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# Does Exercise Motivation Predict Engagement in Objectively Assessed Bouts of Moderate-Intensity Exercise?: A Self-Determination Theory Perspective

**Martyn Standage, Simon J. Sebire, and Tom Loney**
University of Bath

This study examined the utility of motivation as advanced by self-determination theory (Deci & Ryan, 2000) in predicting objectively assessed bouts of moderate-intensity exercise behavior. Participants provided data pertaining to their exercise motivation. One week later, participants wore a combined accelerometer and heart rate monitor (Actiheart; Cambridge Neurotechnology Ltd) and 24-hr energy expenditure was estimated for 7 days. After controlling for gender and a combined marker of BMI and waist circumference, results showed autonomous motivation to positively predict moderate-intensity exercise bouts of ≥10 min, ≥20 min, and an accumulation needed to meet public health recommendations for moderate-intensity activity (i.e., ACSM/AHA guidelines). The present findings add bouts of objectively assessed exercise behavior to the growing body of literature that documents the adaptive consequences of engaging in exercise for autonomous reasons. Implications for practice and future work are discussed.

***Keywords:*** exercise psychology, health behavior, physical activity, health

A compelling body of research documents the numerous physiological and psychological health benefits associated with regular physical activity and/or exercise participation (cf. American College of Sports Medicine [ACSM], 2006).[1] In a recent physical activity and public health recommendation, the ACSM and the American Heart Association (AHA) recommended that to promote and maintain such health benefits, adults should accumulate 30 min or more of *moderate-intensity* activity on a minimum of 5 days each week (ACSM/AHA guidelines; Haskell et al., 2007).[2] Despite the known health benefits of moderate-intensity activity, the World Health Organization (WHO, 2003) estimates that over 60% of the world's population is insufficiently active to profit from regular exercise and/or physical activity. Therefore from a public health perspective, understanding the determinants of moderate-intensity exercise represents an important avenue of research. Representing why an individual is *moved* to act (Ryan & Deci, 2000), an individual's

The authors are with the Motivation for Exercise, Sport, and Health Research Group, School for Health, University of Bath, Bath, United Kingdom.

underlying motivation toward expending the energy and effort required to partake in prolonged bouts of moderate-intensity exercise would appear to represent an important antecedent to such behavioral engagement.

While numerous theoretical models of motivation have been advanced to account for exercise behavior, a growing number of empirical studies have employed self-determination theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2000; see Hagger & Chatzisarantis, 2007, for exercise-specific reviews). An appealing feature of SDT is that motivation is considered from a multidimensional perspective, distinguishing between *autonomous* and *controlled* types of motivational regulation and their differential impact on an individual's psychological well-being, behavioral quality, persistence, functioning, and learning (Ryan & Deci, 2000).

When autonomously motivated, individuals endorse their own actions, acting with a full sense of volition because they find the activity to hold inherent interest and/or personal value (Ryan & Deci, 2006). Autonomous motivation is underpinned by two behavioral regulations, namely *intrinsic motivation* and *identified regulation*.[3] Intrinsic motivation is the prototype of autonomous motivation, reflecting fully self-regulated engagement in activities out of interest and spontaneous enjoyment (Ryan & Deci, 2000). Referring to a relatively autonomous form of extrinsic motivation (i.e., an individual's engagement in an activity is governed by some separable consequence), when an individual freely chooses to perform an activity because they accept and identify the underlying value of a behavior they are acting out of identified regulation. In contrast, when one's behavior is governed by external and/or internal pressures such as being coerced, persuaded, and/or seduced their motivation is classed as being controlled (Moller, Deci, & Ryan, 2006). The behavioral regulations underpinning controlled motivation are *introjected regulation* and *external regulation*. External regulation is the least autonomous form of extrinsic motivation, referring to actions controlled by external contingencies such as rewards and constraints (Ryan & Deci, 2000). As opposed to external contingencies directing one's actions, the impetus for introjected action is regulated by self-imposed sanctions such as shame, self-guilt, ego enhancement, and pride.

Self-determination theory proposes that when individuals are autonomously motivated in their actions, as opposed to being controlled to act, they will experience more interest, excitement, and confidence that will be manifested as enhanced performance and persistence (Ryan & Deci, 2000). With performance and persistence in mind, insight can be gleaned from past SDT-based research that has employed "free-choice" measures of behavioral engagement and/or markers of behavioral persistence. Indeed, experimental work has generally shown that individuals who are induced to participate in tasks for internal (or autonomous) reasons persist longer in free-choice behavior than those motivated by extrinsic factors (cf. Deci, Koestner, & Ryan, 1999; Deci & Ryan, 1985). Similarly, field-based studies in education (e.g., Vallerand & Bissonnette, 1992) and sport (e.g., Pelletier, Fortier, Vallerand, & Brière, 2001) have shown autonomous forms of motivation to positively predict behavioral persistence. As our intent was to explore exercise behavior in a "real life" setting, we chose to use an ecologically valid analog to the free-choice method. Specifically, we objectively assessed 7 days of energy expenditure in free-living conditions to obtain assessments of the participants' behavioral persistence, intensity, and frequency of exercise behavior. This approach is similar to past work that has employed behavioral persistence as a field-based alternative to assessing free-choice behavior (e.g., Pelletier et al., 2001; Vallerand & Bissonnette, 1992), and permits the testing of the utility of autonomous versus controlled motivation in predicting purposeful exercise behavior.

With regard to the behavioral concomitants of motivation in the exercise domain, Ryan and Deci (2007) assert that sustained exercise behavior is most likely when an individual partakes in the activity for autonomous reasons (i.e., they act through intrinsic motivation and well-internalized extrinsic motivation). Recent research has corroborated such theoretical reasoning by supporting the adaptive benefits of autonomous motivation. Indeed, extant work has shown autonomous types of motivation to positively predict higher levels of moderate-intensity self-reported exercise behavior (e.g., Gillison, Standage, & Skevington, 2006; McDonough & Crocker, 2007; Wilson, Rodgers, Blanchard, & Gessell, 2003; Wilson, Rodgers, Fraser, & Murray, 2004), a greater number of pedometer step-counts (Vierling, Standage, & Treasure, 2007), and increased behavioral persistence (Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004, Study 3). Although past work has documented the positive behavioral outcomes of autonomous motivation, past research couched in SDT has not employed accurate and precise objective markers of exercise activity/behavior (Standage & Vallerand, 2008).

As the precise and accurate assessment of activity is paramount to our attempts to better understand the motivational determinants of actual exercise and/or physical activity behavior, in the present work we used a recently developed unit (i.e., Actiheart [AHR]; Cambridge Neurotechnology Ltd). Specifically, the AHR is an extremely lightweight (8 g) unit that combines heart rate and accelerometry data using a novel branched-equation model to estimate 24-hr energy expenditure above rest (see Brage, Brage, Franks, Ekelund, & Wareham, 2005, for a technical overview). Such advancement in technology has made it possible to estimate energy expenditure at up to 15-s intervals for a period of up to 10 days. Previous research validating the AHR has demonstrated excellent estimates for total energy expenditure against indirect calorimetry during walking and running in healthy young individuals (Brage et al., 2005; Thompson, Batterham, Bock, Robson, & Stokes, 2006), and for a range of low-to-moderate intensity lifestyle activities, such as sweeping with a broom, digging and transferring sand into boxes, simulated watering of house plants, and folding and stacking laundry (Thompson et al., 2006). Further, the branched-equation modeling of simultaneous accelerometry and heart rate monitoring should improve the estimation of directly measured energy expenditure for activities involving gross arm and leg movements (e.g., weight lifting, cycling, and rowing), as the sole use of either accelerometry or heart rate telemetry has been shown to underestimate or overestimate energy expenditure during nonlocomotor or upper-body activities (Bassett et al., 2000; Crouter, Albright, & Bassett, 2004).

Using the AHR, the purpose of this investigation was to examine the utility of motivation from an SDT perspective in predicting variance in moderate-intensity exercise behavior. With respect to objectively assessed exercise behavior of moderate intensity, aligned with recent physical activity guidelines (see ACSM, 2006; Haskell et al., 2007), data were extracted based on three thresholds (i) time spent in bouts of moderate exercise for ≥10 min in length, (ii) time spent in bouts of moderate exercise for ≥20 min in length, and (iii) time spent in bouts of moderate exercise for bouts ≥10 min that contribute to meeting the ACSM/AHA guidelines. Based on SDT, we hypothesized that autonomous exercise motivation would positively predict each of the exercise bout durations. Further, we hypothesized that this effect would hold after controlling for two variables that have been shown to be related to exercise behavior in past work (viz., gender and a combined measure of body mass index [BMI] and waist circumference [WC]). Gender was controlled for because past work has shown that being male increases the likelihood of meeting the CDC/ACSM physical activity guideline criteria by 45% (Martin, Morrow, Jackson, & Dunn, 2000). Second, we controlled for the participants' BMI/WC owing to negative associations emerging in past work between BMI and self-reported exercise behavior (Markland & Ingledew, 2007) and BMI and pedometer step counts (Vierling et al., 2007). However, a combined measure of BMI and WC (BMI/WC) was employed in the present work because recent research has shown this anthropometric index to be a better predictor of metabolic and cardiovascular risk associated with excess adiposity than either BMI or WC alone (e.g., Zhu et al., 2004).

# Methods

## Participants

A total of 55 participants provided complete data. Three participants who engaged in swimming during the AHR assessment phase were excluded from data analyses (i.e., despite the numerous advantages of the AHR unit, one of its limitations is that it is not well suited for aquatic-based activities). To provide a more accurate comparison of motivation to the objectively assessed exercise behavior, these participants were therefore removed from the dataset before statistical analyses. As such, the final data set comprised of 26 male and 26 female British university students (*M* age = 22.27 years; *SD* = 3.41; range = 18.53–41.30 years). Anthropometrically, the sample members were within the normal/healthy range for BMI (*M* = 23.15 kg/m$^2$; *SD* = 2.39) and waist circumference (*M* for males = 82.45 cm; *SD* = 6.84; *M* for females = 76.27 cm; *SD* = 5.11; cf. ACSM, 2006). With respect to the physical activity level (PAL)[4] of the total sample (*M* = 1.84, *SD* = 0.24), participants were, on average, classified as being physically active (cf. WHO, 2000). Specifically, 34 participants (65.4%) achieved or exceeded the PAL value of 1.75, which is assumed to be indicative of an individual being physically active. Based on the WHO criteria, 7 participants' activity level fell between the criteria for limited activity to physically active (PAL = 1.61–1.74), 7 participants were classified as achieving limited activity (PAL = 1.55–1.60), and 4 participants were in the sedentary to limited activity range (PAL = 1.40–1.54).

# Procedure

Following institutional ethical approval, participants provided informed consent and completed a questionnaire pack containing a measure of exercise motivation (Time 1). Participants returned to the laboratory 7 days later, at which time anthropometric measurements were taken and the AHR unit fitted (Time 2). In an attempt to reduce any potential reactivity, participants were blinded to the functionality of the AHR and the true objective of the research. Throughout the recruitment process and study duration, participants were informed that the research was a double-blind design and that the research assistants were blinded to the study objectives and mechanics of the new technology/equipment (i.e., the AHR unit). Further, the first 24 hr of AHR recording was deleted to minimize the effect of any possible reactivity. The AHR unit was then worn for 8 days, after which participants returned to the laboratory (Time 3). At this time, the activity data were downloaded and the participants debriefed.

## Measures

***Exercise Motivation.*** The Behavioral Regulation in Exercise Questionnaire (BREQ; Mullan, Markland, & Ingledew, 1997) was used to assess the participants' motivation for exercise. Scored using a 5-point Likert-type scale, the BREQ consists of 15 items designed to tap an individual's *intrinsic motivation*, *identified regulation*, *introjected regulation*, and *external regulation* exercise motives. In the current study, the alpha coefficients for the regulations underpinning autonomous and controlled motivation were intrinsic motivation $\alpha = .93$, identified regulation $\alpha = .75$, introjected regulation $\alpha = .68$, and external regulation $\alpha = .71$. With respect to the motivational regulations, SDT hypothesizes that the various forms of motivational style will conform to quasi-simplex pattern of associations (see Ryan & Connell, 1989). Specifically, this proposition holds that motivational regulations that are adjacent along the self-determined continuum (e.g., intrinsic motivation and identified regulation) are more positively correlated than those more distal (e.g., intrinsic motivation and external regulation). As this structure was supported among the BREQ subscales in the present work (Table 1), aligned with SDT and past research (e.g., Williams, Grow, Freedman, Ryan, & Deci, 1996; Wilson, Blanchard, Nehl, & Baker, 2006), the intrinsic motivation and identified regulation subscales were averaged to form a score for autonomous motivation ($\alpha = .91$), whereas a score for controlled motivation ($\alpha = .68$) was created by averaging the responses provided to the introjected regulation and external regulation subscales.[5]

***Exercise Behavior.*** Participants wore an AHR device for a period of 8 days. The AHR unit, which simultaneously records heart rate and accelerometry data at 1-min epochs and 24 hr per day, was attached to the skin of the participant's chest (midway between and below $V_1$ and $V_2$, with the medial electrode located at $V_5$) using two standard ECG electrodes (Red Dot 2560, 3M; see Brage et al., 2005). Using a branched-equation model, the AHR software (Version 2.171) estimates energy expenditure above rest. With the latter in mind, sleeping heart rate was used to calibrate the unit to the participant's resting value (cf. Thompson et al., 2006). Subsequently, 7 days of energy expenditure data were assessed. In terms of extracting moderate-intensity exercise values, it is recommend that energy expenditure thresholds take account of individual's level of cardiorespiratory fitness (cf. Kesaniemi et al., 2001). Thus, in view of the characteristics of the present sample, *moderate-intensity* exercise behavior was defined as an energy expenditure ≥4.60 METs.[6] The time spent in moderate-intensity exercise for bouts ≥10 min, ≥20 min, and time spent in moderate-intensity exercise bouts ≥10 min that contributed to meeting the ACSM/AHA guidelines are expressed in terms of total time in physical activity equal or greater than 4.60 METs.

**Table 1 Bivariate Correlations Among the Study Variables**

| | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gender (1) | — | — | — | | | | | | | | | | |
| BMI/WC (2) | — | — | –.22 | — | | | | | | | | | |
| Intrinsic motivation (3) | 3.19 | .66 | –.28* | –.13 | — | | | | | | | | |
| Identified regulation (4) | 3.19 | .76 | –.24 | .00 | .74*** | — | | | | | | | |
| Introjected regulation (5) | 1.33 | .23 | .02 | .07 | .30* | .45** | — | | | | | | |
| External regulation (6) | 1.19 | .55 | .32* | –.06 | –.20 | –.08 | .28* | — | | | | | |
| Autonomous motivation (7) | 3.20 | .65 | –.27 | –.07 | .94*** | .93*** | .38** | .12 | — | | | | |
| Controlled motivation (8) | 1.21 | .56 | .17 | .03 | .10 | .29* | .88*** | .68*** | .21 | — | | | |
| Total moderate-intensity exercise ≥10 min (9) | 150.75 | 128.42 | –.49*** | .16 | .39** | .48*** | .18 | –.24 | .47*** | –.03 | — | | |
| Total moderate-intensity exercise ≥20 min (10) | 100.46 | 107.39 | –.38** | .23 | .38** | .41** | .13 | –.17 | .42** | –.02 | .92** | — | |
| Total moderate-intensity exercise ACSM/AHA guidelines (11) | 128.23 | 127.68 | –.50*** | .24 | .34* | .45*** | .22 | –.18 | .42** | .05 | .95** | .91** | — |

*Note*. Square-root-transformed data were used in the correlation analyses but nontransformed mean and *SD* values are presented.

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

## Data Analysis

Data were examined aligned with the assumptions pertaining to homogeneity of variance, linearity, and multicollinearity (cf. Tabachnick & Fidell, 2007). Unless stated, the data met these statistical assumptions. Descriptive statistics, alpha coefficients, and bivariate correlations among the study variables were then computed. Independent samples *t* tests were calculated to examine whether gender differences existed for mean values. Subsequently, and because the main purpose of this work was to ascertain whether exercise motivation predicted variance in exercise behavior above and beyond that accounted for by gender and BMI/WC, three separate sequential regression analyses were conducted for each dependent variable (i.e., each moderate-intensity exercise bout classification). For each of these regression analyses, gender and BMI/WC were entered in Step 1, whereas autonomous motivation and controlled motivation were entered in Step 2. The significance of the $F$ ratio accompanying the change in variance ($R^2$) for each step indicated the significance of the addition of each group of independent variables to the regression equation. If the step was significant, then the $t$ values of each independent variable within the regression equation were assessed.

# Results

## Preliminary Analyses

An inspection of the data revealed a number of the study variables to depart from normality. In view of the relatively small sample size, transformations were applied to variables that had large skewness and/or kurtosis values (Hair et al., 2006; Tabachnick & Fidell, 2007). An evaluation of the $z$ scores for skewness led to the transformation of seven variables to improve the linearity among the variables and the normality of their distributions. Specifically, we applied a *reflect and square root* transformation to intrinsic motivation, identified regulation, and autonomous motivation and a *square root* transformation to external regulation and the three objective assessments of moderate-intensity exercise activity. Following these transformations, skewness values were reduced to acceptable levels. To aid in the interpretation of the intrinsic motivation, identified regulation, and autonomous motivation findings, the value was re-reflected following transformation (cf. Tabachnick & Fidell, 2007). The transformed variables were used in the correlation and regression analyses.[7]

## Descriptive Statistics and Bivariate Correlations

Descriptive statistics and bivariate correlations are shown in Table 1. As shown, participants endorsed autonomous motives for exercise more highly than controlled reasons. Objectively assessed exercise bouts of at least 10 min were achieved, on average, more than an accumulation of 10-min bouts meeting the ACSM/AHA guidelines, and single bouts of 20 min or greater. Inspection of the bivariate correlations (Table 1) revealed gender to share a negative relationship with time spent in the three moderate-intensity exercise bout classifications. Congruent with our hypothesis, autonomous motivation was positively related with time spent in the three moderate-intensity exercise classifications. In contrast, controlled motivation was unrelated to time spent in any of the bouts of moderate-intensity exercise. The two motivational regulations underpinning autonomous motivation (i.e., intrinsic motivation and identified regulation) shared moderate and positive associations with the three objective assessments of exercise behavior. In contrast, the two motivational regulations forming the basis for controlled motivation (i.e., introjected regulation and external regulation) were not related to the three objective assessments of exercise behavior. Autonomous and controlled reasons for exercise behavior were not related. Finally, the three moderate-intensity exercise durations assessed by the AHR were positively and strongly associated.

Independent samples $t$ tests revealed males to record higher levels of objectively assessed exercise bouts of at least 10 min, $t(50) = 3.93$, $p < .001$; 20 min, $t(50) = 2.88$, $p < .01$; and an accumulation of bouts that meet the ACSM/AHA guidelines, $t(50) = 4.05$, $p < .001$. Although not reaching statistical significance, males tended to score higher than females on autonomous motivation, $t(50) = 1.94$ $p = .06$, whereas females tended to report greater levels of controlled motivation, $t(50) = -1.19$ $p = .24$.

## Sequential Regression Analyses

As shown in Table 2, time spent in moderate-intensity bouts of exercise activity for 10 min (or greater) was negatively predicted by gender and positively predicted by autonomous motivation. The addition of the motivation variables to the regression model accounted for an additional 13% of the variance in moderate-intensity exercise behavior. With regard to time spent in moderate-intensity bouts of exercise for 20 min (or greater), gender was a negative predictor in Step 1 but became nonsignificant when the motivational variables were added to the regression model in Step 2. Again, the addition of the motivation variables increased the explained variance by 13%, with autonomous motivation being a positive predictor of moderate-intensity exercise behavior. Time spent in moderate-intensity bouts of exercise for 10 min (or greater) that contributed to the individual meeting the ACSM/AHA guidelines was negatively predicted by gender and positively predicted by autonomous motivation. The addition of the motivational variables to the regression model accounted for an additional 10% of the variance in objectively assessed exercise behavior.

# Discussion

Using a combined heart rate and motion sensor unit (i.e., the AHR), this research sought to extend past work grounded in SDT by examining the utility of the motivation types outlined by SDT in predicting objectively assessed bouts of moderate-intensity exercise. Overall the study hypotheses were supported, thus corroborating and illuminating the benefits that autonomous exercise motivation has for predicting health-enhancing bouts of exercise behavior.

In the present work, autonomous motivation was hypothesized to positively predict moderate-intensity exercise bouts of greater (or equal) to 10 min, 20 min, and an accumulation of activity needed to meet the ACSM/AHA guidelines. When applied to exercise behavior, SDT holds that “sustained exercise is most likely when a person has both intrinsic motivation and well-internalized extrinsic motivation,

**Table 2 Summary of Sequential Regression Analysis for Predicting Exercise Bouts**

| Independent variable | $R^2$ | $\Delta R^2$ | β | *t* |
|---|---|---|---|---|
| **Time spent in moderate exercise for bouts ≥10 min in length** | | | | |
| Step 1: $F_{Change}(2, 49) = 7.69, p < .001$ | .24 | | | |
| Gender | | | −.47 | −3.70*** |
| Combined BMI/WC | | | .06 | .44 |
| Step 2: $F_{Change}(2, 47) = 4.92, p < .01$ | .37 | .13 | | |
| Gender | | | −.35 | −2.71** |
| Combined BMI/WC | | | .11 | .94 |
| Autonomous motivation | | | .39 | 3.10** |
| Controlled motivation | | | −.06 | −.45 |
| **Time spent in moderate exercise for bouts ≥20 min in length** | | | | |
| Step 1: $F_{Change}(2, 49) = 4.77, p < .01$ | .16 | | | |
| Gender | | | −.34 | −2.57** |
| Combined BMI/WC | | | .15 | 1.12 |
| Step 2: $F_{Change}(2, 47) = 4.35, p < .05$ | .29 | .13 | | |
| Gender | | | −.22 | −1.59 |
| Combined BMI/WC | | | .21 | 1.61 |
| Autonomous motivation | | | .39 | 2.94** |
| Controlled motivation | | | −.07 | −.54 |
| **Exercise bouts ≥10 min contributing to meeting the ACSM/AHA guidelines** | | | | |
| Step 1: $F_{Change}(2, 49) = 8.86, p < .001$ | .27 | | | |
| Gender | | | −.47 | −3.71** |
| Combined BMI/WC | | | .14 | 1.12 |
| Step 2: $F_{Change}(2, 47) = 3.87, p < .05$ | .37 | .10 | | |
| Gender | | | −.38 | −2.94** |
| Combined BMI/WC | | | .18 | 1.51 |
| Autonomous motivation | | | .32 | 2.57** |
| Controlled motivation | | | .04 | .32 |

*$p \le .05$; **$p \le .01$; ***$p \le .001$.

as both facilitate what is, normatively speaking, a precarious endeavor" (Ryan & Deci, 2007, p. 5). Supporting such theoretical reasoning and our hypothesis, the results showed that not only was autonomous exercise motivation positively related to all three objectively assessed bouts of moderate-intensity exercise, but sequential regression analyses showed the positive predictive effect of being motivated for self-endorsed reasons to hold when controlling for gender and a combined marker of

BMI/WC. In predicting a significant amount of variance in exercise bouts required to accrue health and fitness benefits (cf. ACSM, 2006), the findings are theoretically congruent and add objectively-assessed exercise behavior to the growing array of adaptive behavioral, cognitive, and affective consequences that have been shown to be positively linked to autonomous functioning in sport, exercise, and health settings (see Vallerand, 2007, for a review).

From a health promotion perspective, an appealing feature of SDT is that it provides valuable insight into how to foster increments in autonomous motivation. Proposing that social factors that satisfy the basic psychological needs as advanced by SDT (viz., for autonomy, competence, and relatedness) serve to facilitate autonomous motivation and well-being (see Deci & Ryan, 2000), a number of malleable antecedents couched in SDT have been identified (see Hagger & Chatzisarantis, 2007). Perhaps because exercise activities that are desirable for health benefit are not always intrinsically interesting, SDT's conceptualization of internalization may hold particular importance for enhancing autonomous motivation in exercise settings. Internalization denotes a progressive process in which controlling motives toward a previously uninteresting task become increasingly autonomous. Since past work has shown the perceived importance placed on physical activity to be positively associated with achieving the CDC/ACSM guidelines related to moderate-intensity activity (Martin et al., 2000), facilitating identified regulation through the internalization process would appear to hold much promise for promoting health-enhancing exercise behavior (see Edmunds, Ntoumanis, and Duda, 2006 for a similar argument). To this end, it is fortunate that Deci and his colleagues (e.g., Deci, Eghrari, Patrick, & Leone, 1994; Deci & Vansteenkiste, 2004) have identified various social preconditions for internalization to occur. These include (i) the interpersonal context being supportive of the basic needs; (ii) a meaningful rationale being provided; (iii) some expression of empathy, or acknowledgment of the concerns that the individual faces with regard to the behavior; and (iv) that the rationale and acknowledgment of empathy should be conveyed in a manner that portrays choice and support (e.g., "you may want to," "you can try"). From a public health perspective, extending the use of recent advancements in technology to assess changes in accurate and precise estimates of exercise and/or physical activity behavior as a function of interventions grounded in SDT represents an exciting avenue of work. It would be interesting in such work to examine the role that health practitioners, exercise leaders, fitness professionals, clinicians, and the wording of health education materials can play in changing autonomous motivation and health-enhancing exercise behavior.

Owing to issues pertaining to multicollinearity, the utility of each motivational regulation underpinning autonomous motivation (i.e., intrinsic motivation and identified regulation) to the prediction of objectively assessed bouts of exercise behavior was not explored. In such instances, the researcher may revert to the correlation values to interpret their data (Hair et al., 2006). As shown in Table 1, bivariate correlation values revealed identified regulation to share a slightly higher association with each of the three exercise behavior classifications than intrinsic motivation. Although the current findings support a positive (and similar) association between intrinsic motivation and bouts of moderate-intensity exercise behavior, recent cross-sectional work has shown identified regulation, not intrinsic motivation, to positively predict self-reported exercise behavior (e.g., Edmunds et al., 2006). To this end, because most people participate in exercise for instrumental reasons such as improving their health/fitness, losing weight, and enhancing their appearance (Ryan & Deci, 2007) and certain exercise activities (e.g., running on a treadmill, exercising on a step machine) can sometimes be construed as being boring and/or not inherently enjoyable, these findings are completely explicable at a cross-sectional level. Indeed, such findings reaffirm the role that identification holds for exercise participation (see Edmunds, Ntoumanis, & Duda, 2007, for a discussion). Although identified regulation has been advanced as a key variable when predicting proximal measures of leisure-time exercise behavior, prior research has shown that when exercising for intrinsic factors individuals are more likely to persist (e.g., Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997). Accordingly, future research attempting to disentangle the contribution that intrinsic motivation and identified regulation have for behavioral engagement in exercise would do well to examine the temporal interplay among these motivational styles. In such longitudinal work, the concurrent assessment of objective exercise behavior coupled with an index of behavioral persistence would allow researchers to test whether identified regulation represents the principal motivation governing immediate (or proximal) behavior while intrinsic motivation permits the inherent satisfaction needed for behavioral persistence.

With respect to controlled motivation, while past work has reported a negative association with self-report measures of exercise behavior (e.g., Wilson et al., 2006), we found no association to exist with objectively assessed bouts of moderate-intensity exercise behavior. Using longitudinal designs, it would be interesting in future work to examine whether controlled motivation is negatively related or unrelated to accurate assessments of exercise behavior. Such insight would allow researchers to examine the question of "if an individual does not come to self-endorse and personally value engagement in exercise behavior, do the negative repercussions assumed to be associated with controlled motivation eventually manifest?" Although not statistically significant, an inspection of the directional effects of the bivariate correlations for external regulation (negative) and introjected regulation (positive) with the three classifications of objectively assessed exercise behavior suggests that it would be interesting in future work to examine the temporal and independent effects of these controlling forms of motivation. Indeed, we feel that it would be particularly interesting in light of past cross-sectional work that has documented a positive association between introjected regulation and self-reported exercise behavior (e.g., Edmunds et al., 2006), to longitudinally examine the temporal relationship between introjected regulation and objective and precise measures of exercise behavior. Akin to work in the sporting domain (e.g., Pelletier et al., 2001) it may be that exercising through self-imposed pressure holds immediate impetus for prompting a behavior, but over time such internal sanctions have negative implications for long-term behavioral engagement and/or participation.

Consistent with past work (e.g., Martin et al., 2000), gender was a negative predictor of exercise bouts of moderate intensity. Specifically, females were less likely to participate in bouts of exercise behavior or meet the ACSM/AHA guidelines than their male counterparts. No relationship was observed between BMI/WC and the three moderate-intensity exercise bout durations. Although the present work used a precise and accurate assessment of moderate-intensity exercise behavior, researchers interested in the relationship between body composition and physical activity and/or exercise behavior may benefit from employing more accurate assessments of both variables. To this end, the use of dual-energy X-ray absorptiometry coupled with the AHR would allow researchers to (i) explore the relationship between exercise behavior and an accurate and precise measurement of body composition and (ii) document changes in body fat and lean body mass as a function of targeted health interventions.

A major strength of the current research was the use of an accurate and precise objective marker of exercise behavior. This said, there were also a number of limitations associated with the work. First, the findings are somewhat limited in terms of generalizability given the healthy nature of the participant sample. Future research using more diverse participants/samples is needed to determine the tenability of the present findings to the general population. Second, although we are confident that the majority of the activity bouts of equal or greater than 10 min at an intensity of at least 4.60 METs were indicative of exercise activity, it is possible that some other purposeful functions were captured by the AHR unit. To this end, we did ask the participants to list the main activities that they participated in during the week that they wore the AHR unit. These listed activities were then compared with the compendium of physical activities (cf. Ainsworth et al., 2000) to ascertain whether the activities with energy costs of 4.60 METs for a prolonged duration were reflected by activities deemed to be other than purposeful exercise behavior. Commensurate with the compendium of physical activities, the data showed the participants' lifestyle activities such as walking to the shops, stair climbing, and home maintenance (e.g., cleaning or moving furniture) not to equal or exceed 4.60 METs, nor were such activities likely to be enacted continuously for a period of 10 min or more without a short drop in intensity (i.e., intermittent in nature). Although we did not directly observe it in the present data, it is possible that other purposeful behaviors which were not planned exercise per se (e.g., active transport such as brisk walking and/or hill walking) of ≥4.60 METs for 10 min or more were captured by the AHR. Clearly, observations based on participant recall do not provide the most accurate and valid means of data analyses. Accordingly, future work in which the intent is not to blind the participant from the function of the AHR would do well to employ time-segmented activity diaries in an attempt to better align the participants' reported activities with AHR data. Third, and although we purposely attempted to reduce participant reactivity to the AHR unit, we did not obtain a measure of the participants' perceptions of the study intent and/or their views pertaining to the functional capabilities of the AHR unit. Such poststudy assessment would represent a worthy addition to future work employing the AHR unit as an objective marker of exercise and/or physical activity behavior. Fourth, in the present work we used the BREQ to assess autonomous and controlling forms of motivation. However, Deci and Ryan (1985) have also proposed that amotivation, which reflects a lack of intention to act or when individuals passively perform activities, should be included when trying to comprehend human motivation. Given that four of the participants in the current study were categorized as being sedentary based on their PAL scores, the addition of the amotivation construct to future work employing objective markers of exercise behavior would appear warranted. Finally, the cross-sectional nature of the current work precludes causal inferences. Future research using longitudinal or experimental designs would allow researchers to tease out the causal and long-term effects that exercise motivation, as postulated by SDT, has on objectively assessed exercise behavior.

In conclusion, the findings from the present investigation provide preliminary support for the utility of adopting an SDT approach to motivation when attempting to predict objectively assessed exercise bouts of moderate-intensity. While we are not advancing that motivation alone is the panacea for public health concerns associated with sedentary lifestyles (i.e., it is clear that a myriad of factors interact to determine exercise engagement such as demographic, biological, cultural, social, and built environment variables), our findings suggest that motivation as advanced by SDT may play a role. Indeed, and although limited to a young healthy sample, autonomous motivation positively predicted moderate-intensity exercise bouts deemed to be health-enhancing (cf. ACSM, 2006). The predictive utility of autonomous motivation was shown to be above and beyond body composition and gender, adding further support to the cogent body of literature documenting the health and well-being benefits of participating in exercise behavior for autonomous reasons.

## Notes

1. The term *exercise* is often used interchangeably with *physical activity*. Exercise is a type of physical activity that is planned, structured, repetitive, and purposeful (Caspersen, Powell, & Christenson, 1985). To continually expend energy in excess of 4.60 METs or greater for more than 10 min at a time, a concerted and conscious effort is essential. In addition, the compendium of physical activities indicates that activities with energy costs of 4.60 METs or greater are mainly reflective of exercise or sport behavior (see Ainsworth et al., 2000). Thus, the term moderate-intensity *exercise* was used to describe the activity assessed by the objective marker of behavior in the present work.

2. The ACSM/AHA report is an update to the consensus statement to the physical activity and public health guidelines published by the Centers for Disease Control and Prevention (CDC) and the ACSM (CDC/ACSM; Pate et al., 1995). Although the recommendation regarding bouts of moderate-intensity physical activity is fundamentally unchanged, it is more specific (i.e., stating a minimum of 5 days per week).

3. Self-determination theory also posits the existence of *integrated regulation* as a type of extrinsic motivation. Integrated regulation refers to when identifications have been incorporated within the self, meaning they have been assessed and brought into congruence with individual's other values and needs (Ryan & Deci, 2000). Most questionnaires (including the one used in this work) that assess motivation from an SDT perspective do not include an integrated regulation subscale. As such, we will not elaborate on this construct in this article.

4. Physical activity level is calculated as the ratio of total energy expenditure to resting energy expenditure (WHO, 2000). According to the WHO (2000), a PAL of 1.75 is indicative of a person who is physically active. The PAL values were included in the manuscript to provide the reader with information related to the participants' general activity levels. Since PAL values express daily 24-hr energy expenditure as a multiple of basal metabolic rate, this marker of energy expenditure encompasses all activities undertaken in a day, including those that are incidental, habitual, and purposeful. As such and even though we expect exercise motivation to contribute to the prediction of PAL via a positive association with autonomous motivation toward physical activity in general, it would seem to be beyond the scope of motivation toward the context of exercise alone to predict this overarching index of energy expenditure. To this end, the bivariate correlations conducted on the present data revealed there not to be a significant relationship between the motivation types and PAL.

5. Two anonymous reviewers suggested that it would be interesting to further explore how each motivational regulation contributed to the prediction of objectively assessed exercise behavior.

We entirely agree with their observations. Indeed, in the absence of issues pertaining to multicollinearity, this would have been our preferred data analytical approach. However, because the correlation between intrinsic motivation and identified regulation exceeded .70 (Tabachnick & Fidell, 2007), VIF values exceeded 2.5 (Allison, 1999), and the condition index approached 30 with more than two variance proportions exceeding .50 for more than two variables (Belsley, Kuh, & Welsch, 1980), the use of a composite *autonomous motivation* score was deemed appropriate. Calculating this composite score is consistent with statistical recommendations (Hair et al., 2006; Tabachnick & Fidell, 2007), aligned with the important autonomous and controlled regulation distinction advanced within SDT (cf. Deci & Ryan, 2000), and is congruent with a large body of past work couched in SDT that has contrasted autonomous versus controlled motivation (e.g., Williams et al., 1996; Wilson et al., 2006).

6. 1 MET (metabolic equivalent) is equal to resting energy expenditure ($\approx 3.5$ mL $O_2 \cdot kg^{-1} \cdot min^{-1}$). METs are multiples of this resting value.

7. It is important to note that analyses of the untransformed data yielded the same pattern of findings as the transformed data (i.e., autonomous motivation emerged as a positive predictor of moderate-intensity exercise above and beyond the variance accounted for by gender and BMI). Thus, we can have confidence in the raw metric of our data (cf. Cohen, Cohen, West, & Aiken, 2003).

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