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Journal

Psychology of sport and exercise, 14(5)

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Publication Date

2013-09-01

Peer reviewed

Published in final edited form as:

Psychol Sport Exerc. 2013 September ; 14(5): 776–785. doi:10.1016/j.psychsport.2013.04.005.

Psychological need satisfaction, intrinsic motivation and affective response to exercise in adolescents

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Abstract

Objectives—To further understanding of the factors influencing adolescents' motivations for physical activity, the relationship of variables derived from Self-Determination Theory to adolescents' affective response to exercise was examined.

Design—Correlational.

Method—Adolescents ($N=182$) self-reported psychological needs satisfaction (perceived competence, relatedness, and autonomy) and intrinsic motivation related to exercise. In two clinic visits, adolescents reported their affect before, during, and after a moderate-intensity and a hard-intensity exercise task.

Results—Affective response to exercise and psychological needs satisfaction independently contributed to the prediction of intrinsic motivation in hierarchical linear regression models. The association between affective response to exercise and intrinsic motivation was partially mediated by psychological needs satisfaction.

Conclusions—Intrinsic motivation for exercise among adolescents may be enhanced when the environment supports perceived competence, relatedness, and autonomy, and when adolescents participate in activities that they find enjoyable.

Keywords

Self-determination; Physical activity; Competence; Relatedness; Autonomy; Bootstrapping

Regular participation in moderate-to-vigorous physical activity (MVPA) during childhood and adolescence is critical for optimal health and chronic disease prevention, yet the majority of adolescents fail to meet recommended levels of MVPA. Physical inactivity during adolescence has been linked to a number of disease risk factors, including obesity and the metabolic syndrome (Reichert, Baptista Menezes, Wells, Carvalho Dumith, & Hallal, 2009; Rowland, 2007). Moreover, physical inactivity during adolescence is a strong predictor of a sedentary adulthood (Alfano, Klesges, Murray, Beech, & McClanahan, 2002; Kelder, Perry, Klepp, & Lytle, 1994), and inadequate physical activity during the adult years increases the risk of a host of health conditions, including atherosclerosis, heart disease, osteoporosis, stroke, and diabetes (Hu, Lakka, Kilpelainen, & Tuomilehto, 2007; Warburton, Nicol, & Bredin, 2006). In light of these deleterious health consequences of adolescent physical inactivity, it is a serious concern that the majority of adolescents do not engage in

regular MVPA. Estimates of the proportion of 14- to 17-year-olds who meet recommended levels of MVPA (60 min per day; Physical Activity Guidelines Advisory Committee, 2008) vary considerably, but fall consistently below 50% (Butcher, Sallis, Mayer, & Woodruff, 2008; Centers for Disease Control and Prevention, 2010), and attempts to increase adolescent activity have met with disappointing results (Van Sluijs, McMinn, & Griffin, 2008). To effectively address this problem, interventionists need more information about what motivates adolescents to engage in physical activity. Self-determination theory (SDT; Ryan & Deci, 2000a) provides a useful framework for exploring why individuals vary in their level of motivation for, as well as engagement and persistence in, physical activity.

Self-determination and exercise

SDT is comprised of several mini-theories. Grounded in the assumption that people have *basic psychological needs* to feel competent, autonomous, and a sense of belonging or relatedness to others, SDT predicts that as a result of developmental experiences that engender competence, autonomy, and relatedness, individuals will advance toward more autonomous (i.e., self-determined) motivational orientations. The most self-determined form of motivation is intrinsic motivation; the desire to engage in an activity because it is inherently pleasurable. This form of motivation is associated with behavioral persistence. Moreover, initially extrinsically motivated behaviors can become internalized and integrated into an individual's sense of self, leading to more *self-determined* forms of extrinsic motivation, to the extent that needs for competence, autonomy, and relatedness are supported by the social environment (Ryan & Deci, 2008). Thus, according to the tenets of SDT, self-determined motivations to exercise are a product of the extent to which the environment supports the satisfaction of psychological needs.

SDT theorists describe this process of internalization as a crucial aspect of children's development and growth into adults who regulate their behavior on the basis of internal values and regulations rather than external rules and regulations (Deci & Vansteenkiste, 2004; Ryan & Deci, 2000a). Adolescents are at a sensitive stage in their development, and are at an active stage of realizing their self-concept (Demo & Savin-Williams, 1992). They may therefore be especially responsive to environmental factors influencing the satisfaction of psychological needs. To the degree that adolescents internalize the value of a behavior, they may be said to be motivated by identified regulation; a form of external motivation in which a behavior is accepted as personally important (Ryan & Deci, 2000a) and that has been shown to be correlated with exercise behavior (Edmunds, Ntoumanis & Duda, 2008; Standage, Gillison, & Treasure, 2007). There is evidence that satisfaction of psychological needs through exercise is associated with more self-determined motivation to exercise among adolescents (Ntoumanis, 2005; Standage, Duda, & Ntoumanis, 2005) and adults (Wilson, Mack, & Grattan, 2008).

Inherent pleasure, enjoyment, and interest in exercise

We posit that an individual's level of intrinsic motivation to exercise will be reflected in the acute affective response to exercise. The affective response to exercise is the subjective experience of positive and/or negative feelings in response to acute exercise. Evidence shows that some people find exercise more pleasant and enjoyable than do others (Ekkekakis, Hall, & Petruzzello, 2005; Rose & Parfitt, 2007; Schneider & Graham, 2009; Welch, Hulley, Ferguson, & Beauchamp, 2007) and that the affective response to exercise appears to have a partial basis in generally invariable or stable personality characteristics of the individual (e.g., extraversion; Rhodes & Smith, 2006; behavioral activation; Schneider & Graham, 2009). There are also, however, situational factors that will influence the affective response to a particular exercise episode. These factors may include, among others, the

recent ingestion of carbohydrates (Backhouse, Bishop, Biddle, & Williams, 2005), the intensity of the exercise stimulus (Ekkekakis, Hall, & Petruzzello, 2008), and autonomy support (Rose & Parfitt, 2010). Recognizing these sources of variability in intra-individual affective response to exercise, the present study is nevertheless premised on the assumption that the acute affective response to a standardized exercise task will yield an indicator of participants' relative level of intrinsic motivation to exercise.

Our investigation builds on a growing body of evidence showing that enjoyment of exercise is a robust correlate of physical activity behavior (Rhodes, Fiala, & Conner, 2009). Specifically, positive affective responses to exercise have been shown to be positively associated with intrinsic and more self-determined extrinsic motivations for exercise (Edmunds et al., 2008; Focht, 2009; Lutz, Lochbaum, & Turnbow, 2003; Robbins, Pis, Pender, & Kazanis, 2004), and predict greater physical activity participation in both adults (Kwan & Bryan, 2010a; Williams et al., 2008) and adolescents (Schneider, Dunn, & Cooper, 2009). Consistent with past research, we expect that adolescents' affective responses to an acute exercise experience will be positively associated with intrinsic motivation for exercise.

According to SDT, intrinsic motivation can be bolstered or thwarted by the extent to which a behavior meets psychological needs for autonomy, competence, and relatedness (Ryan & Deci, 2000b). Therefore, we also predict that the affective response to exercise will be positively associated with intrinsic motivation to exercise, even after accounting for the effects of the satisfaction of psychological needs. In other words, both the affective response to exercise and satisfaction of psychological needs will be independently and directly related to intrinsic motivation for exercise.

Beyond the direct link between affective response to exercise and intrinsic motivation, we further postulate that perceived psychological needs satisfaction partially mediates this relationship. Such a mechanism is consistent with SDT and with more general theoretical work regarding exercise-related affect (Rhodes et al., 2009). According to SDT, intrinsic motivation arises from the *perception* that one's psychological needs for autonomy, competence and relatedness are being met (i.e., an apparently autonomy-supportive context may not necessarily be interpreted as such; Ryan & Deci, 2008). A positive affective experience during exercise could inform this perception (Blanchette & Richards, 2010). That is, we expect that experiencing positive affect during exercise will influence perceptions of the extent to which psychological needs are being met, and therefore indirectly impact intrinsic motivation to exercise.

A burgeoning literature supports the supposition that affect influences cognitions such as judgments, preferences, and evaluations of one's own abilities (Bandura, 1977; see a review by Blanchette & Richards, 2010), perhaps because affective experience is a source of feedback and information about the accuracy and effectiveness of our previous choices and behavior (Baumeister, Vohs, DeWall, & Zhang, 2007). A number of theories concerning the function of affect, such as the affect heuristic (Slovic, Finucane, Peters, & MacGregor., 2002) and affect-as-information (Schwarz & Clore, 2007), posit that affective valence (whether incidental or integral to the target of one's judgments) is used to inform our judgments and decisions. For instance, it has been demonstrated that being reminded of recent major environmental disasters heightens negative affect, which then influences general feelings of well-being and risk perceptions across multiple life domains (Västfäll, Peters, & Slovic, 2008). Recently, in the context of exercise, Kwan and Bryan (2010b) demonstrated that the affective response to exercise prospectively predicts exercise-related cognitive factors, including attitudes, self-efficacy, and intentions. Furthermore, enhanced exercise-related affect has been associated with satisfaction of psychological needs (Wilson, Mack, Blanchard, & Gray, 2009). These findings suggest that exercise-related affect can

provide information that subsequently shapes cognitions related to exercise, such as perceptions of environmental support for the need for autonomy, competence and relatedness. Thus, our expectation that psychological needs satisfaction partially mediates the link between the affective response to exercise and intrinsic motivation to exercise is grounded in both theory and evidence.

Study design considerations

Research into the factors that influence the acute affective response to exercise is relatively new, and has recently been organized conceptually around a dual-mode model that posits exercise intensity as a primary moderator of exercise-related affect (Ekkekakis et al., 2005, 2008). According to this theory, the affective response during exercise at a hard level of intensity (i.e., above the ventilatory threshold; the intensity level at which there is an abrupt increase in blood lactate or a nonlinear increase in expired carbon dioxide relative to oxygen consumption) is predominantly experienced as unpleasant, and will typically generate a negative shift in affect for most individuals. In contrast, the affective response near the ventilatory threshold will vary as a function of individual and situational attributes. Empirical studies have confirmed this pattern (Ekkekakis et al., 2005; Schneider & Graham, 2009; Welch, Hulley, & Beauchamp, 2010). In line with the dual-mode model, and as a further test of its validity, the present study employs both a moderate-intensity and a hard-intensity task, with the expectation that affective responses during the hard-intensity exercise task will be predominantly negative and therefore will obscure the hypothesized relationships between affective response to exercise and intrinsic motivation.

Another fairly recent innovation in research related to the affective response to exercise is the inclusion of measures of affect obtained during an exercise bout, rather than only before and after the exercise session. It has been suggested that studies in which researchers obtained measurements of affect only before and after exercise may have failed to pick up associations with the affective response to exercise because there is a near-uniform rebound toward positive affect following the cessation of exercise (Ekkekakis & Petruzzello, 1999). This rebound may obscure individual differences in affective responding experienced during the exercise session. Studies that have assessed affect during exercise have demonstrated that this approach yields unique and useful information (Bixby, Spalding, & Hatfield, 2001; Kwan & Bryan, 2010a; Sheppard & Parfitt, 2008; Welch et al., 2007, 2010). Accordingly, in the present study, we assessed affect before, during, and after each exercise bout.

It has been suggested that, in the case of exercise, identified regulation may be at least as influential as intrinsic motivation, since many people do not find exercise inherently enjoyable (Daley & Duda, 2006). This suggestion is based primarily on research with adults, with little available evidence among adolescents as to the relative salience of these two forms of motivation. Recognizing the role that relatively internalized forms of extrinsic motivation may play in exercise behavior, this study investigates the role of psychological needs and the affective response to exercise as correlates of both intrinsic motivation and identified regulation.

The present study

The purpose of this study was to extend prior research by simultaneously examining the respective contributions of the affective response to acute exercise and psychological needs satisfaction to intrinsic motivation to exercise. We hypothesized that both the affective response to moderate-intensity exercise and psychological needs satisfaction would be independently associated with intrinsic motivation to exercise, and that perceived psychological needs satisfaction would partially mediate the association between affective response to exercise and intrinsic motivation.

Method

Participants

The sample included 192 healthy (i.e., non-depressed and able to exercise without restrictions) adolescents between the ages of 14 and 16 years ($M_{\text{age}} = 14.78$ years, $SD = 0.45$; 54.7% male; 62% Caucasian, 21% Latino, 10% Asian, 4% multi-racial, 5% other). For details on recruitment procedures and inclusion criteria, see Schneider and Graham (2009).

Measures

Cardiovascular fitness—Participants performed a progressive ramp-type cycle-ergometer exercise test to the limit of exercise tolerance, and received verbal encouragement throughout the fitness testing protocol. Gas exchange was measured breath-by-breath (Cooper, Weiler-Ravell, Whipp, & Wasserman, 1984) and the ventilatory threshold and VO_2 peak were calculated using a Sensor Medics metabolic system (VIASYS, Yorba Linda, CA).

Psychological needs satisfaction—A pool of 15 potential items for assessing psychological needs satisfaction related to exercise was generated by reviewing the theoretical literature and relevant published instruments (see Table 1). All psychological needs items were rated on a 7-point scale from 1 (*not at all true*) to 7 (*very true*). Responses to the pool of 15 items by the 192 adolescents recruited to participate in the present study were used to validate the scales and select the items that would be retained in the analyses. An initial Factor Analysis with oblique rotation (“Principal Axis Factoring” command in SPSS) of the 15 items failed to yield a 3-factor solution, and identified three items that did not clearly load on any one factor. After the removal of these three items, a Factor Analysis with oblique rotation of the remaining 12 items yielded a 3-factor solution (the number of factors was established by examining the scree plot, and factors met the criterion of Eigenvalue greater than 1) that explained 66% of the total variance. Factor 1 accounted for 39% of the total variance, and contained the 5 items assessing perceived competence. Factor 2 accounted for an additional 15% of total variance, and contained the three items measuring perceived autonomy. The third factor accounted for 12% of the total variance, and was comprised of the 4 items assessing relatedness. All of the items loaded as expected on the three factors, with factor loadings uniformly in excess of 0.500. As a further test of the internal consistency of the three scales, Cronbach’s alpha was computed for each one. All of the scales showed very good internal consistency (see Table 1).

Competence: Items employed to assess competence were derived from the Intrinsic Motivation Inventory (IMI; McAuley, Duncan, & Tammen, 1989). The IMI is routinely modified to fit specific activities being studied. In the present case, items were modified to refer to exercise as the activity of interest; for example, “I am pretty skilled at exercising”. Following the factor analysis of the three psychological needs scales, five items were retained in the competence subscale.

Autonomy: At the time that this study commenced, there was no validated instrument available that purported to assess perceived autonomy related to exercise. Therefore, we composed four potential items that were conceptually based on the work of Ryan and Deci (2006), who define autonomy as “self-governance or rule by the self” (p. 1562). These four items, such as “when I exercise, I have control over the types of exercise that I do”, gauged how much control individuals felt that they had over the type of exercise in which they engaged. Three autonomy items were retained for analysis, based on the results of the factor analysis.

Relatedness: The pool of 5 items for measuring perceived relatedness in the context of exercise was obtained from the Motives for Physical Activity Measure-Revised (MPAM-R; Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997; Wilson, Rodgers, & Fraser, 2002). Ryan and Deci (2000c) describe relatedness as a sense of belonging and connectedness to the persons, group or culture disseminating a goal. Although the MPAM-R was designed to tap into individual motives for exercising, the items on the social motives subscale lend themselves readily to the assessment of the degree to which a person feels connected to those persons with whom s/he exercises. One such item reads “when I exercise, I do it because I enjoy spending time with others doing this activity”. Four items were retained in the relatedness scale after factor analysis.

Intrinsic motivation and identified regulation—Items from the Behavioral Regulations in Exercise Questionnaire (BREQ; Mullan, Markland, & Ingledew, 1997) assessed intrinsic motivation and identified regulation for exercise. Intrinsic motivation items reflect how much the respondent exercises because it is fun, enjoys his/her exercise sessions, finds exercise pleasurable, and gets pleasure and satisfaction from participating in exercise. Identified regulation items tap into whether the adolescent has internalized the value of exercise. Respondents indicated how true each item was for them on a scale of 1 (*not true for me*) to 5 (*very true for me*). Factor analysis of the intrinsic motivation items data from the present study revealed that four intrinsic motivation items loaded on a single factor and explained 62% of the variance (a single factor cannot be rotated). Factor analysis of the data from the three identified regulation items also loaded on a single factor and explained 54% of the variance. One additional variable, which has been included in the factor in prior studies, was dropped in this study because it showed poor correspondence with the factor. Table 1 lists the items.

Affective response—The Feeling Scale (FS; Hardy & Rejeski, 1989) is a single-item 11-point bipolar measure of pleasure-displeasure. Respondents rate “how you feel right now” on a scale ranging from -5 (*very bad*) to +5 (*very good*). The FS has been shown to represent a broad measure of affective valence, and is only moderately related to ratings of perceived exertion. Recent work has demonstrated that the FS is sensitive to changes in affect among adolescents during exercise (Sheppard & Parfitt, 2008).

Ratings of perceived exertion—Borg’s rating of perceived exertion (RPE) scale (Borg, 1982) permits the individual to report his or her overall level of perceived exertion. The scale ranges from a low of 6 (*no exertion at all*) to a high of 20 (*maximal exertion*). Participants reported an RPE every three minutes (excluding baseline) throughout the exercise tasks.

Heart rate—Heart rate was monitored continuously using a Sensor Medics V-max system (VIASIS, Yorba Linda, CA) via Cardio System software using a three-lead ECG. Heart rate was recorded every three minutes.

Procedure

Assessments—All assessments took place at a University-based General Clinical Research Center across three visits, with each visit separated by approximately one week. Participant assent and parental consent were obtained prior to study initiation. Study procedures were reviewed and approved by a University-based Institutional Review Board. On visit one, participants completed first the psychological needs and intrinsic motivation questionnaires, and then the cardiovascular fitness test. Using the breath-by-breath gas exchange data from the cardiovascular fitness test, the software provided with the Sensor Medics system was employed to determine the ventilatory threshold (VT) for each

participant. This software uses the V-slope method, which identifies “the transition in the CO₂ production rate in the muscles that occurs when lactic acid is produced faster than it is catabolized” (Beaver, Wasserman, & Whipp, 1986, p. 2025). Visual inspection of the data was used to confirm that the software-estimated VT was a valid reflection of the point where there was a break in the slope depicting the relationship of CO₂ production to O₂ uptake.

Participants completed a 30-min exercise task on a cycle ergometer during visits two and three. FS ratings were obtained at baseline (prior to the task), 10 and 20 min (in-task) and 30 and 40 min (post-task). Heart rate and RPE were obtained every 3 min throughout the exercise task. Each participant completed one exercise task below and one exercise task above the VT. Visits two and three were randomly determined to be either below the VT (moderate intensity; target work rate equivalent to 80% of the work rate at the participant’s VT) or above the VT (hard intensity; target work rate equivalent to the work rate at the mid-way point between the individual’s VO_{2peak} and VT). If the participant exhibited signs of fatigue (i.e., could not maintain a minimum pedaling cadence of 60 rpm), the exercise technician reduced the target work rate in increments of 5–10 W to ensure that the participant would be able to complete the task. Participants were blind to the intensity level of the task that they would be asked to complete, and received \$25 monetary compensation following each clinic visit.

Data analysis

Manipulation checks (repeated measures ANOVAs) were used to confirm that there were effects of the exercise tasks on heart rate, RPE, and FS, and that the hard-intensity task resulted in higher heart rates and RPE and lower FS, as expected. Where the assumption of sphericity was violated, the Greenhouse–Geisser adjustment of degrees of freedom was used. Pearson’s correlations were used to examine bivariate relationships among needs satisfaction, affective ratings, and motivation. Prior to computing the correlation coefficients, affective ratings were residualized to remove the effect of baseline affect to yield a variable that represented the change in affect from baseline levels. To control for Type I error inflation due to the multiple tests of significance, a Bonferroni correction was used, so that only those correlations that were statistically significant at or above the $p < .003$ criterion were identified as significant. Hierarchical regression analysis (controlling for VO_{2peak} and baseline affect) was employed to evaluate the relationship between affective ratings and intrinsic motivation and to examine the independent contributions of the affective ratings and psychological needs satisfaction on motivation. Gender was explored as a covariate, but as results were unchanged with gender in the model, this variable was not included in the final analyses. Cardiovascular fitness (VO_{2peak}), however, was significantly associated with intrinsic motivation, and has been suggested in prior research as a possible confounding variable in analyses of the affective response to exercise (Legrand, Bertucci, & Thatcher, 2009). Therefore, cardiovascular fitness was retained as a covariate. In step 1, cardiovascular fitness (a covariate) and baseline affect (FS at baseline) were entered simultaneously with intrinsic motivation as the dependent variable. In step 2, affective ratings either during or after the task were entered into the equation. In step three, the needs satisfaction variables (autonomy, competence and relatedness) were added. To confirm that the association between affective ratings and motivation was truly independent of psychological needs, the regression analyses were also examined when psychological needs were entered in step 2, and affective ratings were entered in step 3. Because the results were substantively unchanged, we report only the results of the equations in which affective ratings were entered in step two. Four models were created for in-task and post-task moderate-intensity and hard-intensity exercise. To further test our hypothesis that affect would be associated with motivation even after accounting for the effects of perceived needs satisfaction, we tested direct and indirect effects of affect on motivation using a

bootstrapping approach in a structural equation modeling framework, as described by Preacher and Hayes (2008). In these models, we examined both direct effects of affect on intrinsic motivation controlling for needs satisfaction, and indirect effects of affect on intrinsic motivation, mediated by the three needs satisfaction variables.

Results

Participant characteristics

A sample size of 182 was used, representing 95% of the full sample. Ten participants were excluded because they failed to complete all three of the required clinic visits. Means and standard deviations for SDT constructs and participant characteristics are shown in Table 2. The mean VO_2 at the VT was 1.30 L/min ($SD = 0.33$), and there was a high correlation between VT and $\text{VO}_{2\text{peak}}$ ($r = 0.81, p < .001$). On average, the VT was at 44% of $\text{VO}_{2\text{peak}}$ ($M = 0.44, SD = 0.10$; range = 21%–72%). The target work rate used to guide the moderate-intensity task averaged 35% of the work rate at $\text{VO}_{2\text{peak}}$ (mean 0.35, $SD = 0.08$; range 0.17–0.58), and the target work rate used to guide the hard-intensity intensity task averaged 71% of the work rate at $\text{VO}_{2\text{peak}}$ (mean = 0.71, $SD = 0.06$; median = 0.71; range = 0.42–0.86).

Exercise task work rate

During the moderate-intensity exercise task, 98% of the study participants maintained the target work rate throughout the exercise task. Two participants exhibited signs of fatigue, resulting in a reduction in work rate of 10 and 15 W, respectively. During the hard-intensity exercise task, 85% of study participants exhibited signs of fatigue, resulting in a mean reduction in the target work rate of 29W per participant for these 161 individuals (range = 5–90 W).

Manipulation checks

Heart rate—A 2 (exercise intensity) by 11 (time points: baseline, min 3, 6, 9, 12, 15, 18, 21, 24, 27, 30) repeated measures ANOVA on the heart rate data showed a significant main effect of exercise intensity, $F(1, 140) = 637.25, p < .001, \eta^2 = 0.82$, a significant main effect of time, $F(10, 131) = 431.28, p < .001, \eta^2 = 0.97$, and a significant intensity by time interaction, $F(10, 131) = 65.40, p < .001, \eta^2 = 0.83$. During the moderate-intensity task, average heart rate increased from 77.03 beats per minute (bpm) ($SD = 13.94$) during the warm-up to 143.18 bpm ($SD = 19.88$) at 30 min. Average heart rate during the hard-intensity exercise task increased from 77.45 bpm ($SD = 15.43$) to 180.06 bpm ($SD = 13.34$) at 12 min, and then remained relatively stable for the rest of the task.

Ratings of perceived exertion—A 2 (exercise intensity) by 10 (time points: min 3, 6, 9, 12, 15, 18, 21, 24, 27, 30) repeated measures ANOVA on the RPE data showed a significant main effect of exercise intensity, $F(1, 163) = 592.99, p < .001, \eta^2 = 0.78$, a significant main effect of time, $F(9, 155) = 92.86, p < .001, \eta^2 = 0.84$, and a significant intensity by time interaction, $F(9, 155) = 13.01, p < .001, \eta^2 = 0.43$. Average RPE during the moderate-intensity exercise task increased from 8.88 (very light; $SD = 2.04$) at 3 min to 13.68 (somewhat hard; $SD = 3.26$) at 30 min. During the hard-intensity exercise task, the average RPE increased from 12.19 (somewhat hard; $SD = 2.15$) to 17.01 (very hard; $SD = 2.13$) at 15 min, and then remained constant throughout the rest of the task.

Affective response to exercise—A 2 (exercise intensity) by 5 (time points: 0, 10, 20, 30, 40 min) repeated measures ANOVA on the FS data revealed a significant main effect of exercise intensity, $F(1, 179) = 230.36, p < .001, \eta^2 = 0.56$, a significant main effect of time, $F(4, 176) = 90.50, p < .001, \eta^2 = 0.67$, and a significant intensity by time interaction, $F(4,$

176) = 42.81, $p < .001$, $\eta^2 = 0.49$. Average FS ratings declined from 2.81 ($SD = 1.47$) at baseline to 2.27 ($SD = 1.84$) at 20 min ($t(182) = 4.38$, $p < .001$) during the moderate-intensity task and rebounded to a mean of 3.29 ($SD = 1.44$) by 40 min. During the hard-intensity exercise task, average FS ratings declined from 2.75 ($SD = 1.55$) at baseline to 0.14 ($SD = 2.26$) at 20 min, ($t(182) = 14.92$, $p < .001$) and remained depressed at 40 min ($M = 2.42$, $SD = 1.93$; see Fig. 1).

Intrinsic motivation, needs satisfaction, and affective ratings

Zero-order correlations between key study variables were examined as an initial test of our hypotheses, and were consistent with expectations (Table 3). Intrinsic motivation was significantly correlated with all psychological needs and with affective change during moderate-intensity exercise and after both moderate- and hard-intensity exercise. Identified regulation showed a similar pattern of associations except that it was not related to autonomy or change in affect during moderate exercise. Affect change during hard intensity exercise was not significantly correlated with any SDT variables. Based on coefficients of determination (r^2), it appeared that the effects for in-task and post-task affective response to moderate-intensity exercise were about two times larger for intrinsic motivation than for identified motivation. However, further evaluation of differences in the strength of these associations, using methods described by Steiger (1980) and adjusting for the number of tests of significance, revealed no statistically significant differences in variance explained in intrinsic motivation vs. identified regulation. For the sake of simplicity, the multivariate analyses reported below employed only intrinsic motivation as the dependent variable.

Multivariate analysis of predictors of intrinsic motivation

Hierarchical linear regression analysis was employed to examine the contributions of psychological needs and affective ratings to explaining the variance in intrinsic motivation. In the first step, VO_{2peak} and baseline affect were entered as covariates. On the second step, affect ratings were added to the equation. Psychological needs were added on the third step (see Table 4). Looking across the four models, it is evident that affect ratings during moderate-intensity exercise and affect ratings after both exercise tasks were associated with intrinsic motivation. Moreover, in each model for which affect ratings were associated with intrinsic motivation in Step Two, the magnitude of that association decreased in Step Three, following the addition of psychological needs in the equation. Based on the changes in R^2 values at each step, affect ratings during moderate exercise explained about 7% of the variance in intrinsic motivation, and psychological needs explained an additional 28%. The affect ratings after moderate exercise explained 13% of the variance in intrinsic motivation, with psychological needs contributing another 32% of variance explained. As expected, affect ratings during hard-intensity exercise were unrelated to intrinsic motivation, but affect ratings after hard-intensity exercise explained 7% of variance in intrinsic motivation. As hypothesized, the results suggest that whereas there are independent contributions to intrinsic motivation by both affective ratings and psychological needs (predominantly competence and autonomy), the latter may play an intermediary role in the association between the affective ratings and intrinsic motivation. We formally tested the mediation hypothesis using bootstrapping in a path analysis.

Tests of direct and indirect effects using bootstrapping

As a test of the hypothesis that perceived needs satisfaction plays an intermediary role in the association between affective ratings during exercise and intrinsic motivation, a path analysis using 5000 bootstrap samples and bias-corrected confidence intervals (95% confidence level) was specified in AMOS version 17.0 (maximum likelihood estimation), as recommended by Preacher and Hayes (2008) for testing multiple mediation (Fig. 2). The primary statistics for evaluating our hypothesis are point estimates and confidence intervals

for total, direct and indirect effects and variance explained in the dependent variable (i.e., intrinsic motivation). We also present model fit statistics (overall χ^2 test and Root Mean Square Error of Approximation, *RMSEA*), although with single degree of freedom tests (only one unspecified path), interpretation of the model fit statistics is limited.

As hypothesized, the direct effect of affect ratings on intrinsic motivation and indirect effects via needs satisfaction were estimated, controlling for the effects of baseline affect. The first model tested the direct and indirect effects of average in-task affect for moderate-intensity exercise on intrinsic motivation via perceived needs satisfaction (Fig. 2; model fit: χ^2 ($N = 182$, $df = 1$) = 0.65, $p = .42$, *RMSEA* = 0.00 (0.00, 0.18)). There were significant total ($est = 1.30$, 95% CI: 0.62, 1.95, $p < .001$), direct ($est = 0.53$, 95% CI: 0.04, 1.04, $p = .04$) and indirect ($est = 0.79$, 95% CI: 0.27, 1.38, $p = .003$) effects of average in-task FS on intrinsic motivation.

An analogous procedure was employed to test the same direct and indirect effects with respect to the affective ratings after the moderate-intensity task (Fig. 2; model fit: χ^2 ($N = 182$, $df = 1$) = 1.39, $p = .24$, *RMSEA* = 0.047 (0.00, 0.21)). There were significant total ($est = 1.60$, 95% CI: 0.98, 2.19, $p < .001$), direct ($est = 0.82$, 95% CI: 0.30, 1.42, $p = .002$) and indirect ($est = 0.77$, 95% CI: 0.29, 1.32, $P = .001$) effects of average post-task FS after moderate-intensity exercise on intrinsic motivation, supporting the hypothesis that affect would explain unique variance in motivation after accounting for indirect effects via needs satisfaction.

Next, we tested direct and indirect effects of in-task affect on motivation for hard-intensity exercise (Fig. 3; model fit: χ^2 ($N = 182$, $df = 1$) = 0.15, $p = .70$, *RMSEA* = 0.00 (0.00, 0.14)). There was a significant indirect ($est = 0.44$, 95% CI: 0.12, 0.81, $p = .004$) effect of average in-task affective ratings during hard-intensity exercise on intrinsic motivation, but no direct effect ($est = 0.07$, 95% CI: -0.29, 0.46, $p = .73$). Finally, an analysis of post-task affect for hard-intensity exercise revealed significant total ($est = 0.95$, 95% CI: 0.46, 1.46, $p = .001$), direct ($est = 0.56$, 95% CI: 0.17, 1.02, $p = .007$), and indirect ($est = 0.39$, 95% CI: 0.06, 0.77, $p = .02$) effects of average post-task ratings after hard-intensity exercise on intrinsic motivation (Fig. 3; model fit: χ^2 ($N = 182$, $df = 1$) = 0.96, $p = .33$, *RMSEA* = 0.00 (0.00, 0.20)).

Discussion

This study was designed to test the hypothesis that both exercise-associated affective ratings and perceived satisfaction of psychological needs in the context of exercise would each be independent predictors of intrinsic motivation to exercise; the results supported this hypothesis. Even after accounting for psychological needs, there was a significant positive association between the affective response to exercise (during moderate-intensity and after both moderate- and hard-intensity exercise) and intrinsic motivation for exercise. In a path analysis utilizing bootstrapping, affective responses exhibited both direct and indirect effects on intrinsic motivation. It appears that one way in which the affective response to exercise influences intrinsic motivation is through an association with the perception that psychological needs have been met.

It has been demonstrated that the affective response to exercise is associated with general intentions to exercise; a relationship that was also shown to be partially attributable to cognitive factors (exercise self-efficacy and attitudes; Kwan & Bryan, 2010b). Our findings are consistent with previous research in this respect. Our conclusion is therefore that adolescents' intrinsic motivation to exercise is a function of both the acute positive affective response to exercise and the perceived satisfaction of psychological needs for autonomy,

competence, and relatedness. Intrinsic motivation for exercise might thus be cultivated by repeated exposure to exercise experiences that generate acute positive affect and by a needs-supportive social context.

An additional hypothesis, derived from the dual-mode model (Ekkekakis et al., 2008), was the expectation that the association between intrinsic motivation and the affective response to exercise would be weak, if not entirely absent, for in-task responses to hard-intensity exercise. This expectation was based on the presumption that virtually all adolescents would report negative affect during hard-intensity exercise (above the VT), but would then report a relative rebound in affect after terminating the hard-intensity exercise session. Our findings are consistent with these expectations. In contrast to affective responses to moderate-intensity exercise, in-task affective responses to hard-intensity exercise were less positive, and were only weakly associated with intrinsic motivation (and not associated at all after controlling for cardiovascular fitness). However, post-task affect for hard-intensity exercise tended to recover to near-baseline levels and the relationship with intrinsic motivation increased. Upon the cessation of hard-intensity exercise, the oxygen deficit and accompanying unpleasant sensations dissipate with physiological recovery, so that the affective experience generally becomes positive. It appears that with the cessation of the physical demand, adolescents in the recovery phase experienced variable magnitudes in the affective rebound that typically occurs after exercise, and that some portion of this variability was associated with their intrinsic motivation for exercise. This pattern of findings is consistent with prior research (Parfitt, Eston, & Connolly, 1996; Sheppard & Parfitt, 2008) in which exercisers reported more positive affective valence during exercise of lower, compared to higher, intensities and more positive affect after compared to during exercise.

It should be noted that the hard-intensity task in this study was clearly at a level of intensity that pushed the participants to the upper limits of their abilities. The majority of the adolescents in this study (85%) were unable to maintain a pedaling cadence of 60 rpm at the target work rate, thus requiring downward adjustments of the work rate to enable them to complete the 30-min task. Consequently, participants may have been working at relatively different levels of intensity in relation to their ventilatory threshold. Despite this apparent variability in participants' levels of exertion, data on heart rates and RPE obtained during the exercise tasks illustrate clearly that the hard-intensity task was experienced as subjectively and physiologically more challenging than the moderate-intensity task. We therefore are confident that the protocol successfully resulted in two exercise conditions at distinctly different intensity levels, although future work in this area might yield similar results with less need for in-task adjustments if the initial target work rate were set somewhat lower than in the present study.

We examined the relative contributions of exercise-associated affect and psychological needs satisfaction to intrinsic motivation because of the strong theoretical rationale for proposing that feeling good during exercise would be associated with being intrinsically motivated to exercise. There are, however, other forms of relatively self-determined motivation enumerated in SDT that may also positively influence behavior. Identified regulation is one form of motivation that has emerged as potentially salient in exercise behavior (Daley & Duda, 2006; Wilson & Rogers, 2008), perhaps because many individuals exercise to achieve goals that are internally valued (e.g., fitness, appearance), rather than for the simple pleasure the activity affords. To allow comparison with these prior studies, we included analyses of identified regulation in the present investigation, and found that the associations between identified regulation and psychological needs were less consistent than those between intrinsic motivation and psychological needs. There was no association, for example, between identified regulation and affective ratings during the moderate-intensity

exercise task. Intuitively and theoretically, it makes sense that the affective response to acute exercise would have a stronger relationship with intrinsic motivation, which is based in an emotional association, than with identified regulation, which is grounded in the cognitive internalization of valued outcomes. Each of these sources of motivations may, of course, shape behavioral choices related to physical activity.

In interpreting our results, it should be noted that measures of intrinsic motivation and psychological need satisfaction were assessed with reference to exercise in general, whereas affective responses were assessed during a laboratory-supervised cycle ergometer task. It is possible that participants were considering very different types of activities when responding to questions about their motivation to exercise, and that these imagined contexts were not sufficiently similar to the laboratory setting to reveal the true relationship between intrinsic motivation and affective response. Still, Hagger, Chatzisarantis, Culverhouse, and Biddle (2003) showed that the relationship between autonomy satisfaction in one context of physical activity (physical education classes) can translate into increased participation in physical activity in a separate context (leisure-time physical activity). Thus, we expect that our measures of intrinsic motivation and need satisfaction for exercise in general would transfer to some extent to exercise conducted in a laboratory environment, and that, if anything, our findings underestimate the strength of the relationship between affective responses and intrinsic motivation.

Limitations

Certain methodological limitations should be noted, including the correlational nature of the design and the lack of correspondence between assessments of affective response to exercise in a laboratory setting and assessments of motivation and needs satisfaction that reference non-laboratory exercise, as discussed above. Future research might further illuminate the direction of influence between these variables by employing an experimental design and by exploring the stability of the affective response to a given exercise task across time and contexts. However, the inherent trade-off associated with testing these hypotheses in a more ecologically valid setting is loss of experimental control, such as the ability to objectively control intensity.

An additional limitation concerns the measurement of needs satisfaction. Recently, two newly developed measures were introduced to assess the satisfaction of psychological needs in relation to exercise. One, the Psychological Needs Satisfaction in Exercise scale (PNSE; Wilson, Rogers, Rogers, & Wild, 2006), has shown initial construct validity among undergraduate college students. The second, the Basic Psychological Needs in Exercise Scale (BPNES; Vlachopoulos & Michailidou, 2006), has been found to meet initial tests of validity among Greek-speaking adults who are participating in exercise programs. Neither of these instruments was published at the time that the present study was initiated, and they have not been validated among adolescents. Inspection of the items included on the PNSE and BPNES suggests that adolescents with a wide range of levels of exercise participation might have difficulty responding to the questions as they are worded. Our own scale analyses suggest that the measures used in the present study met standards for reliability, and comparison of the items that we used with those on the PNSE and BPNES indicates considerable similarity in content. However, it is possible that our results might have been different had another measure of psychological needs satisfaction been employed.

Although we did control for cardiovascular fitness in our analyses, there may be additional ways in which adolescents' recent participation in physical activity influenced the affective response to exercise. For instance, adolescents who had recently participated in team sports or other physical activity that would likely involve hard-intensity exercise may have been more accustomed to the physiological sensations that accompany exercise, and might

therefore have been less affectively influenced by the physiological sensations that accompany exercise. In contrast, sedentary adolescents might have been more sensitive to these sensations. Such differences would have introduced unmeasured variance into our analyses, and might have obscured some of the explanatory power of our models. We recommend that future research include objective assessments of the duration and intensity of recent aerobic activity.

Implications

The present findings have several implications for understanding adolescents' motivations to exercise. The results indicate that both the affective response to exercise and satisfaction of psychological needs contribute independently to intrinsic motivation. Among those adolescents, then, who tend to find exercise unpleasant, intrinsic motivation may still be cultivated if activities satisfy the basic psychological needs. Thus, interventions and resources might be targeted to encourage the growth of self-determined exercise motivations through supporting experiences of competence, relatedness, and autonomy as well as promoting the external benefits of exercising (to encourage identified regulation). Such efforts might be effective in preventing the decline in physical activity that often occurs during adolescence, and might complement the cultivation of intrinsic motivation for exercise through offering adolescents the opportunity to engage in physical activities that they find enjoyable.

Acknowledgments

This work was supported by National Institutes of Health grant HD-37746, and the UCI Satellite GCRC (MO1 RR00827). Many individuals contributed to the successful completion of this project. We would like to acknowledge the contributions of Lisa Bouchard, M.A., Dan Graham, Ph.D., Loren Sedano, Patrick Stanley, Pam King, Ph.D., and Dan Cooper, M.D.

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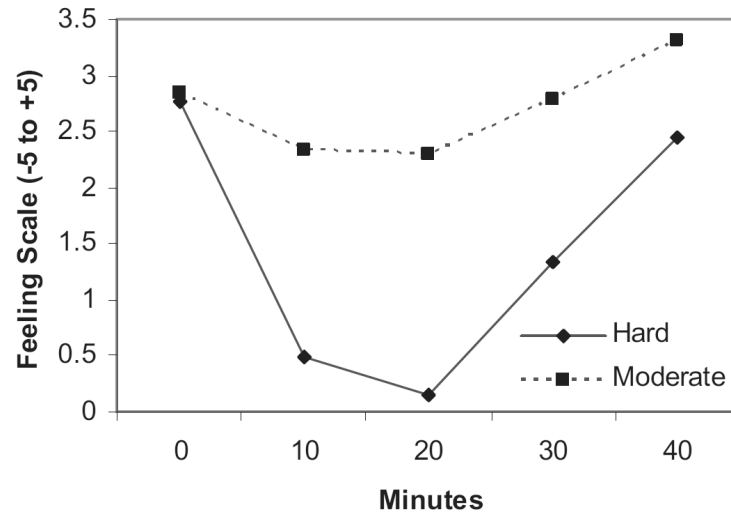


Fig. 1.
FS changes during moderate- and hard-intensity exercise.

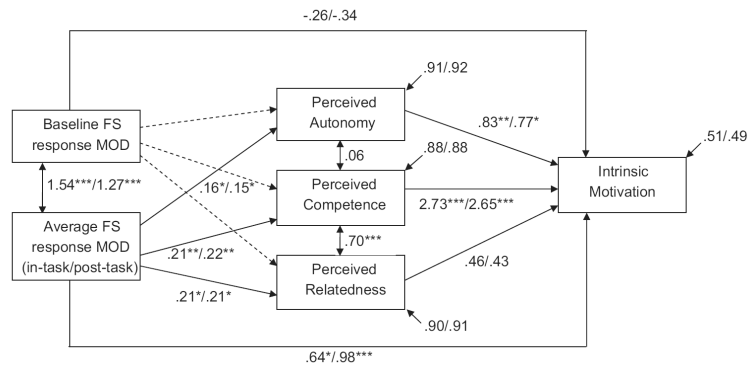


Fig. 2. Path models for testing direct and indirect effects of average FS ratings during and after moderate-intensity exercise on intrinsic motivation. Path coefficients are shown for in-task/post-task affective responses. Unstandardized path coefficients, covariances, and residual variances are shown. Non-significant paths are shown as dashed lines. * $p < .05$, ** $p < .01$, *** $p < .001$.

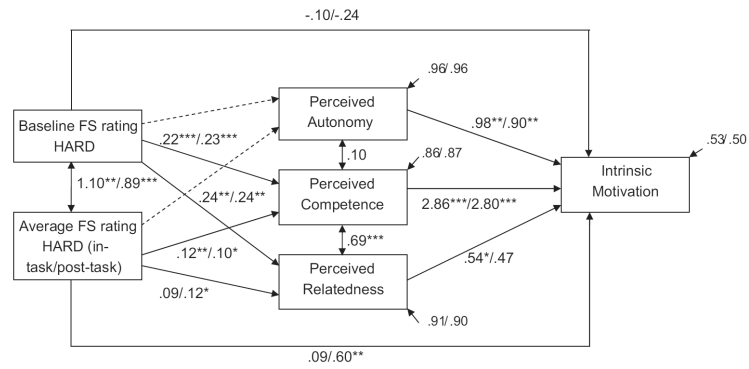


Fig. 3. Path models for testing direct and indirect effects of average FS ratings during and after hard-intensity exercise on intrinsic motivation. Path coefficients are shown for in-task/post-task affective responses. Unstandardized path coefficients, covariances, and residual variances are shown. Non-significant paths are shown as dashed lines. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 1

Scale items assessing psychological need satisfaction and intrinsic and identified regulations for exercise.

Scale	Cronbach's alpha
Competence	0.86
I think I am pretty good at exercising.	
I think I do pretty well at exercising, compared to other students.	
After exercising for a while, I feel pretty competent.	
I am satisfied with my performance when I exercise.	
I am pretty skilled at exercising.	
Exercising is something that I can't do very well. (reverse scored) ^a	
Autonomy	
When I exercise, I have control over the types of activities that I do.	0.81
I don't really have a choice about the types of activities I do when I exercise. (reverse scored)	
When I exercise, I do the types of activities that I want to.	
I feel like I have to do certain activities when I exercise. (reverse scored) ^a	
Relatedness	0.86
I exercise because.	
I want to be with my friends.	
I like to be with others who are interested in this activity.	
I want to meet new people.	
I enjoy spending time with others doing this activity.	
My friends want me to ^a	
Intrinsic regulation	0.88
I exercise because it's fun.	
I enjoy my exercise sessions.	
I find exercise a pleasurable experience.	
I get pleasure and satisfaction from participating in exercise.	
Identified regulation	0.77
I value the benefits of exercise.	
It's important to me to exercise regularly.	
I think it's important to make the effort to exercise regularly.	
I get restless if I don't exercise regularly. ^a	

^aItems removed from final scales based on factor analysis results.

Table 2

Descriptive statistics.

	Boys (<i>n</i> = 99)		Girls (<i>n</i> = 83)		Full sample (<i>n</i> = 182)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Perceived competence**	5.57	1.11	4.86	1.35	5.25	1.27
Perceived relatedness	5.10	1.45	4.65	1.66	4.90	1.56
Perceived autonomy	5.90	1.13	5.85	1.21	5.88	1.16
Intrinsic motivation	4.01	0.88	3.74	0.91	3.89	0.90
BMI (kg/m ²)	21.32	3.38	22.54	3.69	21.87	3.57
BMI percentile*	55.74	27.65	65.15	25.66	60.03	27.10
VO ₂ peak (l/min)***	2.83	0.53	2.02	0.40	2.46	0.63
VO ₂ peak (ml/kg/min)***	44.32	7.27	34.02	6.91	39.62	8.76

Note. Asterisks indicate significant difference between genders. BMI = Body Mass Index (weight/height²); BMI percentile = BMI relative to age- and gender-specific norms; VO₂peak = peak oxygen uptake. Ranges of all psychological needs scales = 1–7. Range for Intrinsic Motivation scale = 1–5.

* $p < .05$;

** $p < .01$,

*** $p < .001$.

Table 3

Correlations between psychological needs satisfaction, residualized affect ratings, and motivations for exercise.

Measure	Intrinsic motivation	Identified regulation
Competence	0.66 [*]	0.51 [*]
Relatedness	0.42 [*]	0.25 [*]
Autonomy	0.29 [*]	0.19
Affect during mod ^a	0.30 [*]	0.21
Affect after mod ^b	0.38 [*]	0.25 [*]
Affect during hard ^c	0.17	0.16
Affect after hard ^d	0.29 [*]	0.29 [*]

^{*} $p < .003$.

^a Mean of Feeling Scale ratings at 10 and 20 min (moderate exercise) regressed on baseline Feeling Scale ratings.

^b Mean of Feeling Scale ratings at 30 and 40 min (moderate exercise) regressed on baseline Feeling Scale ratings.

^c Mean of Feeling Scale ratings at 10 and 20 min (hard exercise) regressed on baseline Feeling Scale ratings.

^d Mean of Feeling Scale ratings at 30 and 40 min (hard exercise) regressed on baseline Feeling Scale ratings.

Table 4

Summary of regression analyses examining unique contributions of psychological needs and affective response to exercise to intrinsic motivation.

Predictor	Model 1 During moderate			Model 2 After moderate			Model 3 During hard			Model 4 After hard					
	B	SE	β	ΔR^2	B	SE	β	ΔR^2	B	SE	β	ΔR^2			
Step 1				0.08				0.12				0.02	0.07		
Residualized Affect	1.43 ^{***}	0.37	0.27		1.76 ^{***}	0.35	0.35		0.52 [*]	0.25	0.15		0.92 ^{***}	0.25	0.27
Step 2				0.42				0.39				0.45			0.43
Residualized Affect	0.62 [*]	0.29	0.12		0.95 ^{**}	0.27	0.35		0.09	0.18	0.03		0.57 ^{**}	0.18	0.17
Competence	2.78 ^{***}	0.31	0.55		2.71 ^{***}	0.31	0.53		2.84 ^{***}	0.31	0.56		2.80 ^{***}	0.31	0.55
Autonomy	0.89 ^{**}	0.31	0.16		0.84 ^{**}	0.29	0.15		0.97 ^{**}	0.32	0.17		0.91 ^{**}	0.30	0.16
Relatedness	0.49	0.25	0.12		0.47	0.24	0.11		0.53 [*]	0.25	0.13		0.47	0.25	0.11
FStatistics	$F(4, 177) = 42.34$ ^{***}				$F(4, 177) = 46.02$				$F(4, 177) = 40.30$				$F(4, 177) = 44.745$		

Note. Intrinsic Motivation variable was squared for analyses;

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Residualized affect was computed by taking the mean of the Feeling Scale ratings at 10 and 20 min (during exercise) and at 30 and 40 min (after exercise) and then regressing them on baseline affect.