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Reciprocal within-day associations between incidental affect and exercise: An EMA study

Jessica A. Emerson[a,*], **Shira Dunsiger**[a,b], and **David M. Williams**[a]

[a]Department of Behavioral and Social Sciences, Brown University School of Public Health, Providence, RI, USA

[b]Centers for Behavioral and Preventive Medicine, The Miriam Hospital, Providence, RI, USA

Abstract

Previous research suggests that how people feel throughout the course of a day (i.e. incidental affect) is predictive of exercise behaviour. A mostly separate literature suggests that exercise can lead to more positive incidental affect.

Objective—This study examines the potential reciprocal effects of incidental affect and exercise behaviour within the same day.

Design—Fifty-nine low-active (exercise <60 min/week), overweight (BMI: 25.0–39.9) adults (ages 18–65) participated in a six-month print-based exercise promotion programme.

Main outcome measures—Ecological momentary assessment was used to record self-reported exercise sessions in real time and incidental affective valence (feeling good/bad) as assessed by the 11-point Feeling Scale at random times throughout the day.

Results—Use of a within-subjects cross-lagged, autoregressive model showed that participants were more likely to exercise on days when they experienced more positive incidental affect earlier in the day ($b = .58$, SE = .10, $p < .01$), and participants were more likely to experience more positive incidental affect on days when they had exercised ($b = .26$, SE = .03, $p < .01$), with the former association significantly stronger than the latter ($t = 23.54$, $p < .01$).

Conclusion—The findings suggest a positive feedback loop whereby feeling good and exercising are reciprocally influential within the course of a day.

Keywords

exercise; incidental affect; ecological momentary assessment

Regular physical activity (PA) is associated with reduced risk of cancers of the breast and colon (McTiernan et al., 2003; Slattery, 2004), cardiovascular disease (Li & Siegrist, 2012), and type 2 diabetes (Cloostermans et al., 2015). In addition, PA is a critical component of successful weight loss and weight maintenance programmes (Shaw, Gennat, O'Rourke, &

*Corresponding author. jessica_emerson@brown.edu.

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Del Mar, 2006). Despite these benefits, in 2014 only 49.2% of US adults achieved the recommended amount of PA – a minimum of 1000 kcal/week, which equals roughly 150 min of moderate intensity PA per week (Garber et al., 2011; Ward, Schiller, Freeman, & Clarke, 2013). Moreover, based on data collected via accelerometry, as few as 10% of US adults may be reaching these goals (Troiano et al., 2008). Thus, a better understanding of the factors that influence PA is needed.

Research on the determinants of PA behaviour has traditionally been rooted in social-cognitive theories, which focus on cognitive, social and environmental factors (Ajzen, 1991; Bandura, 1986; Prochaska & Velicer, 1997; Rosenstock, Strecher, & Becker, 1988). These factors explain a significant, but modest amount of variation in PA behaviour (Baranowski, Anderson, & Carmack, 1998; Rhodes & Pfaeffli, 2010; Rogers & Prentice-Dunn, 1997). Missing from research on the psychosocial determinants of PA, until recently, is attention to the affect-related factors that may influence PA behaviour.

Affect is a broad term that encompasses discrete moods (e.g. irritable, contented) and emotions (e.g. joyful, angry, embarrassed), as well as core affect, which underlies discrete moods and emotions and is characterised by two orthogonal dimensions: valence (i.e. positive vs. negative) and activation (i.e. high vs. low) (Russell, 1980). Additionally, affect can be classified as either integral – i.e. in response to a target behaviour (e.g. in this case in response to PA) – or incidental – i.e. occurring outside the context of the target behaviour (even if it is partially determined by the target behaviour; Bodenhausen, 1993; Williams & Evans, 2014).

One important area of research involves the association between incidental affect and PA behaviour within the course of a single day. Multiple theorists have argued that more positive incidental affect allows people to expand their resources, thus encouraging approach behaviours, such as PA (Fredrickson, 2001; Isen, 2000; Lyubomirsky, King, & Diener, 2005). Engaging in PA may, in turn, lead to more positively valenced incidental affect later in the day as a direct function of increased neurotransmitter release (Deslandes et al., 2009; Rasmussen et al., 2009), as well as stress relief (Wipfli, Rethorst, & Landers, 2008) and perceived satisfaction with the positive instrumental outcomes of engaging in PA (Baldwin, Baldwin, Loehr, Kangas, & Frierson, 2013).

In a recent systematic review, Liao, Shonkoff, and Dunton (2015) identified 14 studies examining acute (i.e. within a few hours) associations between incidental affect and PA behaviour in the context of everyday life. Several studies showed associations between incidental affect and subsequent PA behaviour (i.e. within the same day) or between PA behaviour and subsequent incidental affect (Liao et al., 2015; see also Kanning & Schoebi, 2016; Niermann, Herrmann, von Haaren, van Kann, & Woll, 2016). However, in order to disentangle the extent to which the two effects are interdependent and to what extent the effects are stronger in one direction or the other, it is necessary to examine the within-subjects effects of the bidirectional relationship within the same group of study participants. Such a study may suggest that the observed bidirectional association between PA and incidental affect is mainly driven by the effects of the former on the latter or vice versa. Alternatively, such a study could show that both effects are significant, thus suggesting a reciprocal relationship in which more positive incidental affect both leads to and is caused by PA behaviour within the course of a single day. Findings would have implications for the timing of interventions to increase PA behaviour and improve affective states.

Three prior studies include such a research design (Carels, Coit, Young, & Berger, 2007; Dunton et al., 2014; Schöndube, Kanning & Fuchs, 2016). In one study, conducted among adolescents (9–13 years old), Dunton and colleagues (2014) time-matched accelerometer data with randomly administered assessments of incidental affect on mobile devices over four days. Affect was conceptualised as two separate dimensions composed of positive activated (happy, joyful) and negative activated (stressed, mad or angry, sad, nervous or anxious) states consistent with the rotated circumplex model (Watson & Tellegen, 1985) with the exception of ‘sad’ (i.e. negative deactivated affect) in the negative-activated affect scale. The analysis compared the number of minutes in moderate to vigorous activity during the 30 min before and after randomly timed affect reports. More PA was followed by more positive activated affect and less negative activated affect. However, levels of positive activated and negative activated affect did not predict the amount of PA over the following 30 min (Dunton et al., 2014). A limitation of this study is that it does not account for any potential effects of the PA-affect relationship in either direction beyond 30 min. This is important because respondents may have engaged in PA at other times, or may not have had the opportunity to engage in PA (e.g. they may have been at the movies) in the 30-min periods surrounding each randomly administered incidental affect assessment.

In another study, Carels and colleagues (2007) examined the potential within-subjects reciprocal relationship between incidental affect and PA among obese adults in a weight loss programme over two 4-week periods at the beginning and end of the programme. Participants were given paper diaries and instructed to report their incidental affect on a single bipolar good–bad scale consistent with the affective valence dimension of the unrotated circumplex model (Russell, 1980), at four pre-determined times: upon waking, before bedtime, and before and after self-reported PA bouts. More positive incidental affect in the morning was associated with a greater likelihood of PA later on. Additionally, on days when participants engaged in PA, they reported more positive incidental affect in the evening, controlling for morning affect (Carels et al., 2007). These findings support the within-subjects reciprocal association between PA and positive incidental affect. However, a limitation to this study is that affect reports were non-random – i.e. the participants knew when they would be reporting their affect each day – and not time-stamped. Thus, findings could be a function of expectancy biases regarding the association between incidental affect and PA.

In a third study, Schöndube and colleagues (2016) examined within-subjects associations between daily incidental affect and daily self-reported PA on mobile devices over four weeks among university students who exercised for at least 30 min/week. Incidental affect was assessed at random times within four pre-determined one-hour periods (morning, noon, afternoon, evening) and included the incidental affect and arousal dimensions of the unrotated circumplex model as well as the negative-activated/positive-deactivated dimension of the rotated circumplex model. Each evening, participants were asked to retrospectively report the duration of exercise they had engaged in that day (from 0 to 300 min). Only affective arousal in the morning was predictive of duration of exercise that day, while duration of exercise was only predictive of affective valence in the evening. Thus, no reciprocal effects were obtained for any one incidental affect measure. A potential limitation of this study is that the participant population was moderately active university students, and thus the findings may not generalise to other populations.

Finally, in all three studies (Carels et al., 2007; Dunton et al., 2014; Schöndube et al., 2016), there was no comparison of the relative strength of the bidirectional effects of the PA-affect relationship.

The present study

The present study examines the potential reciprocal relationship between incidental affect and structured exercise – discrete PA performed for the purpose of health and fitness – among overweight and obese adults enrolled in a randomised pilot study examining the effects of two different exercise prescriptions (self-paced vs. moderate intensity) on adherence to a six-month exercise promotion programme (Williams et al., 2015). Incidental affect and exercise behaviour were assessed via ecological momentary assessment (EMA), which minimises potential biases through real-time and (for incidental affect) random assessments, as well as time-stamping of responses (Shiffman, Stone, & Hufford, 2008). Additionally, multiple assessments of incidental affect, along with exercise behaviour, within the course of a single day allows for within-subjects analyses of their reciprocal effects and the extent to which these effects are independent. That is, within-subjects analyses can be used to examine (a) to what extent a person is more likely to exercise on days when his or her incidental affect is more positive earlier in the day, and (b) to what extent a person is likely to experience more positive incidental affect on days when he or she has exercised earlier in the day. Such within-subjects analyses can be performed while controlling for changes in both incidental affect and exercise over time, as well as the between-subjects effects of individual differences in incidental affect and exercise behaviour.

In the present study, we hypothesise that there will be significant within-subjects effects in both directions. Specifically, within participants, a more positive incidental affect on a given day will be associated with a greater likelihood of exercise later that day. Additionally, on days when a participant exercises, he or she will experience more positive incidental affect later that day relative to days when he or she does not exercise. Lastly, we will explore the relative strength of the two effects – incidental affect on exercise behaviour and exercise behaviour on incidental affect. We did not have a priori hypotheses regarding which effect would be stronger given the absence of prior studies examining both effects within the same analysis.

Methods

Participants

Participants (n = 59) were recruited through radio and newspaper ads distributed throughout the greater Providence, RI community. The research was described as a six-month print-based exercise (i.e. brisk walking) promotion programme designed to help people overcome barriers to regular exercise (see Williams et al., 2015). Eligible adults (18–65) were low-active (<60 min/wk of structured exercise) and overweight or obese (BMI between 25.0 and 39.9), but otherwise generally healthy and able to walk for exercise. Participants were primarily female (88%) and non-Hispanic White (76%). Mean age was 47.71 (SD = 11.06), mean BMI was 31.93 (SD = 3.99), 85% were employed, and 54% had a household income over $50,000 per year (see Table 1).

Design

All participants received a print-based intervention focused on reducing barriers to walking for exercise and were surreptitiously randomly assigned to either walk at moderate intensity or a self-selected intensity (further details of this protocol are described elsewhere; Williams et al., 2015). Effects of random assignment are not a focus of the present study and are controlled in all analyses. Participants were asked to self-report on a daily basis about their structured exercise behaviour and incidental affect in real-time on a handheld PDA (HP IPAQ v.111) or *e-diary*. Training on the e-diaries took place prior to the start of the monitoring period and included researcher-guided assessments and a three-day practice period. Participants self-reported structured walking-for-exercise (i.e. not lifestyle PA) in real time on their e-diary throughout the six-month period. Incidental affect was assessed at random times throughout the day during the first 29 days (weeks one through four) and 8 days during weeks 12 (month 3) and 25 (month 6) of the 6-month study period. The e-diaries automatically date- and time-stamped each exercise and affect report. The Brown University Institutional Review Board approved the study protocol.

Measures

Exercise behaviour—For purposes of this analysis, only exercise reports entered in real-time were used. Participants were asked to indicate each time they began and ended a session of structured walking-for-exercise. To indicate the start of an exercise session, participants were instructed to press the *Begin Exercise* button. After reporting the start of an exercise session, the e-diary displayed an *End Exercise* button that participants were instructed to press at the end of each exercise session. Additionally, participants were able to enter begin- or end-exercise times after they had already begun or had stopped exercising; we used these entries to adjust the begin- and end-exercise times prior to calculating session duration. Session duration was calculated by subtracting exercise end- from exercise begin-times, which were automatically time-stamped. Durations ≥10 min were included in this analysis as exercise sessions. Participants were also able to indicate on wake-up reports administered each morning whether they had exercised the previous day but had not recorded the exercise in real time. These retrospective exercise reports accounted for only 19% of exercise reporting over the course of the six-month programme, and were not included in the analysis because such retrospective reporting did not allow for examination of temporal relationships with incidental affect. Additionally, we restricted our analysis to days in which participants reported only a single bout of exercise (87.80% of exercise days).

Incidental affect—Participants were asked to report their affect using the Feeling Scale (Hardy & Rejeski, 1989). The Feeling Scale is a single-item measure of the valence dimension of affect. Participants were asked the question, *how are you feeling right now?*

and responded on a scale from −5 *Very Bad* to +5 *Very Good* (Hardy & Rejeski, 1989). The Feeling Scale has been used to measure incidental affect in numerous prior studies of PA (for a review see Ekkekakis, 2003) and has been shown to be related to other self-report measures of incidental affect (Hall, Ekkekakis, & Petruzzello, 2002; Hardy & Rejeski, 1989).

Incidental affect was assessed using automated prompts administered at random times throughout the day when participants were not exercising (random prompts were also withheld for 15 min following each exercise session). Participants indicated the start of their day by completing a report each morning, after which the e-diary audibly prompted participants on a semi-random schedule, once within each 3-h block of the day (i.e. 9:00 am–12:00 pm, 12:00 pm–3:00 pm …) except during exercise reporting. Participants received these audible prompts during weeks one through four, weeks 12 and 25 (for eight days prior to month 3 and month 6, respectively) of the 6-month study period. The prompting schedule was continuous throughout 24 h, and participants were instructed to turn the prompts off during sleep or temporarily during waking hours when necessary (e.g. religious services, job-related meetings). Upon hearing the beep, participants had the option to delay the report for a period of 20 min, after which they were no longer able to respond. Random prompts included additional questions not examined in the present analysis.

Affect was also assessed immediately prior to, during, immediately after and 15 min after each exercise session. These affect reports are conceptualised as affective response to exercise (i.e. integral affect; see Williams et al., 2016) and are distinct from the incidental affect (i.e. assessed at random times throughout the day) that is the focus of the present study.

Data reduction

In order to analyse the within-day associations between incidental affect and exercise behaviour, valid days were defined as days with at least one assessment of incidental affect with or without an exercise report. Across participants, 88% of the randomly administered prompts (incidental affect reports) were completed. Incidental affect ratings were selected based on proximity to exercise reported in real-time. On days when participants did not exercise, we selected affect ratings at times that were closest to the affect ratings on the nearest subsequent exercise day. Each participant ($n = 59$) contributed an average of 38.0 (SD = 9.41) valid days of data (out of a possible 45), which included an average of 21.69 (SD = 10.03) exercise days and 15.22 (SD = 8.91) non-exercise days per participant.

Analysis

An autoregressive cross-lagged model (Selig & Little, 2012; Figure 1) was used to simultaneously account for changes over time in incidental affect and exercise behaviour (trajectories), as well as autoregressive (e.g. association between successive days of exercise) and cross-lagged effects (e.g. association between affect earlier in the day and the likelihood of exercising that day and vice versa) (Bollen & Curran, 2004). Note that Figure 1 is a simplification of the model schematic but is inserted here to give a depiction of the concept of what is being estimated. One can think of the model as a means for estimating (1) the changes over time in incidental affect, (2) the changes over time in exercise behaviour, (3) the effects of incidental affect on subsequent exercise and (4) the effects of exercise on subsequent incidental affect. All four *paths* were estimated using a single multilevel model that separates out both within and between subject effects. Simply put, if we think of specifying changes over time in incidental affect (y), this variable is indexed by both individual i and time t. The trajectory of mean valence over time can be written as $E(y_{it}) = \alpha_{0i} + \alpha_{1i}x_{it} + \alpha_{2i}x_{it}^2$ where α_{0i} is the intercept for participant i, α_{1i} is the slope of the affect trajectory for participant i and α_{2i} is the quadratic effect for participant i. However, these intercept and slope terms can be further specified as functions of both a fixed effect (not indexed by i) and a random effect (which is indexed by participant). This second level equation for the intercept and slope terms in the trajectory of incidental affect are the between subject differences in the within person change in affect over time. For the purpose of this study, effects were specified in this way (separated out to index both individual and time and thus separately estimating within and between person changes). Thus, all reported results reflect within-subjects effects over and above between-subject effects.

Adding another layer of complexity to the model was the fact that participants were randomised to self-paced vs. moderate intensity exercise. As there may have been differences across participants based on their randomisation to the two different treatment arms in the pilot study from which we drew our data (Williams et al., 2015), we additionally tested whether the changes over time and cross-lagged effects (effects of exercise on subsequent incidental affect and the effects of incidental affect on subsequent exercise behaviour) differed by condition. Since there were no significant differences between conditions in either incidental affect or exercise behaviour trajectories, we include the entire sample in the present study and controlled for treatment condition.

Models included intercept, slope and quadratic terms (α_0, α_1, α_2). That is, rather than assuming that exercise behaviour, for example, was only a linear function of time, we also tested a quadratic function to see whether it represented a better fit to the data. Overall model fit was assessed via χ^2 likelihood ratio test and between-model fit assessed using a Bayesian Information Criterion. These tests revealed non-significant results ($p > .05$), indicating good model fit. We used these autoregressive paths to control for changes in incidental affect and exercise over time. This means that our results are specific to within-day effects, versus a reflection of within-day variation coupled with changes over time.

The primary analysis examined the relationship between incidental affect and exercise behaviour controlling for time of day. We examined incidental affect at comparable times on exercise and non-exercise days. The timing of each *Begin* and *End* exercise report was used to determine which incidental affect reports to include from prior non-exercise days in each comparison. That is, the average of the Feeling Scale scores reported prior to/following each exercise session was compared to the average of the Feeling Scale scores prior to/following the same time of day on the non-exercise days leading up to each exercise day. Exercise was conceptualised as a binary indicator of participating in one exercise session and tracked in real time (thus models of exercise behaviour are on the logit scale and effect sizes are odds ratios).

Finally, we examined which direction of the reciprocal effects was stronger. As effects of exercise on subsequent incidental affect and incidental affect on subsequent exercise were standardised coefficients and estimated from a single model, we were able to directly compare effects in order to make a statement about the relative strength of the associations.[1]

Results

The results suggested significant within-subjects changes in incidental affect and exercise over time. That is, autoregressive paths were significant. In both cases (exercise trajectory and trajectory of incidental affect) the intercepts were significantly different from 0 ($b = -1.70$, SE = .13, $p < .001$ for exercise and $b = 5.05$, SE = .17, $p < .001$ for incidental affect). In the case of exercise, the autoregressive path indicated significant positive associations between successive days (exercising one day increased the log odds of exercising the following day; $b = 3.58$, SE = .17, $p < .01$). In the case of incidental affect, results indicated significant positive associations between successive days (more positive incidental affect one day was associated with more positive incidental affect the following day; $b = .36$, SE = .01 $p < .01$). The *b*s presented here are the within-subjects slope terms. Since both autoregressive paths were significant, it is important to control for the fact that both constructs were changing over time when considering the cross-lagged effects (how exercise influences subsequent incidental affect and vice versa).

As hypothesised, there were significant within-subjects cross-lagged effects such that more positive incidental affect at the beginning of a given day was associated with increased log odds of exercising that day ($b = .58$, SE = .10, $p < .01$). Specifically, controlling for other factors, one standard unit difference on the Feeling Scale reported earlier in the day was associated with a 79% increase in the odds of exercising (namely $100 \times (\exp(.58) - 1)$ as b is the coefficient on the logit scale).

There were also significant within-subjects cross-lagged effects of exercise on incidental affect (see Table 2 for raw means). Controlling for incidental affect earlier in the day, exercise was associated with more positive incidental affect after exercise ($b = .26$, SE = .03, $p <$ 01). Specifically, comparing an average non-exercise day to an average exercise day, there was a .51 unit difference in Feeling Scale ratings of incidental affect.

Finally, there was a stronger within-subjects association between incidental affect and subsequent exercise behaviour than between exercise behaviour and subsequent incidental affect (difference between standardised coefficients, $t = 23.54$, $p < .01$).

Discussion

In the present study we examined the potential within-day reciprocal relationship between exercise and incidental affect across a six-month period in a sample of overweight/obese adults. Participants self-reported in real time when they engaged in structured walking-for-

[1]We explored the effects of controlling for latency (log transformed to handle skewness) in the model. Results did not suggest a significant main effect of latency, nor a significant change in the estimated cross-lagged effects after controlling for latency. Thus we removed it from the final model.

exercise as well as their incidental affect at times when they were not exercising. We found that more positive incidental affect earlier in the day increased the likelihood of exercise, and, independently, that exercise was associated with more positive incidental affect later in the day. A comparison of the strength of each of these effects showed that there was a significantly stronger effect of incidental affect earlier in the day on whether or not a person exercised that day.

In examining potential reciprocal effects we used cross-lagged autoregressive analyses to control for the observed changes in incidental affect and exercise over time. Among the full sample of participants there was a shift towards more positive incidental affect and a decrease in exercise behaviour over time. However, these trends in incidental affect and exercise must be interpreted independent of the within subjects autoregressive associations. Specifically, a one unit difference in the measure of incidental affect (i.e. 11-point Feeling Scale) on one day was associated with a .36 unit difference in Feeling Scale scores the following day, reflecting strong within-person tendencies to feel either good or bad from one day to the next. Likewise, exercising one day increased the odds of exercising the following day by 36 times. The sizable strength of the autoregressive associations for successive days of exercise behaviour reflects the fact that some participants were engaging in regular exercise, consistent with intervention goals, whereas others were doing very little exercise.

Because we controlled for autoregressive effects in the cross-lagged analysis, we can be more confident that the within-person bidirectional associations between incidental affect and exercise behaviour reflect true reciprocal effects – i.e. the causal effects go both ways. Indeed, consistent with our hypothesis, compared to days when a participant reported more negative incidental affect, on days when that participant reported more positive incidental affect, he or she was more likely to exercise. Specifically, one standard unit difference in Feeling Scale ratings of incidental affect earlier in the day was associated with a 79% increase in the odds of exercising at some point later the same day. These results are similar to previous studies showing acute (within a few hours) benefits of positive incidental affect on the amount of subsequent PA people engage in (e.g. Kanning & Schoebi, 2016; Niermann et al., 2016; for a review see Liao et al., 2015). There are multiple processes that have been theorized to play a role in the link between more positive (or less negative) incidental affect and exercise behaviour. For example, more negative (or less positive) incidental affect may reduce impulse control, leading to behaviours associated with immediate benefits to boost one's mood (e.g. watching television) rather than those associated with long-term goals such as engaging in regular exercise (Tice, Bratslavsky, & Baumeister, 2001). Additionally, more positive (or less negative) incidental affect may encourage approach behaviour by increasing internal motivational resources, facilitating behaviours such as PA (Fredrickson, 2001; Isen, 2000; Lyubomirsky et al., 2005).

Also as hypothesised, on days when participants exercised they experienced more positive incidental affect later on compared to days when they did not exercise. Specifically, controlling for incidental affect earlier in the day, participants' scores on the 11-point Feel Scale were .53 units more positive (or less negative) on days when they exercised compared to days when they did not exercise. These results are consistent with prior research showing the beneficial effects of exercise on incidental affect within the same day (e.g. Schöndube et al., 2016; for a review see Liao et al., 2015), which may be a function of increased neurotransmitter release (Deslandes et al., 2009; Rasmussen et al., 2009), stress relief (Wipfli et al., 2008) and/or perceived satisfaction with the positive instrumental outcomes of engaging in PA (Baldwin et al., 2013).

The present study extends prior research by examining both directions of the exercise-incidental affect relationship in the same model to determine whether the strength of each effect is similar or if one is stronger. By conducting simultaneous analyses of both directions of effects, the strength of each effect is standardised and comparable. We found that the influence of incidental affect earlier in the day on likelihood of exercise behaviour is significantly larger in magnitude than the effects of whether or not someone exercised on subsequent incidental affect. In fact, the influence of incidental affect on whether or not a participant subsequently exercised is more than two times the effects of exercise on later incidental affect. From a practical perspective these findings suggest an increased focus on leveraging positive incidental affect to promote exercise. It may be important to capitalise on days when individuals are feeling more positive than usual, as these are days when people are more likely to exercise. Conversely, it may be necessary to provide additional techniques to reduce barriers to exercise on days that begin with more negative incidental affect or to focus on reducing individual barriers to exercise to make it more easily accessible (e.g. walking paths) and more enjoyable (e.g. based on activities the individual enjoys).

There are several strengths to our study. First, we examined exercise-incidental affect associations among a population of overweight/obese adults from the community who were inactive prior to enrolling in the study. Therefore, these findings are potentially relevant to a substantial proportion of the population that currently does not engage in the amount of PA recommended to achieve health benefits (Garber et al., 2011; Troiano et al., 2008). Second, we employed EMA to collect real time reports of exercise in the context of people's everyday environment, which enhances the ecological validity of our findings. Third, we applied a broad approach to measuring incidental affect using a simple bipolar good-bad scale. There are theoretical strengths to this approach such as the generalisability of core affect relative to more discrete affective states, such as specific moods (e.g. depressed, invigorated) and emotions (e.g. angry, embarrassed; Ekkekakis, 2008). Additionally, the use of random assessments allows for sampling of incidental affect at various times throughout the day and also lessens the likelihood of expectation biases that can occur if participants know when assessments are coming. Fourth, we followed participants over the course of six months, which allows us to make conclusions about an individual's average day and protects against biases that could arise from shorter time frames (e.g. flu, vacation). Finally, and most importantly, this is the first study to compare the strength of effects in each direction of the within-day associations between exercise and incidental affect. The present study therefore advances our understanding of the reciprocal relationship between exercise and incidental affect and improves on the design of previous prospective studies that tested only unidirectional associations.

Despite the methodological strengths, there are some limitations to this study. First, the relationship between exercise and incidental affect among overweight and obese adults who have chosen to engage in a PA promotion study may not generalise to other populations.

Specifically, evidence suggests that weight and sedentary status can influence affective response to PA (i.e. how people feel during exercise; Ekkekakis & Lind, 2006; Hoffman & Hoffman, 2008), and thus it is reasonable to expect that the association between PA and incidental affect could also vary by weight status and as people become more active. Moreover, while the effects of the intervention are controlled for, engaging in a study about increasing PA may influence the association between PA and incidental affect. Second, we assessed exercise using self-report, which can be influenced by a number of biases such as social desirability bias. However, we believe that there is a low chance of social desirability bias due to the fact that participants were not monitored in person when entering exercise and because they were not paid for these reports. Nonetheless, an objective measure of exercise would help to corroborate self-reported behaviour (e.g. using accelerometry). Third, although use of a broad conceptualisation of incidental affect (i.e. core affect) is a strength in some ways, it does not allow for conclusions about discrete moods and emotions, which may have specific relations with exercise behaviour. Yet since there is little evidence at this point regarding the within-day association between incidental affect and exercise behaviour, using a broad conceptualisation of affect is a useful starting point.

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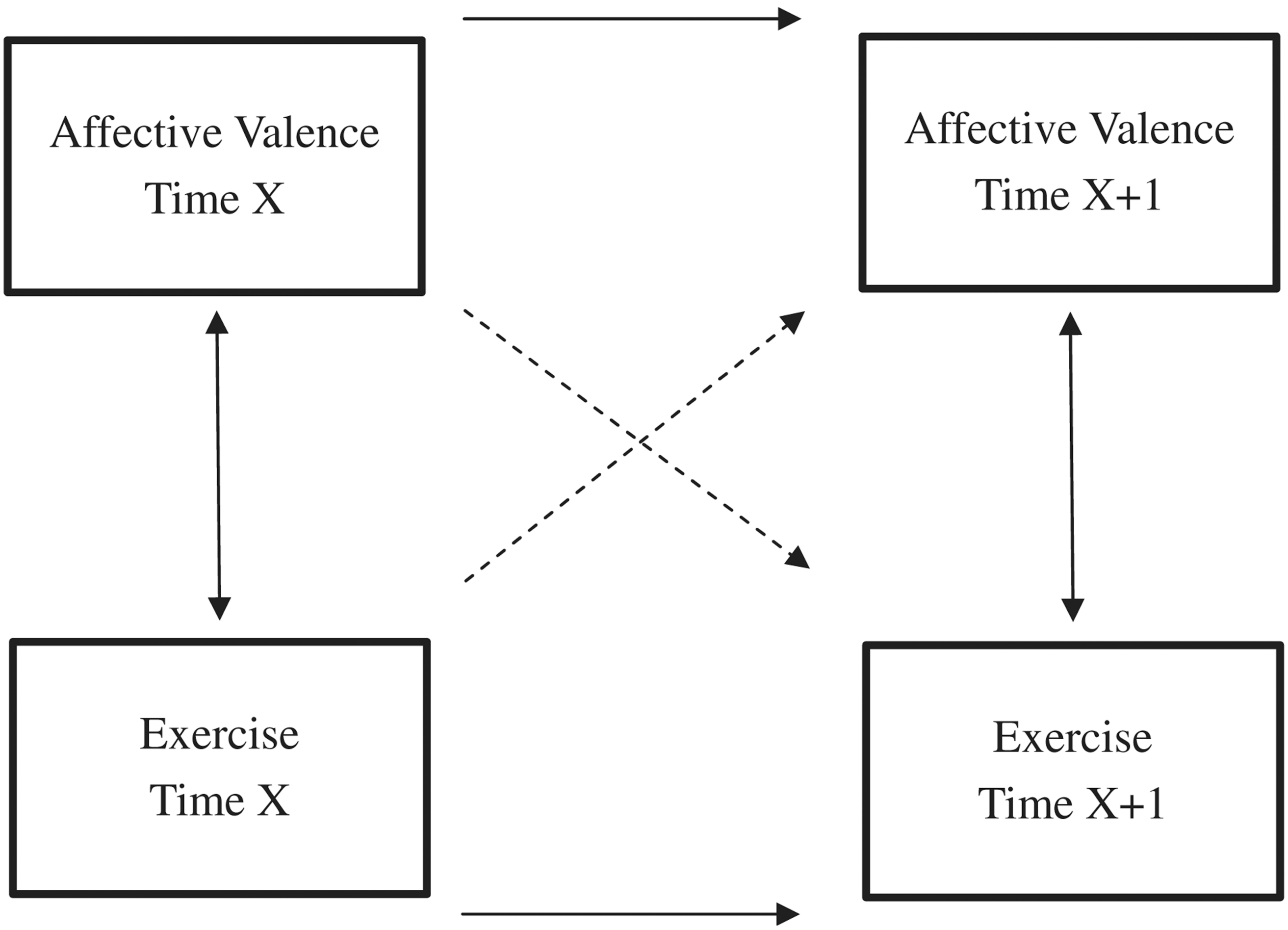

Figure 1.
Model schematic.

Table 1

Characteristics of the study population.

Variable	Sample (n = 59)
Age – mean (SD)	47.71 (11.06)
Gender (% Female)	88%
BMI – mean (SD)	31.93 (3.99)
Race/Ethnicity (% Non-Hispanic White)	88%
Household Income (% Over 50k)	54%
Employment (% Employed)	85%

Table 2

Means and standard deviations of incidental affect earlier and later in the day (i.e. before and after exercise on exercise days) on exercise and non-exercise days.

	Exercise days *M*(SD)	**Non-exercise days *M*(SD)**
Incidental affect earlier in the day	+1.56 (2.23)	+1.26 (2.64)
Incidental affect later in the day	+2.50 (1.63)	+1.83 (2.24)

Notes: *M* = Mean. SD = Standard Deviation. Incidental affect as reported on the Feeling Scale, which ranges from −5 *very bad* to +5 *very good*, and 0 is *neutral*. Incidental affect ratings were before ('earlier') and after ('later') exercise on exercise days. For non-exercise days, selected incidental affect reports were those that were closest in time to the incidental affect ratings reported on subsequent exercise days. See text for analysis.