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Article Title: Are we underestimating the affective benefits of exercise? An experience sampling study of university aerobic students.

Address:
Heather White (hwhite)
2514 25th street
Lubbock, Te
Are We Underestimating the Affective Benefits of Exercise?  
An Experience Sampling Study of University Aerobics Participants  
Rafer Lutz  
Baylor University  

Marc R. Lochbaum  
Tyler Carson  
Staci Jackson  
Texas Tech University  

Mike Greenwood  
Baylor University  

Allyn Byars  
Angelo State University  

This research sought to examine how exercise-related affective states compared with average daily affect. To answer this question, this investigation combined naturalistic methods (i.e., experience sampling) with a more typical exercise protocol. Participants were 36 university students enrolled in step aerobics classes. Participants were asked to carry Palm data recorders set to randomly cue them to complete a questionnaire to tap the affective dimensions of arousal (AD ACL; Thayer, 1989) five times per day over a 7-day period. In addition, participants were asked to complete the AD ACL immediately before, at the midpoint of exercise, and after a 15-min cool-down period after engaging in a bout of aerobic exercise in a class setting. Intensity of exercise was self-chosen, and mean intensity was “strong” (M = 5.28, SD = 1.73) based on Borg’s 10-item RPE scale. Daily affect, based on the mean of experience sampling points, and preexercise scores were significantly different for the tension and tiredness subscales. Tension and tiredness were greater during daily recordings than during the preexercise baseline. Results suggest that researchers may be underestimating the tension- and tiredness-reducing effects of exercise if this finding is replicable. The limitations of this research, such as possible contamination by diurnal variations in affective states, are considered.
There is considerable support for the ability of acute bouts of exercise to influence affective states (e.g., Arent, Landers, & Etnier, 2000; Landers & Petruzzello, 1994; Thayer, 1987a). Studies have generally shown that exercise increases states of positive affect or energetic arousal (Gauvin & Rejeski, 1993; Lutz, Lochbaum, & Turnbow, 2003; Thayer, 1987a), and reduces anxiety, tension, or negative affect (Breus & O’Connor, 1998; Kennedy & Newton, 1997; Petruzzello, Jones, & Tate, 1997; Thayer, 1987a). Interestingly, research has demonstrated that exercise may be similarly effective in the treatment of depression compared with other commonly-employed modalities such as selective-serotonin reuptake inhibitors (Dunn, Trivedi, Kampert, Clark, Chambliss, 2005). A limitation exists, however, in that most studies compare postexercise affect to preexercise affect rather than daily affect. This is problematic because the magnitude of the influence of exercise on affective states may be misrepresented if baseline measures are influenced by the laboratory situation or knowledge of impending exercise engagement, or if such baselines are simply different than the affect individuals experience on a daily basis. While several studies have examined affective states in naturalistic settings (Gauvin, Rejeski, & Norris, 1996; Giacobbi, Hausenblas, & Frye, 2005; Thayer, 1987a), only one known study (Petruzzello, 1995) has yet combined the common pre-post exercise methodology with a naturalistic assessment of affective states. The present investigation, therefore, sought to examine how average daily affect compares to affective states reported before, at the mid-point, and after an exercise session.

Closely related to the present question of interest, Petruzzello (1995) examined whether commonly-reported reductions in state anxiety after exercise might be due to a “sense of relief” that exercise is over. He recruited participants for a study to assess “coping strategies and psychological control” and, upon arrival in the laboratory, two resting baselines of heart rate and state anxiety (10-item State Anxiety Inventory, SAI; Spielberger, 1983) were taken. Next, participants were told that they would be required to run on a treadmill for 15 minutes and two more resting heart rate and state anxiety baselines were taken. There was no significant change in either heart rate or state anxiety comparing the baselines taken before revelation of the exercise requirement with those taken after this revelation. Additionally, Petruzzello had participants take four SAI’s during the course of a 24-hr period outside the lab. The mean levels of state anxiety taken outside the lab were in fact slightly greater (Study 1 $M = 16.3, SD = 5.0$ & Study 2 $M = 17.7, SD = 4.5$) than the mean of the baseline SAI’s taken in the lab (Study 1 $M = 15.4, SD = 3.99$ & Study 2 $M = 16.1, SD = 4.3$), though these were not significant differences. Based on these results, Petruzzello stated that it is unlikely that anxiety reduction following exercise is an artificial finding, due to a sense of relief that exercise is over.

At present, the “sense of relief” phenomenon investigated by Petruzzello (1995) does not appear to be an important factor related to the anxiolytic effects of exercise. One could
make this case considering Petruzzello’s findings, the relatively long-lasting (up to 2 hrs or more) anxiety-reducing effects of exercise (e.g., Raglin & Wilson, 1996), and the fact that anxiety-reduction occurs after a wide range of physical activities at low to moderate intensities (see Ekkekakis & Petruzzello, 1999) which wouldn’t be expected to invoke a sense of relief upon completion. Still, research has not often addressed the possibility of a sense-of-relief occurring after exercise and it should not be ignored. Even if the sense-of-relief explanation for anxiety reduction is not valid, it is important to consider how exercise influences affect considering pre and postexercise affective states and how they may differ from an individual’s “average” affective states. For example, subjects in Petruzzello’s research were slightly more anxious (though not significantly) outside the laboratory than in the laboratory.

Considering the question regarding whether daily affect and preexercise affect differ and Petruzzello’s (1995) study, it would be of interest to examine this question using a broader set of affective dimensions than just anxiety. Exercise appears to have somewhat different effects on positive and negative affective states (Bartholomew, 1999), so it would appear important to consider several points on the affective “circumplex” (see Carroll, Yik, Russell, & Barrett, 1999) as opposed to only one. Another potential limitation of Petruzzello’s study was that there were a very limited number of measures of daily affect (four) taken, and it is unclear if they occurred randomly throughout the day.

The Importance of the Baseline

It is important to understand how affect may be influenced at the baseline time point because preexercise affect appears to influence the effects of exercise on postexercise affect. For example, O’Connor, Petruzzello, Kibitz, and Robinson (1995) found that those with higher preexercise anxiety levels exhibited larger reductions in anxiety following maximal aerobic exercise testing (r’s = .27 to .65). Also, postexercise improvements in revitalization have been shown to exist only if participants’ baseline scores were low or moderate (Rejeski et al., 1995). In fact, Rejeski and colleagues state that “some of the confusion in the existing literature regarding effect sizes from psychological research on exercise may have been caused by differences in level of baseline functioning” (p. 357).

Experience Sampling Method (ESM)

A problem arises, however, in determining how to best measure affective experience in participants’ daily lives. One potential solution is the use of the ESM (Csikszentmihalyi & Larson, 1987; Diener & Larsen, 1984), which provides a means of collecting information about daily life in its natural setting by allowing participants to respond to repeated assessments over time. In this method, participants can be signaled with a pager or electronic device at fixed
or random intervals throughout the day to complete brief self-report forms. The ESM reduces problems in research of daily life due to memory recall and it is an effective means by which to measure within-subject variance across situations and/or over time (Hektner & Csikzentmihalyi, 2002; Scollon, Kim-Prieto, & Diener, 2003). A benefit of the ESM is that it allows for sampling of daily experience without contamination by expectancy effects that might be due to prior knowledge of the sampling period (Alliger & Williams, 1993). Thus, employing the ESM in addition to a more commonly-used exercise protocol may allow for an interesting comparison of daily vs. exercise-related affective states.

Statement of the Problem

Raglin (1997) and Morgan (1997) have suggested that behavioral artifacts (e.g., volunteerism, experimenter expectancy effects, Hawthorne effect, and participant expectancies) may be influencing the magnitude of the effects of exercise on affect. Yet, we have very little information concerning how affective states measured pre and postexercise relate to affective states experienced through the course of daily life. Understanding whether any such differences occur between daily and preexercise affect may be useful for better understanding different magnitude effects demonstrated by individual studies and would allow a more comprehensive understanding of the role exercise plays to influence affective states. If differences were observed between daily and preexercise affective states, it might indicate that artifacts such as participant expectancy may be influencing the magnitude of affective response to exercise. Therefore, the intent of the present study is to compare affective states before, at the mid-point, and after a class exercise session to daily affect reported over one week.

Method

Participants

College-aged males \((n = 15)\) and females \((n = 21)\) were recruited for the present investigation. All participants were enrolled in one of three separate sections of step aerobics led by one of two instructors and were recruited by open invitation by one of the investigators during one of their class periods. Of the total number of students in these classes \((n = 75)\), 48% agreed to participate. Participants’ ages ranged from 18 to 23 years \((M = 20.26, SD = 1.15)\), and participants reported a relatively frequent amount of physical activity as they engaged in an average of 2.97 \((SD = 1.48)\), 3.00 \((SD = 1.83)\), and 3.34 \((SD = 2.77)\) bouts of exercise per week at strenuous, moderate, and mild intensities, respectively (Leisure-Time Exercise Questionnaire, LTEQ total score: \(M = 51.72, SD = 20.93; \) Godin & Shepherd, 1985).
Measures

Activation Deactivation Adjective Checklist (AD ACL). The AD ACL short form (see Thayer, 1989, Appendix A, pp. 178-180) was used to assess four dimensions of affective space—energy (unipolar scale items: active, energetic, vigorous, lively, full-of-peak), tiredness (sleepy, tired, drowsy, wide-awake, wakeful), calmness (placid, calm, at-rest, still, quiet), and tension (jittery, intense, fearful, clutched-up, tense). In all instances, participants were to respond to these items by indicating how they felt “at this moment.” The AD ACL assesses two bipolar dimensions of arousal, energetic arousal and tense arousal, considered somewhat analogous to positive affect and negative affect in Watson and Tellegen’s (1985) two-factor model. Yet, it has been argued that affect is best represented in circumplex space (Carroll et al., 1999), and Ekkekakis and Petruzello (2002) have made a case for the use of the circumplex model in the study of exercise, thus the four unipolar dimensions of affect represented by the AD ACL (energy, tiredness, calmness, and tension) were employed as the dependent measures in the present investigation.

There are a wide variety of affective measures that have been employed in past studies in this area and could have been chosen for the present investigation. Certainly, there seems to be no shortage of controversy regarding the choice of affective measures related to exercise (see Ekkekakis & Petruzello, 1999, 2002). Yet, the underlying theory behind the development of the AD ACL is well suited to studies of exercise engagement and resultant effects on affective states. As physical exercise strongly influences physical activation, it makes sense to examine affective dimensions that may be related to the body’s harnessing of resources for energy expenditure. The AD ACL was originally developed to measure nondirective arousal states (Thayer, 1986), but eventually revealed the presence of two underlying arousal dimensions—one related to energetic arousal which is related to circadian rhythms but which can be temporarily influenced by thoughts and experiences, and the other related to tense arousal which functions as a warning system and is more strongly tied to environmental experience (Thayer, 1989). Thus, this scale seems particularly appropriate in regards to the study of exercise and affective states as it should capture the complex dynamics related to changes in the body’s activation systems which should be expected upon engaging in physical exercise. Additionally, the AD ACL’s reliability and construct validity are well established (Purcell, 1982; Thayer, 1986), and Ekkekakis, Hall, and Petruzello (2005) found that the AD ACL possessed satisfactory circumplex structure for use in physical activity contexts.

Ratings of perceived exertion (RPE). RPE was completed based on Borg’s (1998) 10-point, category-ratio scale. The scale ranges from 0 nothing at all to 10 very, very strong to a single point of maximal exertion. While Borg’s 15-point scale has been widely used, the 10-point category-ratio scale was designed using ratio properties to avoid ceiling effects. This
version, as other versions of Borg’s scales, has been shown to be a valid and reliable indicator of fatigue and physical exertion (Chen, Fan, & Moe, 2002; Noble & Robertson, 1996).

**Procedure**

After receiving permission from the class instructors to perform research in their aerobics classes, students were approached within the class periods (8:00am, 9:00am, and 12:30pm classes) and provided an overview of the investigation. Interested individuals were then given the informed consent form as approved by a University Human Subject’s Institutional Review Board to read and sign.

Before participants were recruited, the Experience Sampling Program (ESP; Barrett & Feldman Barrett, 2003) was loaded onto 10 Palm PDA devices (Palm Zire Handheld PDA with 2MB memory, Palm, Inc.), which was designed for experience sampling studies using the Palm operating system. These Palm recorders were programmed to cue participants to complete the AD ACL five times per day over a 7 day period (35 recordings possible) using the signal-contingent experience sampling method (Csikszentmihalyi & Larson, 1987), which has been used in a large number and variety of studies as a means of examining average daily affect (e.g., Alliger & Williams, 1993; Emmons & King, 1989; Penner, Shiffman, Paty, & Fritzschke, 1994; Scollon, Diener, Oishi, & Biswas-Diener, 2005; Swendsen, 1998; Van Eck, Nicolson, & Berkhof, 1998). The ESP was programmed to sound the Palms’ warning signals at five random time points through the day between the hours of 9:00am and 10:00pm. The warning signal sounded for 120 seconds, during which time the participant was allowed to respond by tapping the touch screen with the stylus to begin answering the AD ACL. The AD ACL items were presented in the same order each time and participants were allowed 120 seconds to respond to each scale item. If participants did not tap the touch screen within the 120 second window, there was no opportunity to complete the experience sampling recording, thus avoiding the possibility that participants might complete affect scales at times other than when they were signaled.

Students who gave consent were told that the study was about the daily lives of college students and that they would be required to carry the Palm unit for 1 week. They were encouraged to carry the Palm device everywhere they went during waking hours (they were given a note to share with their professors/others demonstrating their participation in a research project that required them to carry a Palm device that may sound during any activity and which would require their brief response) and to return the device to their class the following week. Participation was solely on a voluntary basis and those who participated were not given extra credit in their aerobics class. Data collection started on a Tuesday or Wednesday and progressed over the next 7 day period. After volunteers signed the consent form, participants
were instructed how the Palm device would signal for their response through the day, and before they left class that day participants completed a trial experience sampling moment under the supervision of a research assistant to ensure that they understood how to use the touch screen and complete the AD ACL on the Palm device. Experience sampling data collection occurred for the next 7 days.

On the second day of the experiment, participants completed the AD ACL immediately before, at the mid-point of, and 15 minutes after engaging in a 20-min bout of step aerobic exercise in the context of a class environment. To complete the AD ACL in the middle of the exercise bout, a clock alarm signal sounded 10 minutes into the participation of the aerobics class to cue participants to stop exercising and complete a form which had been placed below their aerobics step at the beginning of the class. Intensity of exercise was self-selected with RPE (asked retrospectively on the mid-point AD ACL form to indicate at what level they had been exercising) halfway through completion of exercise ranging from 2.0 to 10 ($M = 5.28$, $SD = 1.73$).

**Data Analysis**

Preliminary analyses were conducted to examine compliance with experience sampling procedures (i.e., percentage response rates) and to examine potential influences of time of day of experience sampling moments. To examine the effects of time of day on affective measures, all experience sampling moments ($n = 390$) were treated as individual cases and the following procedures were conducted: a) Frequencies of experience sampling moments occurring at different times of the day were examined; and b) scatterplots depicting the relationship between time of recording and AD ACL subscale scores were examined. Also, because individual differences in mood may introduce error into the latter analyses, the mean of each participants’ experience sampling points within morning (9:00am to noon, $n = 91$), mid-day (12:01pm to 3:00pm, $n = 104$), late afternoon/early evening (3:01pm to 6:00pm, $n = 96$), and late evening (6:01pm to 10:00pm, $n = 99$) time periods were computed. Only participants who had two or more recordings in each time category ($n = 23$) were used for this analysis. Then, time category was treated as a within-subjects variable in a one-way (Time Category) MANOVA using the four AD ACL subscales as dependent variables.

Another set of preliminary analyses were conducted to examine within-subjects variability in AD ACL subscale scores over the experience sampling recordings. To examine such variability we used two approaches. First, the standard deviations of participants’ AD ACL subscale scores were calculated to examine the dispersion of subscale scores over recording moments. Second, we examined individual patterns of AD ACL subscale scores over the experience sampling time points. In the latter respect, one representative case was chosen as
a means to represent how AD ACL subscale scores varied over experience sampling time points in addition to before, during, and after exercise.

The mean of scores from all Palm-recording experience sampling time points were computed to form a measure of average daily affect. Daily affect was operationalized as the mean of experience sampling moments, and was compared to affect scores before, at the mid-point of exercise, and after exercise using one-way (Time) repeated measures MANOVA with the four AD ACL subscales comprising the dependent variables.

Results

Compliance

Given the difficulty of experience sampling designs, participants are expected to miss some signal prompts (see Scollon, Kim-Prieto, & Diener, 2003). Of course, exactly what constitutes a problematic level of noncompliance is unclear (Stone & Shiffman, 2002). Therefore, the best alternative is to give an accurate and comprehensive picture of the nature of compliance to experience sampling procedures (Stone & Shiffman, 2002). In the present study, there was a wide range of compliance. Of 35 possible experience sampling moments per subject, compliance ranged from 1 (2.8%) to 25 (69.4%) responses, and the mean response rate equaled 12.72 (35.3%). This is quite lower compliance than found in other ESM studies (e.g., Updegraff, Gable, & Taylor, 2004, 56% mean response rate; Van Eck et al., 1998, 83% mean response rate; Yip, 2005, 70% mean response rate2), perhaps because we did not provide sufficient financial or other incentive or perhaps because we set a short time limit after the warning signal (120 seconds) for participants to respond (see Feldman Barrett & Barrett, 2001; Scollon et al., 2003).

Twenty-three (8 male & 15 female) participants exhibited greater than 25% compliance (completed more than 8.75 AD ACL's over the course of the week and missed no more than 2 days of recording) and were included in subsequent analyses. This cut-off for compliance was chosen based on a commonly-used level reported by Hektner and Csikszenmihalyi (2002).3 These participants were very active, reporting exercising strenuously an average of 3.05 (SD = 1.72) times per week. Only one participant reported engaging in no strenuous exercise per week.

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1 In Van Eck et al. (1988), participants were required to achieve a 40% response rate to be included in the analysis. Five (of 95) participants did not meet this criterion and are not reflected in the mean response rate reported here.

2 Yip (2005) used a 40% response rate cut-off criterion. Five (of 67) participants did not meet this standard and are not reflected in this mean value.

3 It is also acknowledged that other cut-off values could be used, and it should be noted that exploratory MANOVA and follow-up tests to compare the mean of daily affect and exercise-related affect were also performed using all participants (n = 36) and participants who exhibited greater than 33% compliance (> 11 experience sampling moments; n = 20) and results were comparable.
on average. For these participants, mean RPE at the mid-point of exercise equaled 5.48 ($SD = 1.75$) and ranged from a minimum of 3.0 to a maximum of 10.0. Of these remaining participants, 12 students were enrolled in the 9:00am class, seven were in the 12:30pm class, and four were in the 8:00am class.

**Time of Day of Experience Sampling Recordings**

These participants’ compliance was somewhat higher for the first day of the study as indicated by number of experience sampling moments ($M = 3.22$, $SD = 1.31$) compared to the second ($M = 2.30$, $SD = 1.15$), third ($M = 2.00$, $SD = 1.41$), fourth ($M = 1.91$, $SD = 1.31$), fifth ($M = 2.48$, $SD = 0.85$), sixth ($M = 2.70$, $SD = 1.26$), and seventh ($M = 2.35$, $SD = 1.15$) days. For the entire week, these participants averaged 2.42 ($SD = 0.70$) experience sampling moments per day with the total number experience sampling moments per participant ranging from 9 to 25 ($M = 16.96$, $SD = 4.92$). Thus, the mean response rate for participants included in subsequent analyses equaled 48.46%.

Despite the use of a cut-off value related to participant compliance with experience sampling procedures, there is still the possibility that the mean of experience sampling points is not representative of participants’ typical affect. Of particular concern, it is possible that experience sampling recordings over-represent a certain portion of the day. Examining the frequency distribution for experience sampling moments by time of day demonstrated a somewhat leptokurtic distribution with a clustering of experience sampling reports between 10am and noon (see Figure 1).

Examining the relationships between time of day and mood scores for each of the AD ACL subscales using scatterplots and curve fitting procedures showed no apparent associations between time and the mood dimensions considering linear, quadratic, or cubic trends for all subscales ($R^2 < .002$; see Figure 2). The latter analysis, it should be noted, ignores the possibility for individual differences in sampling across the time of day. To better account for such differences another analysis was conducted using mean AD ACL subscale scores for each participant grouped morning, mid-day, late afternoon/early evening, and late evening categories. Participants’ mean values were subjected to one-way (Time Category) repeated measures MANOVA on the four AD ACL subscales. There was no significant multivariate main effect, Wilks’ Lambda = .87, $F(12, 166.97) = 0.65$, n.s. Participants’ experience sampling mean values by morning, mid-day, late afternoon, and late evening categories, respectively, equaled 10.71 ($SD = 2.84$), 10.60 ($SD = 2.99$), 10.37 ($SD = 3.55$), and 10.36 ($SD = 2.99$), for energy; 7.05 ($SD = 2.56$), 6.92 ($SD = 2.04$), 6.96 ($SD = 1.97$), and 7.28 ($SD = 2.46$), for tension; 14.08 ($SD = 2.87$), 13.28 ($SD = 3.13$), 13.55 ($SD = 3.70$), and 13.42 ($SD = 2.76$), for tiredness; and 11.11 ($SD = 1.85$), 11.48 ($SD = 1.98$), 11.11 ($SD = 2.29$), and 10.78 ($SD = 2.46$), for calmness.
Within-Subject Variability of Experience Sampling Recordings

The impact of any differences exhibited between daily affect, as calculated using the mean of experience sampling points over 7 days, and exercise-related affective states would be lessened if there were substantial within-subject variance for any of the AD ACL subscale scores over experience sampling time points. The mean of the within-subject standard deviations for the four subscales were 3.23 (SD = 0.78), 2.66 (SD = 0.52), 1.87 (SD = 1.21), and 3.71 (SD = 1.11), for the energy, calmness, tension, and tiredness subscales, respectively. This would indicate that the greatest within-subject variance occurred for the energy and tiredness subscales, while calmness and tension demonstrated less within-subjects variability (see Figure 3) over the 1 week experience sampling period.

Another method for examining within-subject variability of reporting across experience sampling time points is to examine individual patterns of reporting. While this would be overly laborious to present here for 23 participants, one representative participant’s scores were plotted for all experience sampling time points and is visually represented in Figure 4. In this ‘case study,’ the participant clearly exhibited reduced tension before, at the mid-point, and after exercise in comparison to his/her daily recordings. Also, calmness, in this case was notably reduced at the mid-point of exercise in relation to all other time points, and tiredness was reduced at the exercise mid-point and after exercise in comparison to before and during the week. Examining participants’ affective scores in this manner is clearly informative as it indicates the magnitude of effects in relation to typical variability in the course of a week.

Comparison of Mean Daily Affect with Exercise-Related Affect

Examining the main question of interest when comparing the average of experience sampling (daily affect) with exercise-related affective states, there was a significant multivariate Time effect, Wilks’ Lambda = .18, F(12, 166.97) = 12.71, p < .001. Examination of Mauchly’s test results demonstrated that data for three (energy, tiredness, & tension) of the AD ACL subscales failed to meet the sphericity assumption. Thus, for all follow-up univariate analyses, degrees of freedom were adjusted using the Greenhouse-Geisser correction (epsilon = .71 for energy, .63 for tiredness, .69 for tension, and .85 for calmness). Follow-up analyses revealed significant Time effects for energy, F(2.13, 46.77) = 30.10, p < .001, tiredness, F(1.90, 41.70) = 43.24, p < .001, tension, F(2.06, 45.21) = 3.85, p < .05, and calmness, F(2.56, 56.25) = 13.38, p < .001, subscales. Descriptive statistics and results of Bonferroni-corrected pairwise comparisons for each of the AD ACL subscales are presented in Table 1. Energy was no different before exercise than mean daily affect and was elevated both at the mid-point and at 15-min post exercise. Tiredness was lower before exercise than mean daily affect and dropped even lower at the mid-point and postexercise. Tension was lower before exercise than mean daily
Figure 2. Scatterplots depicting paired AD ACL subscale scores and time of day of experience sample recording.
Figure 4. AD ACL subscale scores for experience sampling recordings and exercise-related affect for one representative case. On the x-axis, "1" is the mean of daily affect, "2" is pre-exercise affect, "3" is affect at the mid-point of exercise, "4" is 15 min post exercise affect, and "5-22" are the individual experience sampling affect recordings for this subject.
affect, but not compared to the mid-point or postexercise. Calmness was no different before exercise than the daily mean, dropped at the mid-point of exercise, and elevated slightly postexercise.

**Discussion**

The results of the present investigation suggest that preexercise baseline measures may not be reflective of daily affect. Specifically, tension and tiredness were both at lower levels prior to exercise than they were based on recordings from the week prior. Energy and calmness, however, did not differ across these two time points.

Considering the affective response to exercise, the pattern of results was mostly as that demonstrated by previous research. At the mid-point of exercise, participants reported greater energy and reduced tiredness and calmness, and 15-min after exercise participants’ energy remained elevated, tiredness remained reduced, and calmness had risen but was still reduced from both baseline measures. This pattern follows the expected pattern of results where exercise increased tension during exercise, and resulted in positive affective changes (Biddle, 2000; Bixby, Spalding, & Hatfield, 2001; Thayer, 1987a, 1987b; Thayer, Peters, Takahashi, & Birkhead-Flight, 1993; Saklofske, Blomme, & Kelly, 1992). However, the typical reduction in anxiety (tension) was not evidenced. This may be due to the possibility of a delayed anxiolytic effect that may take 15 minutes or longer (Bartholomew, 1999), and that higher intensities may actually elevate tension for a time period (Ekkekakis & Petruzzello, 1999) as the mean intensity during exercise was relatively high. The failure to obtain more time points postexercise is a weakness, yet the present investigation was constrained by participants’ class schedules, thus only permitting a 15 minute window postexercise. In the study’s design, this was deemed an acceptable situation due to the study’s focus on comparison of daily affect and preexercise affect. Certainly, more attention to the ability of exercise to reduce tension as measured by the AD ACL is warranted as tension scores in the present sample were very low (particularly preexercise) indicating potential floor effects.

It is only possible to speculate why tension and tiredness are reduced prior to exercise compared to daily affect. One possibility is that the time of the day influenced affective scores. For most participants in this study (n = 16) exercise occurred during the morning (8:00am or 9:00am) when tiredness would be expected to be higher (Adan, 2005; Thayer 1978; Thayer, Takahashi, & Pauli, 1988). Our findings contradict, therefore, what we might expect concerning our comparison between preexercise tiredness and average tiredness at all points across the day (preexercise tiredness should be higher based on time of day). Also, examining the experience sampling scores by time did not suggest a major impact in this regard for any of the
<table>
<thead>
<tr>
<th>Affective Dimension</th>
<th>Daily Affect</th>
<th>Preexercise</th>
<th>Exercise</th>
<th>Postexercise</th>
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<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
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<tr>
<td>Energy</td>
<td>10.60$^a$ (2.46)</td>
<td>10.00$^a$ (3.93)</td>
<td>-0.18</td>
<td>15.43$^b$ (2.97)</td>
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<tr>
<td>Tiredness</td>
<td>13.54$^a$ (2.31)</td>
<td>9.91$^b$ (4.24)</td>
<td>-1.06</td>
<td>5.78$^c$ (2.88)</td>
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<tr>
<td>Tension</td>
<td>7.08$^a$ (2.06)</td>
<td>5.87$^b$ (1.87)</td>
<td>-0.62</td>
<td>7.30$^{a,b}$ (2.08)</td>
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<tr>
<td>Calmness</td>
<td>11.10$^a$ (1.74)</td>
<td>11.30$^a$ (3.23)</td>
<td>0.08</td>
<td>7.70$^b$ (2.72)</td>
</tr>
</tbody>
</table>

Note. ESM = Experience Sampling Moments; $ES = (M_{Preexercise} - M_{ESM}) / \text{pooled } SD$. All means within each affective dimension not sharing the same superscript letter differ significantly ($p < .05$).
subscapes. There is, however, an existing line of research that may explain why tiredness may be reduced preexercise. In the present investigation, participants knew they would soon be exercising and may have already begun harnessing resources to engage in the bout. Decety, Jeannerod, Germain and Pastene (1991) have demonstrated that motor imagery of actions such as exercise increase heart and respiratory rates in a similar and proportional, though reduced, manner to the action imagined. As participants knew they would soon be exercising, it is logical that they engaged in some amount of imagery of this activity either before or upon arriving at class. Such imagery may have elevated physiological arousal, thus reducing tiredness. It is also noteworthy that the present sample employed experienced exercisers who may even have a conditioned response based on repeated exercise at a specific time of day. As Watson (2000) points out, predictable patterns in affective fluctuations may arise from consistent lifestyle factors. Because this group of individuals were enrolled in the aerobics classes for several weeks before this research began, it is possible that their affective pattern through the day had already been influenced. Though these ideas are speculative, they are logically appealing and warrant further investigation.

Considering the other observed difference between daily mean affect and preexercise affect for the tension subscale, present results follow the non-significant trend evidenced by Petruzzello (1995, Study 1 & 2) who found participants reported slightly higher levels of state anxiety outside the laboratory than before exercise in the laboratory. This finding, considering Petruzzello’s (1995), albeit weak (non-significant), corroboration is interesting. The tension mood dimension is little affected by time of day, allowing greater clarity of interpretation than that for tiredness in the present investigation. Nonetheless, tension is expected to be highest at mid-morning compared to other times of the day (Thayer, 1987b). It is somewhat possible, therefore, that because the majority of experience sampling points were recorded near the mid-morning (see Figure 1) and the majority of preexercise tension scores were recorded at 8:00am or 9:00am, that this may account for some of the difference observed here. Previous investigations examining changes in negative mood states through the day, however, have generally shown relatively small variations over the day (Watson, 2000), and it is probable that there are other reasons for a difference of the magnitude observed here ($ES = -0.62$). Likely, it is the case that people completed experience sampling moments at time points when they were facing more significant challenge/threat than that posed by a short aerobics class. Considering this possibility, it should be noted that results may be quite different examining a less experienced sample of exercisers (e.g., obese individuals, novice exercisers) who may be more threatened by exercise participation than the population represented by the present sample. While some may read the present results and dismiss them as situational, we argue that this is entirely the point. To get a true measure of the effect of exercise on affect, it seems that we should consider
participants' overall affective patterns in addition to those exhibited before, during, and after an exercise stimulus. In this manner, it should be possible to better understand the nature of the effect of exercise on affective states.

Considering the energy and calmness dimensions, though there were no differences observed between daily mean affect and preexercise affect, there were very clear benefits observed as a result of participation in the bout of aerobic exercise. Energy was elevated at the mid-point of exercise and remained elevated 15-min postexercise. Calmness, on the other hand, was reduced at the mid-point of exercise and then returned toward the preexercise baseline at 15-min postexercise. This matches previous findings concerning exercise's ability to enhance feelings of energy and temporarily influence feelings of calmness (Ekkekakis et al., 2005; Thayer et al., 1993; Saklofske et al., 1992).

While the present study suggests that preexercise affective states are different from daily states, there are some important shortcomings of the present study that should be noted. It is acknowledged that time of day may influence affect, and this study did not account for diurnal effects. Next, while compliance to experience sampling procedures did not appear to have a large impact on our findings (see footnote #3), our compliance rate was low relative to other studies. While Heikner and Csikszentmihalyi (2002) state that low response rates do not appear to diminish ability of experience sampling to accurately depict content of individuals' daily lives, future research may want to utilize more experience sampling time points and take additional steps to ensure compliance to experience sampling procedures. Finally, the findings of the present research are limited in their generalizability as the exercise session involved group activity and a healthy and active university-aged sample. Findings may not be indicative of exercise performed individually or in different populations.

The final limitation, that our sample included healthy and experienced exercisers, is an important consideration for future research. Ekkekakis and Petruzzello, in their 1999 review, suggest that aerobic fitness may be an important moderator of the relationship between exercise intensity and affective responses. Specifically, less fit or less active individuals seem to exhibit a reduced affective benefit to exercise at high intensities. Related to the present investigation, it might be expected that unfit, inexperienced or obese participants might experience greater levels of negative affect or less positive affect before exercise in anticipation of the exercise bout (thus, producing the opposite of the present findings) and the exercise stimulus might heighten negative affect or reduce positive affect even more during exercise. Yet, it is impossible to determine how such expectancies may be influencing affective states for less experienced exercisers as both the present research and Petruzzello (1995) used healthy, university students to investigate the relation between daily affect and exercise-related affect and to examine expectancy effects, respectively. In Petruzzello's study, the exercise history and
fitness levels of participants is not thoroughly described, but we can probably assume they were at least moderately fit and healthy as 20 male in their early 20’s served as subjects in this study (both Study 1 & 2 had similar samples).

In conclusion, this research highlights an important point in the study of exercise and affect. Namely, researchers should carefully consider what constitutes an effective “baseline” measure of affect. Time of day, expectancies, and participants’ fitness levels are among variables that deserve greater attention when making these judgments. While this research raises many questions, it does nonetheless point out that affective responses to exercise, as measured in many studies, may give only a portion of the picture reflecting how exercise impacts how we feel.

References


