and health behavior is moderated by self-regulatory skills such as response inhibition or working memory capacity. In a study of college students, positive alcohol-related implicit attitudes predicted drinking behavior among those with low response inhibition (as measured by the Stroop task), but not among those with high response inhibition (Houben & Wiers, 2009). Similarly, high working memory capacity dampened the association between positive implicit attitudes toward drugs and self-reported substance use (Grenard et al., 2008). Thus, although evidence suggests that maladaptive implicit attitudes are more strongly associated with unhealthy behavior among poorer self-regulators, this tenet of dual-process models has not been tested in the context of PA.

Leisure-Time Physical Activity

In prior studies, researchers have investigated the effects of implicit attitudes on overall PA level, often using pedometers. In these studies, participant step counts were averaged across days or weeks (Conroy et al., 2010; Hyde et al., 2012). However, little is known about the association between implicit attitudes and exercise during leisure time. Leisure-time physical activity (LTPA) is planned exercise that occurs during a person's free time and includes walking, sport participation, and working out in a gym or group class. Compared with total PA and activity in other domains (e.g., work-related PA), LTPA is more strongly associated with cardiovascular fitness (Schmidt, Cleland, Thomson, Dwyer, & Venn, 2008).

Moreover, implicit attitudes and self-regulation should be particularly important for average LTPA duration. According to the SEM, individuals rely more on explicit attitudes when engaging in deliberate, planned behavior (Rydell & McConnell, 2006). Therefore, explicit attitudes may be more important in the planning of future exercise activity, whereas implicit attitudes may guide a person's decision to persist in an exercise session despite negative outcomes, such as discomfort or boredom. Given this, implicit attitudes may be more closely related to the average amount of time a person spends exercising instead of the total number of steps one takes each day, which may be related to factors outside individual control, such as a person's schedule or work demands. This may be especially true when self-regulation is low, due to deficits in planning, persistence, and the ability to suppress negative impulses.

Current Study

This study of active, young adults assessed whether implicit attitudes toward exercise were associated with

average, weekly LTPA, as well as the amount of time individuals reported exercising during a typical leisure-time workout session. Young adults were recruited to maximize variability in PA levels, as estimations of PA variance appear to decrease with older age (Troiano et al., 2008). Consistent with prior research on overall PA levels, we hypothesized that both explicit and implicit attitudes would be associated with average LTPA and workout duration.

Effortful control (indicative of self-regulatory capacity) was tested as a moderator of these relationships to explore whether individuals high in effortful control were better able to suppress the effects of negative implicit attitudes on average LTPA and workout length. We hypothesized that effortful control would emerge as a moderator, because individuals low in this capacity may have a harder time persisting in an exercise session if they have negative implicit attitudes. For any outcomes in which effortful control significantly moderated the association between implicit attitudes and LTPA, attentional control, inhibitory control, and activation control were also tested as moderators to determine the facets of effortful control that may be relevant in this relationship. Given prior literature suggesting that strong inhibitory control weakens the relationship between implicit attitudes and maladaptive health behaviors (e.g., Haynes, Kemps, & Moffitt, 2015; Houben & Wiers, 2009), we hypothesized that inhibitory control would be the facet of effortful control most likely to explain any effect.

Another tenet of the SEM model is the idea that discrepancies between explicit and implicit attitudes may be important in predicting exercise behavior, and resolving these discrepancies may be especially difficult among those low in effortful control (McConnell & Rydell, 2014). As such, the interaction between implicit and explicit attitudes was explored, as well as

a three-way interaction between implicit attitudes, explicit attitudes, and effortful control. We hypothesized that individuals with positive implicit and explicit attitudes would be the most active and that attitude discrepancies would result in lower PA levels among those with less effortful control.

Methods

Participants

The sample consisted of 150 undergraduate students at a large, Midwest university, who received course credit for study participation. The majority of the participants were White (70.3%), women (59.5%), and in their first academic year of college (63.5%). Additional sample characteristics are included in Table 1.

Procedure

All participants completed informed consent. Following a brief relaxation period, participants completed a computerized implicit attitudes task, the personalized Single Category Implicit Association Test (SC-IAT). Participants then completed a packet of questionnaires including demographic information, PA level, effortful control, and explicit attitudes.

Self-Report Measures

Leisure-time physical activity. The International Physical Activity Questionnaire (IPAQ; long form) was used to assess how often participants engage in various physical activities (Booth, 2000). Participants were asked to report how much time they spent engaging in vigorous activity, moderate activity, or walking over the past 7 days across four domains of living. The IPAQ uses

Table 1 Demographic Information for the Sample Without Outliers ($n = 148$)

| Measure | <i>M</i> | <i>SD</i> | Range |
|---|----------|-----------|----------------|
| Age | 19.28 | 1.63 | 18 to 31 |
| Body mass index (kg/m^2) | 23.46 | 4.09 | 14.86 to 41.19 |
| Implicit attitude (D-score) | 0.21 | 0.41 | -0.74 to 1.59 |
| Explicit attitude | 34.76 | 4.62 | 18 to 40 |
| Affective attitude | 16.14 | 3.36 | 5 to 20 |
| Instrumental attitude | 18.63 | 1.80 | 13 to 20 |
| Effortful control (ATQ) | 4.42 | 0.70 | 2.72 to 6.47 |
| Effortful control subscales | | | |
| Inhibitory control | 4.45 | 0.83 | 2.64 to 6.82 |
| Attentional control | 3.94 | 0.87 | 1.92 to 6.17 |
| Activation control | 4.86 | 0.86 | 2.17 to 7.00 |
| LTPA MET minutes per week ^a (IPAQ) | 2,123.15 | 2,162.93 | 0 to 10,788.00 |
| Average LTPA duration (IPAQ) | 35.60 | 28.97 | 0 to 140 |

Note. ATQ = Adult Temperament Questionnaire; LTPA = leisure-time physical activity; MET = metabolic equivalents; IPAQ = International Physical Activity Questionnaire.

^aMET minutes per week is a measure of total weekly energy expenditure.

metabolic equivalents (METs) to allow for calculation of the energy expended while engaging in PA over the past week. One MET is defined as one's metabolic rate during rest or quiet sitting. Activity METs index the energy expended during various physical activities relative to energy expended at rest. For example, the MET for singles tennis is 8.0 (Ainsworth et al., 1993), indicating that, on average, eight times more energy is expended playing singles tennis than at rest. The LTPA MET minutes per week score was generated by weighting the products of each leisure activity's duration and intensity using METs from the 2000 Compendium of Physical Activities (Ainsworth et al., 1993). Therefore, LTPA MET minutes per week index the total energy expended during LTPA throughout the week.

An additional outcome variable was created for the current study to index the average number of minutes a participant spent engaging in a single bout of LTPA. This variable was computed by averaging the number of minutes participants reported that they "usually" spent in a single session of walking or moderate-to-vigorous PA during their leisure time. LTPA was chosen in an effort to reduce the effect of double counting and unreliable reporting errors of self-reported PA (Rzewnicki, Vanden Auweele, & De Bourdeaudhuij, 2003). The IPAQ is appropriate for use among college students. For example, the IPAQ has been associated with PA log data (Spearman's $\rho = 0.55$) and aerobic fitness levels (Spearman's $\rho = 0.21$), and its performance is consistent with other PA self-report measures (Craig et al., 2003; Hagströmer, Oja, & Sjöström, 2006).

Explicit attitudes toward exercise. Explicit attitudes were assessed with a self-report scale commonly used in health behavior research, adapted from Ajzen and Driver's theory of planned behavior (Ajzen & Driver, 1991; Courneya & Bobick, 2000). The scale assessed participants' explicit attitudes toward exercise by asking them to identify the extent to which they believe exercise is: important/unimportant, harmful/beneficial, healthy/unhealthy, enjoyable/unenjoyable, pleasant/unpleasant, satisfying/unsatisfying, interesting/boring, and foolish/wise on a 5-point Likert scale. The internal consistency estimate for this scale was $\alpha = .85$.

Effortful control. The Adult Temperament Questionnaire-Long Form (Evans & Rothbart, 2007) is a 177-item questionnaire that assesses personality facets such as effortful control, negative affect, and extraversion. Participants responded to items such as "I hardly ever finish things on time" and "I can keep performing a task even when I would rather not do it" on a 7-point Likert scale, where 1 indicated "extremely untrue of you" and 7 indicated "extremely true of you." Responses from the 35 items addressing effortful control are averaged to create an effortful control score. Individual subscales that make up the effortful control score (attentional control, activation control, and inhibitory control) were also explored to determine if facets of effortful control were associated with the attenuation

of implicit attitudes. In the current study, internal consistency estimates were as follows: overall scale $\alpha = .87$, attentional control subscale $\alpha = .77$, activation control subscale $\alpha = .80$, and inhibitory control subscale $\alpha = .66$.

Implicit Attitudes Toward Exercise Task

A personalized SC-IAT (Karpinski & Steinman, 2006), a computerized task, was utilized to measure participants' implicit attitudes toward PA. Participants were presented with words on a computer monitor and asked to sort them into categories labeled "I like" or "I don't like" as quickly as possible by pressing marked keys on the computer. Words were randomly sequenced. There were three blocks composed of 39 trials: a practice block, PA + "I like," and PA + "I don't like." For example, in the PA + "I like" block, participants were asked press the key corresponding with "I like" for all PA stimuli (e.g., run, lift weights) and to press the "I like" or "I don't like" keys for non-PA normative stimuli (e.g., love, death). The order in which participants sorted PA words into either "I don't like" or "I like" categories for the second and third blocks was counterbalanced. PA stimuli were drawn from prior research demonstrating an association between implicit attitudes and PA level (Conroy et al., 2010; Hyde, Doerksen, Ribeiro, & Conroy, 2010). Non-PA normative items were those used in traditional Implicit Association Test (IAT) research (Greenwald, McGhee, & Schwartz, 1998).

The SC-IAT is a modification of the original IAT (Greenwald et al., 1998). Unlike the original IAT, participants are not forced to make comparisons between complementary pair words (e.g., positive-negative, male-female, Black-White) when using the SC-IAT. Previous work investigating the association between implicit attitudes and PA used a traditional SC-IAT to measure implicit attitudes (Calitri, Lowe, Eves, & Bennett, 2009; Conroy et al., 2010). In a traditional SC-IAT, participants are asked to classify words into either a "pleasant" or "unpleasant" category and receive feedback for all incorrect responses. Critics of the traditional IAT and SC-IAT contend that extrapersonal factors (e.g., social influence) may distort the measurement of an individual's personally held attitude (Olson & Fazio, 2004). For example, when someone is asked to place a stimulus into a "good" or "bad" category, he or she may draw on societal norms to place the stimulus as opposed to his or her own personal attitude. To obtain a more "pure" measurement of participants' implicit attitudes, a personalized SC-IAT was used. The personalized SC-IAT has different category labels (e.g., "I like" instead of "pleasant/good") and removes error feedback. The personalized IAT was more strongly associated with eating and voting behavior compared with a traditional IAT (Olson & Fazio, 2004). The personalized IAT was also more stable following a brief priming manipulation compared with the traditional IAT (Han, Czellar, Olson, & Fazio, 2010).

Data Analysis

Implicit attitude scores were derived from the SC-IAT D-score algorithm (Karpinski & Steinman, 2006), which involves subtracting the average response time of the PA + “I don’t like” block from the PA + “I like” block. This difference score was then divided by the pooled standard deviation of the test trials. Higher scores indicate that the participant was more quickly able to associate PA words with the “I like” category than the “I don’t like” category, therefore representing more favorable implicit attitudes toward PA. To adapt the scoring algorithm to our personalized IAT procedure, two changes were made to the D-score calculation as outlined by Greenwald, Nosek, and Banaji (2003). First, all SC-IAT reaction times were natural log transformed to correct for skew (Greenwald et al., 1998; Olson & Fazio, 2004). Although the traditional D-score algorithm does not include log-transformed response latencies, prior research using the personalized IAT includes log transformation of all response latencies prior to D-score calculation. Additionally, the traditional D-score algorithm includes an error penalty of 400 ms added to incorrect responses, and prior work indicates that removing error penalties may reduce the validity and reliability of IAT scores (Richetin, Costantini, Perugini, & Schönbrodt, 2015). However, the personalized SC-IAT does not include error feedback, and therefore, no error penalty was added to response latencies. In prior research using this amended D-score calculation method, the personalized IAT was more highly correlated with explicit measures of attitudes and behavioral intention compared with a traditional IAT (Olson & Fazio, 2004).

Two outliers were identified and subsequently excluded from the analyses based on excessively high self-reported workout durations (average workout duration >250 min). The excluded participants did not differ significantly from the remainder of the sample on

measures of body mass index ($t = -0.69, p = .631$); explicit attitudes ($t = 0.83, p = .518$); or implicit attitudes ($t = -0.52, p = .517$).

Hierarchical multiple regressions (i.e., successive linear regression models) were conducted in SPSS (version 22.0; IBM Corp, Armonk, NY) to test hypotheses. In the first step, affective and instrumental attitudes were entered as predictors of the outcome variable (either LTPA MET minutes per week or average LTPA duration). In the second step, implicit attitudes were added to the model to determine if they accounted for a significant portion of the variance in LTPA after accounting for explicit attitudes. Effortful control was tested as a moderator using the PROCESS macro for SPSS (Hayes, 2012). The Johnson–Neyman approach (Johnson & Neyman, 1936) was used to probe significant interactions. These analyses were repeated to test each individual facet of effortful control (inhibitory control, activation control, and attentional control). Implicit attitudes and effortful control data were standardized in moderation analyses to meaningfully interpret any interactions.

Assumptions of linear regression were tested for each model and indicated that all regression assumptions were met. Specifically, visual inspection of residual plots of regression models indicated that the regression assumption of homoscedasticity was met. Calculation of the variance inflation factor and tolerance indicated that multicollinearity was not present.

Results

Attitudes and Average PA Duration

Implicit and explicit attitudes toward PA were not significantly related ($r = .074, p = .373$; see Table 2 for bivariate correlations between all study variables). Instrumental ($b = -0.34, SE = 1.62, p = .832$) and affective attitudes ($b = 0.05, SE = 0.87, p = .958$) were not associated with average workout duration. However, implicit

Table 2 Bivariate Correlations Between Study Variables

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|------------------------------|--------|------|-------|------|-------|------|------|-------|------|------|------|----|
| 1. Implicit attitude | – | | | | | | | | | | | |
| 2. Explicit attitude | .07 | – | | | | | | | | | | |
| 3. Affective attitude | .04 | .95* | – | | | | | | | | | |
| 4. Instrumental attitude | .11 | .80* | .57* | – | | | | | | | | |
| 5. Effortful control | .06 | .10 | .13 | .01 | – | | | | | | | |
| 6. Inhibitory control | .13 | .10 | .08 | .11 | .83* | – | | | | | | |
| 7. Attentional control | –.01 | .13 | .17* | .02 | .84* | .58* | – | | | | | |
| 8. Activation control | .04 | .01 | .08 | –.11 | .79* | .47* | .48* | – | | | | |
| 9. LTPA MET minutes per week | .12 | –.04 | –.01 | –.07 | .15** | .06 | .11 | .21* | – | | | |
| 10. Average LTPA duration | .17* | –.01 | –.01 | –.02 | .07 | –.01 | .03 | .16** | .77* | – | | |
| 11. Age | –.02 | .12 | .15** | .04 | .05 | .04 | .06 | .02 | –.13 | –.08 | – | |
| 12. Body mass index | –.15** | .12 | .11 | .09 | –.03 | .01 | .02 | –.11 | –.08 | –.12 | .17* | – |

Note. LTPA = leisure-time physical activity; MET = metabolic equivalents.

* $p < .05$. ** $p < .01$.

attitudes significantly improved model fit when entered into Step 2 of the model, and the full model accounted for 3% of the variance in average workout duration ($b = 12.45$, $SE = 5.88$, $p = .036$, $R^2 = .030$). That is, for every one unit increase on the implicit attitudes task (indicating a more favorable attitude), individuals exercised 12.45 min longer during a typical LTPA session. Instrumental ($b = -108.47$, $SE = 120.37$, $p = .369$) and affective attitudes ($b = 24.57$, $SE = 64.72$, $p = .705$) were not associated with LTPA MET minutes per week, and implicit attitudes did not significantly improve model fit; however, the nonsignificant effect was in the hypothesized direction ($b = 676.59$, $SE = 441.12$, $p = .127$).

A test of the interaction between instrumental attitudes and implicit attitudes was significant for LTPA MET minutes per week ($b = -605.25$, $SE = 270.13$, $p = .027$) but not significant for average workout duration ($b = -5.05$, $SE = 3.64$, $p = .167$). Individuals with negative implicit and instrumental attitudes were the least active group, whereas those with positive implicit attitudes and negative instrumental attitudes were the most active. The test of the interaction between affective attitudes and implicit attitudes was nonsignificant in predicting both LTPA MET minutes per week and average workout duration. See Table 3 for a summary of these results.

Effortful Control Capacity as a Moderator

The interaction between implicit attitudes and effortful control was a significant predictor of average LTPA duration ($b = -6.27$, $SE = 2.42$, $p = .011$). The Johnson–Neyman technique was used to probe the interaction, which identifies the range of values of the moderator at which the conditional association between implicit attitudes and average LTPA duration is significant. As shown in Figure 1, individuals who scored 0.24 SDs below the effortful control mean or lower (i.e., effortful control ≤ -0.24 SDs) evidenced a significant, positive association between implicit attitudes and average LTPA duration ($p < .05$), such that individuals with lower effortful control and stronger negative attitudes had the shortest predicted average LTPA duration. Those with effortful control scores greater than 0.24 SDs below the effortful control mean (i.e., effortful control > -0.24 SDs) evidenced no association between implicit attitudes and average LTPA duration. The interaction between implicit attitudes and effortful control did not emerge as a significant predictor of LTPA MET minutes per week ($b = -82.90$, $SE = 183.70$, $p = .653$).

Three-way interactions between implicit attitudes, explicit attitudes, and effortful control were tested to investigate whether discrepancies in implicit and explicit attitudes predicted exercise behavior under varying levels of effortful control. The three-way interaction

Table 3 Results of Multiple Regressions Predicting LTPA MET Minutes per Week and Average LTPA Duration From Implicit and Explicit Attitudes

| Predictor | Outcome | | | | | | | |
|--|---------------------------|-----------|----------|------|-----------------------|--------|-------|------|
| | LTPA MET Minutes per Week | | | | Average LTPA Duration | | | |
| | R^2 | b | SE | p | R^2 | b | SE | p |
| Model 1 | .006 | | | | <.001 | | | |
| Intercept | | 3,747.28 | 1,871.21 | .047 | | 41.24 | 25.13 | .103 |
| Instrumental attitudes | | -108.47 | 120.37 | .369 | | -0.34 | 1.62 | .832 |
| Affective attitudes | | 24.57 | 64.72 | .705 | | 0.05 | 0.87 | .958 |
| Model 2 | .022 | | | | .030 | | | |
| Intercept | | 3,926.24 | 1,866.20 | .037 | | 44.54 | 24.88 | .076 |
| Instrumental attitudes | | -127.65 | 120.47 | .291 | | -0.70 | 1.61 | .666 |
| Affective attitudes | | 26.91 | 64.44 | .677 | | 0.09 | 0.86 | .918 |
| Implicit attitudes | | 676.59 | 441.12 | .127 | | 12.45 | 5.88 | .036 |
| Model 3 | .054 | | | | .043 | | | |
| Intercept | | 2,617.87 | 1,901.00 | .171 | | 34.09 | 25.60 | .185 |
| Instrumental attitudes | | -31.79 | 102.30 | .756 | | -0.04 | 1.38 | .978 |
| Implicit attitudes | | 11,976.94 | 5,064.10 | .019 | | 106.75 | 68.19 | .120 |
| Instrumental \times Implicit attitudes | | -605.25 | 270.13 | .027 | | -5.05 | 3.64 | .167 |
| Model 4 | .026 | | | | .035 | | | |
| Intercept | | 1,742.60 | 932.86 | .064 | | 31.00 | 12.44 | .014 |
| Affective attitudes | | 16.46 | 56.96 | .773 | | 0.14 | 0.76 | .857 |
| Implicit attitudes | | 3,496.16 | 2,161.91 | .108 | | 38.52 | 28.83 | .184 |
| Affective \times Implicit attitudes | | -179.30 | 132.36 | .178 | | -1.65 | 1.77 | .352 |

Note. LTPA = leisure-time physical activity; MET = metabolic equivalents.

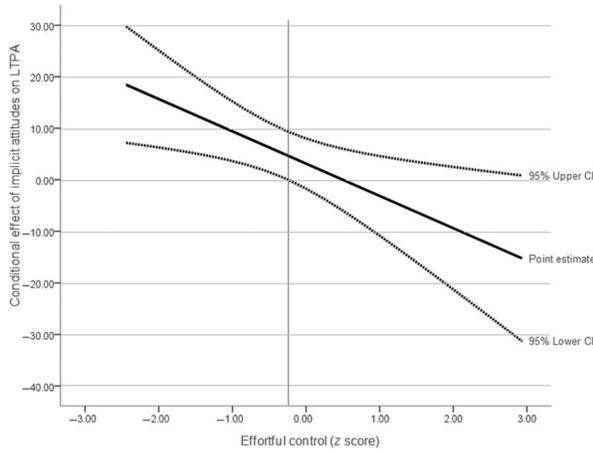


Figure 1 — Johnson–Neyman plot depicting the conditional effect of implicit attitudes on average LTPA duration at different effortful control values. Individuals who fell 0.24 *SDs* below the effortful control mean or lower evidenced a positive, significant ($p \leq .05$) relationship between implicit attitudes and average LTPA duration. All those that fell above 0.24 *SDs* did not evidence a relationship between implicit attitudes and workout duration. LTPA = leisure-time physical activity; CI = confidence interval.

between implicit attitudes, instrumental attitudes, and effortful control was nonsignificant in predicting LTPA MET minutes per week ($b = 243.69$, $SE = 432.78$, $p = .574$) and average workout duration ($b = 4.45$, $SE = 5.74$, $p = .440$). Results were also nonsignificant for the three-way interaction between implicit attitudes, affective attitudes, and effortful control in predicting LTPA MET minutes per week ($b = 20.96$, $SE = 203.75$, $p = .918$) and average workout duration ($b = 0.96$, $SE = 2.68$, $p = .721$).

Attentional control, activation control, and inhibitory control were tested to investigate whether individual effortful control facets attenuated the association between implicit attitudes and average LTPA duration (see Table 4). Only inhibitory control emerged as a significant moderator ($b = -6.50$, $SE = 2.12$, $p = .003$). As seen in Figure 2, individuals who fell 0.23 *SDs* below the mean or lower on inhibitory control (i.e., inhibitory control ≤ -0.23 *SDs*) evidenced a significant, positive relationship between implicit attitudes and average LTPA duration ($p < .05$). Those with inhibitory control scores > -0.23 *SDs* evidenced no association between implicit attitudes and average LTPA duration. The full model including the interaction between implicit attitudes and inhibitory control accounted for 9% of the variance in average workout duration. Attentional

Table 4 Results of Multiple Regressions Predicting Average LTPA Duration From Individual Effortful Control Subscales

| Predictor | R^2 | b | SE | p |
|---|-------|-------|------|-------|
| Attentional control model | .053 | | | |
| Intercept | | 35.54 | 2.36 | <.001 |
| Instrumental attitudes | | -1.40 | 2.90 | .630 |
| Affective attitudes | | 0.24 | 2.92 | .933 |
| Implicit attitudes | | 3.65 | 2.52 | .149 |
| Attentional control | | 0.44 | 2.41 | .856 |
| Implicit attitudes \times Attentional control | | -4.57 | 2.55 | .076 |
| Activation control model | .062 | | | |
| Intercept | | 35.78 | 2.35 | <.001 |
| Instrumental attitudes | | -0.20 | 2.93 | .945 |
| Affective attitudes | | -0.42 | 2.90 | .885 |
| Implicit attitudes | | 4.45 | 2.40 | .065 |
| Activation control | | 3.92 | 2.44 | .110 |
| Implicit attitudes \times Activation control | | -3.62 | 2.91 | .215 |
| Inhibitory control model | .092 | | | |
| Intercept | | 36.40 | 2.32 | <.001 |
| Instrumental attitudes | | -0.61 | 2.84 | .829 |
| Affective attitudes | | 0.65 | 2.81 | .819 |
| Implicit attitudes | | 3.19 | 2.44 | .194 |
| Inhibitory control | | -0.63 | 2.33 | .787 |
| Implicit attitudes \times Inhibitory control | | -6.50 | 2.12 | .003 |

Note. b represents unstandardized regression coefficients. Attentional, activation, and inhibitory control subscales come from the ATQ. ATQ = Adult Temperament Questionnaire; LTPA = leisure-time physical activity.

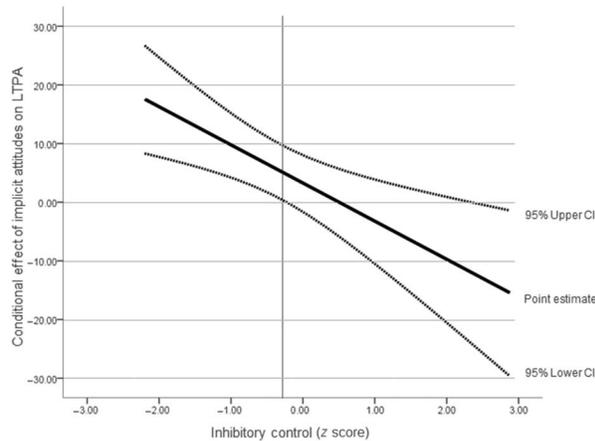


Figure 2 — Johnson–Neyman plot depicting the conditional effect of implicit attitudes on average LTPA duration at different inhibitory control values. Individuals who fell 0.23 *SDs* below the inhibitory control mean and lower evidenced a positive, significant ($p = .05$) relationship between implicit attitudes and average LTPA duration. LTPA = leisure-time physical activity; CI = confidence interval.

control was a marginally significant moderator ($b = -4.57$, $SE = 2.55$, $p = .076$), and activation control did not emerge as a significant moderator ($b = -3.62$, $SE = 2.91$, $p = .215$).

Discussion

In this study of active, young adults, individuals with more negative implicit attitudes toward PA reported spending less time in LTPA during an average workout. Implicit attitudes and average workout duration were related among lower and effortful control individuals, but not among those higher in effortful control.

These data are consistent with prior evidence indicating that implicit attitudes predict overall PA when measured objectively with pedometers (Conroy et al., 2010; Rebar et al., 2015). However, this study extends prior research by specifically addressing workout duration as an outcome. Evidence suggests that workout duration has important effects on mood and health. For example, in a study of 135 young adults, participants engaging in longer and low-impact workouts reported less negative mood post-exercise compared with those who worked out for shorter durations (Rocheleau, Webster, Bryan, & Frazier, 2004). Longer workout durations are also associated with greater muscular secretions of interleukin-6 into the blood. Although interleukin-6 is considered a proinflammatory cytokine, it appears to improve insulin sensitivity and decrease acute inflammation following exercise (Fisman & Tenenbaum, 2010; Petersen & Pedersen, 2006). Given the health benefits associated with longer workout durations, continued research of factors that drive this specific exercise behavior is warranted.

As hypothesized, individuals with higher levels of effortful control capacity relied less on implicit attitudes toward PA to guide behavior than those with lower effortful control. These results extend an important tenet of the SEM to the case of exercise, as implicit attitudes were associated with workout duration, but only among poorer self-regulators.

Additional analyses were conducted to explore the role of specific effortful control skills as moderators of the relationship between implicit attitudes and LTPA duration. The results of the current study provide evidence suggesting that this association was moderated by a person's inhibitory control or their ability to forgo a dominant response to choose a more appropriate one. Individuals with negative implicit attitudes may be using these skills to shift attention away from thoughts and reactions associated with those negative attitudes and to focus instead on thoughts/observations that may foster persistence, such as one's progress toward long-term goals. Activation control, the ability to initiate a behavior despite low motivation, did not influence the extent to which implicit attitudes influence PA duration. Activation control may be more important in determining the number of workouts a person engages in per week, as opposed to workout duration.

Although inhibitory control has not been studied as a moderator of the link between implicit attitudes and PA, prior research in other areas has demonstrated the importance of inhibitory control in attenuating the effects of implicit attitudes. For example, in one prior study, inhibitory control moderated the effect of implicit attitudes on food intake, such that positive implicit attitudes were only associated with increased food intake among those low in inhibitory control capacity (Haynes et al., 2015). Another research group examining the dual-process model in the context of employee safety found that individuals' automatic bias toward risk predicted failure to comply with safety regulations in the workplace, but only for those with poor inhibitory control (Xu, Li, Ding, & Lu, 2014). Also, in a study examining implicit attitudes toward alcohol and self-reported drinking behavior, the association between implicit attitudes and behavior was moderated by activity in the lateral prefrontal cortex, a neural correlate of inhibitory control (Friesse, Gianotti, & Knoch, 2016). Data from the current study extend prior research by suggesting that high inhibitory control may also weaken the association between implicit attitudes and average workout duration.

Unlike prior studies' findings (Calitri et al., 2009; Conroy et al., 2010; Hagger, Chatzisarantis, & Biddle, 2002), explicit attitudes were unrelated to weekly PA and average workout length, possibly due to our sample's low variability in explicit attitude scores and the high levels of PA in our sample. Indeed, the vast majority of participants in the current study reported very positive attitudes toward PA, with many responding as positively as possible, indicating that social desirability may have influenced explicit attitude responses in this

sample. Unfortunately, the current study did not assess participants' tendency toward social desirability bias, and therefore cannot address whether this altered their responses. Explicit attitudes were also unrelated to implicit attitudes; however, this finding is consistent with prior research (Hyde et al., 2010).

Contrary to hypotheses, the current study also did not find a significant association between implicit attitudes and LTPA energy expenditure. A power analysis conducted prior to study initiation indicated that 135 participants would provide 80% power to detect an association between implicit attitudes and energy expenditure, assuming a small effect size. However, given that the relationship was nonsignificant but in the expected direction, it is possible that the study did not have sufficient power to detect a significant relationship between implicit attitudes and weekly LTPA. The null association between implicit attitudes and total LTPA energy expenditure may also be due to high rates of PA reported by our sample. On average, participants reported engaging in over 350 min of LTPA per week. In contrast, the American College of Sports Medicine recommends 150 min of weekly PA, a goal reached by only 25% of American adults (Centers for Disease Control, 2014). Therefore, differences in results could be due, in part, to sample differences between the current study and prior studies.

Limitations

Ideally, PA would have been objectively monitored using actigraphs or pedometers, as self-report measures of PA are susceptible to overreporting and memory errors (Rzewnicki et al., 2003; Sallis & Saelens, 2000). Objective PA data may help to increase accuracy of PA estimates in subsequent studies of implicit attitudes and PA. However, it should be noted that most individuals tend to recall PA during leisure time fairly reliably (Booth, Owen, Bauman, & Gore, 1996). Participants also self-reported their effortful control as an index of self-regulatory capacity. Although self-report and behavioral measures of self-regulatory capacity (e.g., Stroop task) are frequently not correlated, this is likely because these measures capture different aspects of self-regulatory capacity. Recent findings suggest that behavioral measures are likely to gauge specific self-control processes (e.g., working memory capacity), whereas self-report measures tap into global, trait self-regulatory capacity (Allom, Panetta, Mullan, & Hagger, 2016). Given that trait self-regulatory capacity appears to be more strongly related to PA than behavioral tasks (Allom et al., 2016), a self-report measure was chosen for the current study.

Another limitation may be the use of an amended D-score algorithm for calculating implicit attitude scores from the IAT. Recent research indicates that alternative scoring methods (e.g., the EZ-diffusion model; Rebar et al., 2015) may be more strongly related to PA measures compared with the traditional D-score

algorithm. However, our use of the amended D-score algorithm is consistent with prior research using a personalized IAT, which indicates that personalized IAT scores calculated using the amended D-score algorithm were more closely tied to explicit attitudes and behavior compared with traditional IAT scores (Olson & Fazio, 2004).

An important limitation of the current study is the cross-sectional design. Therefore, one cannot rule out the possibility that with increased LTPA, individuals experience more positive attitudes toward PA over time. Also, participants in this study were highly active undergraduate students. Although participants reported broad ranges of PA levels, approximately 75% of our sample met national PA guidelines of 150 min of moderate-to-vigorous activity per week. In contrast, a large study of U.S. adults found that only 64% of young adults (age 20–29) met national recommendations (Tucker, Welk, & Beyler, 2011). Given this important limitation, results should be replicated in other samples to support generalizability to less active populations.

Implications and Future Directions

Novel results of the current study indicate that implicit attitudes relate to workout duration, an outcome important for mood and long-term physical health. Additionally, these results are the first evidence of a moderation effect of effortful control on the relationship between implicit attitudes and average LTPA duration.

The current study included a trait measure of effortful control to determine whether individual differences in cognitive control capacity influence the relationship between implicit attitudes and exercise behavior. These findings help identify an individual characteristic that may drive the extent to which people rely on implicit attitudes to guide their decisions. However, self-regulatory capacity is a limited resource that can fluctuate drastically from day to day (Baumeister, Vohs, & Tice, 2007). An individual's self-regulatory capacity at any given time may influence how individuals use implicit and explicit attitudes to guide their decisions. Additionally, there is some evidence to suggest that implicit attitudes have both stable and time-varying components (Hyde et al., 2012), and new evidence suggests that implicit attitudes are malleable in response to intervention (Berry, 2016). Given findings suggesting that both implicit attitudes and self-regulatory capacity may fluctuate over time, future studies should investigate the role of state cognitive control in the relationship between attitudes and exercise behavior, perhaps using ecological assessment techniques.

Importantly, the interaction between implicit and explicit attitudes was tested as a predictor of exercise behavior because the SEM suggests that discrepancies between implicit and explicit attitudes may be important predictors of behavior. Interestingly, the significant interaction between instrumental and implicit attitudes in

our sample was contrary to expectations. As hypothesized, individuals with negative instrumental and implicit attitudes were the least active; however, those with positive instrumental and implicit attitudes were not the most active. Instead, those with negative instrumental attitudes and positive implicit attitudes were the most active. We suspect that differences in self-regulatory capacity contribute to variability in exercise behavior among those with discrepant attitudes. The SEM asserts that poor self-regulatory capacity may be especially detrimental among those with larger discrepancies between their implicit and explicit attitudes because resolving such discrepancies is cognitively demanding (McConnell & Rydell, 2014). We attempted to test this theory directly by looking at three-way interactions between implicit attitudes, explicit attitudes, and effortful control, hypothesizing that attitude discrepancies would result in less PA compared with positive implicit and explicit attitudes, particularly among poor self-regulators. We did not find a significant three-way interaction; however, three-way interactions can be difficult to detect without a large sample size. The theory that self-regulatory capacity moderates the relationship between implicit and explicit attitude discrepancies and behavior should be tested in larger sample sizes, where there is sufficient power to detect a three-way interaction, should one exist.

Our evidence suggests that stronger inhibitory control may weaken the relationship between implicit attitudes and workout duration, and these results have important implications for intervention development. Improving implicit attitudes may be an important target for intervention, particularly for people with lower effortful control, or poorer self-regulatory capacity more broadly. Few researchers have explored the malleability of implicit attitudes toward PA and the behavioral effects of attitude change. However, research thus far suggests that interventions may be effective in altering implicit attitudes about exercise. Markland et al. (2015) administered a guided imagery intervention aimed at improving both implicit and explicit affective attitudes toward exercise. Regardless of PA level, individuals who completed the guided imagery intervention had more positive implicit attitudes toward exercise immediately following the intervention. Additionally, findings from the current study indicate that inhibitory control may serve as an intervention target. Intervention studies have found support for a number of different strategies for improving executive functioning performance. In conclusion, implicit attitudes may uniquely influence workout duration, specifically among those lower in self-regulatory capacity. These results have important implications for the development of interventions targeting exercise behavior.

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