Published in final edited form as:

Psychol Sport Exerc. 2020 March ; 47: . doi:10.1016/j.psychsport.2019.03.010.

The association between negative affect and physical activity among adults in a behavioral weight loss treatment

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Abstract

Introduction: Many individuals engaged in behavioral weight loss make suboptimal increases in moderate-to-vigorous physical activity (MVPA). Theoretically, reductions in negative affect could reinforce MVPA. However, little work has been done investigating the association between facets of negative affect (e.g., average levels of negative affect, variability in negative affect) and MVPA among individuals attempting to increase MVPA as part of a behavioral weight loss attempt.

Methods: Participants ($n = 139$) provided data at month 6 of a year-long behavioral weight loss program (at which point the prescription for MVPA had reached the highest level). Participants wore an accelerometer and provided EMA ratings of affect over the same week.

Results: Individuals engaged in more frequent and longer periods of MVPA had lower average negative affect and variability in negative affect across the assessment period. Lower negative affect one day predicted greater time spent in MVPA on the next day; lower variability in negative affect than one's average level also predicted greater time spent in MVPA on the next day. Greater engagement in MVPA than one's own mean on one day did not predict mean or variability in affect.

Discussion: Engaging in MVPA over time may reduce negative affect, while lower negative affect may increase motivation to engage in MVPA. Importantly, day-to-day effects indicated that affect is an important acute predictor of MVPA behavior. It is possible that individuals, particularly those with higher negative affect or variability in negative affect, may benefit from the inclusion of skills to manage negative affect in programs prescribing physical activity.

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Declarations of interest: None

Keywords

Physical activity; obesity; behavioral weight loss; negative affect; affective variability

Introduction

Adherence to prescribed moderate-to-vigorous physical activity (MVPA) within behavioral weight loss programs is highly variable and many individuals fall short of MVPA goals. Increasingly, affect has been highlighted as an important correlate of physical activity behavior. Engagement in physical activity could engender changes in affect (increased positive affect or decreased negative affect) through psychological pathways, such as feelings of achievement, increased self-efficacy, and feelings of competence (Scully, Kremer, Meade, Graham, & Dudgeon, 1998), or through physiological pathways, such as the release of endogenous opioids and beta-endorphins (Dinas, Koutedakis, & Flouris, 2011). Lower negative affect and higher positive affect may additionally promote better engagement with physical activity by increasing energy and motivation. However, the association between negative affect and physical activity has been insufficiently explored, especially among individuals engaged in prescribed MVPA as part of a behavioral weight control program.

Prior studies evaluating the associations between MVPA and affect have observed positive relationships between MVPA and positive affect and mixed evidence regarding the relationship between MVPA and negative affect (Liao, Shonkoff, & Dunton, 2015). Studies of the PA-negative affect link often include individuals whose weight falls within the normal range and utilize either lab-based activity or typical (i.e., not prescription-based) levels of free-living activity. Engagement in and enjoyment of activity is known to vary by weight status, with those whose BMIs fall in the overweight or obese range engaging in lower levels of MVPA and enjoying prescribed activity less (Ekkekakis, Lind, & Vazou, 2010; Unick, Michael, & Jakicic, 2012). Moreover, affective responses to physical activity were observed to be less positive and more negative when individuals were recently (within six months) adopting activity behavior compared to those who had no regular activity routine and those with regular activity routines (Dunton, Leventhal, Rothman, & Intille, 2018). Thus, it is particularly important to evaluate the association between MVPA and affect among individuals with overweight/obese BMIs attempting to adopt MVPA.

Only a small handful of studies have evaluated the relationship between MVPA and affect among individuals with overweight or obese BMIs engaging in prescribed activity. One study did not observe an immediate reduction in negative affect following activity in a lab setting among adults (not engaged in treatment) with overweight or obese BMIs (Unick et al., 2012). Importantly, negative affect is often low among non-clinical samples and measuring negative affect at a single time-point preceding or following a bout of exercise may fail to capture important relationships between negative affect and MVPA (e.g., exercise may buffer against future increases in negative affect, consistent activity may reduce overall average affect). Two studies of individuals who are overweight or obese and engaged in weight loss (Carels, Coit, Young, & Berger, 2007) or exercise promotion (Emerson, Dunsiger, & Williams, 2018) programs did observe significant relationships between MVPA and average affect. Each study observed both between-subject (i.e., an individual compared to others in the sample) and within-subject (i.e., a day compared to other days for a single individual) associations between affect and MVPA, observing that MVPA was associated with lower levels of negative affect. However, both studies utilized self-reported activity (which is prone to bias and overestimation) and a single bipolar affect scale (i.e., rating positive to negative), which precludes separating positive from negative affect. Despite these limitations, these studies underscore the importance of evaluating relationships both between individuals as well as within-individuals. Ecological momentary assessment (EMA) allows for repeated evaluation of constructs that naturally vary over time (e.g., evaluating affect multiple times over the course of a single day). Such measurement allows for the disaggregation of a person's average level of affect across all measurements (between-subjects) from the relative increase or decrease from their own mean at a given time (within-subjects). Using EMA to evaluate relationship between objectively-measured MVPA and negative affect among individuals who have overweight or obese BMIs and are engaged in prescribed activity is an important next step.

In addition to mean levels of negative affect, research has increasingly evaluated variability in affect related to engagement with health behaviors. Within-day variations in negative affect occur across the population (Peeters, Berkhof, Delespaul, Rottenberg, & Nicolson, 2006). Higher variability in affect is associated with increased risk for cigarette smoking (Mermelstein, Hedeker, & Weinstein, 2010), alcohol use (Jahng et al., 2011), and developing chronic health conditions (Piazza, Charles, Sliwinski, Mogle, & Almeida, 2012), underscoring the importance of evaluating variations in affect in addition to mean levels. Several prior studies suggest that variability in negative affect and MVPA are related. One study observed that children who generally engaged in more MVPA had lower average variability in negative affect (Dunton et al., 2014). To our knowledge, no work has yet evaluated the link between daily negative affective variability and MVPA among individuals increasing activity as part of an intervention. Several studies have evaluated the relationship between MVPA variations in affect, observing MVPA is associated with lower variability in affect under naturalistic (Puterman, Weiss, Beauchamp, Mogle, & Almeida, 2017) and lab-based settings (Edwards, Rhodes, & Loprinzi, 2017). However, neither study utilized ecological momentary assessment techniques for evaluating negative affect variability, which overcomes recall bias (e.g., individuals may over- or underreport negative affect) and also allows for ecologically-valid assessments of variations in affect over time. Mean-squared successive difference (MSSD) is one technique for calculating variability over time. MSSD utilizes the temporal information inherent in EMA ratings to account for degree of change from rating to rating; given that dramatic or sudden shifts in affect are associated with poorer psychological functioning (Thompson, Berenbaum, & Bredemeier, 2011; Trull et al., 2008), MSSD may be an important measure of daily variability in negative affect.

The current study sought to evaluate the associations between negative affect (mean and variability) and physical activity among individuals who are overweight or obese and were prescribed physical activity as part of weight loss treatment. Our first aim evaluated the association between negative affect (daily average and variability) and engaging (versus not engaging) in physical activity on the same day. We hypothesized that individuals with lower average negative affect or lower average variability in negative affect across the 7-day assessment period exercised more often (between-subjects effects) and that an individual is more likely to have exercised on days where negative affect or variability in negative affect was lower, relative to his or her own average levels (within-subjects effects). Our second aim evaluated the association between negative affect (daily average and variability) and the duration of physical activity on the same day. We hypothesized that those with lower average levels of negative affect or lower average variability in negative affect exercised for longer periods (between-subjects effects) and that an individual would have exercised for longer on days where negative affect or variability in negative affect was lower, relative to his or her own average levels (within-subjects effects). Our third aim evaluated the directional effects of the relationship between daily MVPA and daily affect. We hypothesized that bidirectional within-person relationships would exist, such that higher MVPA on one day would predict lower average and variability in negative affect on the next day; we also hypothesized that lower within-person negative affect on one day would predict MVPA on the next day.

Methods

Participants

The current study was part of a larger randomized controlled behavioral weight loss trial (Forman et al., 2016). Data from the six-month assessment of the year-long behavioral weight control program were selected for analyses as this is the point in time at which the prescription level for physical activity had reached 250 minutes; thus, this captured a period in which individuals had recently reached the highest MVPA prescription. Of the 190 adults enrolling in this trial, 139 completed assessments of activity and affect at the six-month time point and provided adequate data for inclusion in analyses for the current study (see Data Analysis section for more information). Participants were recruited through radio advertisements, flyers, and referrals from health care providers. Eligible participants had a BMI of 27 to 50 kg/m^2, were between the ages of 18 and 70 years, able to walk at least 2 blocks without stopping for rest, not pregnant or planning to become pregnant during the study timeframe, and had not lost significant (5% or more) weight in the previous six months.

Procedures

As part of the larger trial, participants were randomly assigned to one of two treatment conditions (standard behavioral treatment vs. acceptance-based behavioral treatment). Over the course of the year-long treatment period, participants attended a total of 25 75-minute-long group sessions during which they engaged in brief individual check-ins, learned a new skill(s) for weight control, and completed skill building exercises and goal setting. During the first six months of treatment, participants were provided with an exercise prescription that increased in intensity to the maximum prescription of 250 minutes of MVPA per week accumulated in bouts of 10+ minutes. Data for the current study were collected as part of the six-month assessment.

Measures

Moderate-to-vigorous physical activity.—Waist-worn Actigraph GT3X+ accelerometers were given to participants to wear during all waking hours for one week at the six-month assessment. Consistent with the physical activity prescription, bouts of 10+ minutes of MVPA (> 2019 counts/minute with two minutes of drop time) were measured (Troiano et al., 2008; Tudor-Locke, Brashear, Johnson, & Katzmarzyk, 2010). Sixty or greater minutes of consecutive zero counts were considered non-wear time; days of accelerometer wear were considered valid if there were > 10 hours of wear time.

Negative affect.—Participants were loaned an Android Samsung Galaxy Player 4.0 pre-loaded with a customized EMA app (*DrexelEMA*) to use for seven days concurrently with the accelerometer. Participants received six EMA surveys at semi-random intervals (i.e., +/− 30 minutes of 9:30 a.m., 12:00 p.m., 2:30 p.m., 5:00 p.m., 7:15 p.m., 9:30 p.m.) on each of the seven days, and were instructed to initiate an EMA survey whenever they experienced a dietary lapse (i.e., eating or drinking likely to cause weight gain and/or put weight loss or maintenance at risk). If participants did not respond to the EMA survey immediately, they were signaled every 5 minutes until they completed the survey or until 45 minutes had passed (at which time the survey expired). Participants lost $1 in compensation from a potential maximum of $42 for every semi-random EMA survey that they did not complete.

The date and time of each survey was automatically recorded by the EMA app. At each survey (both semi-random and self-initiated due to a dietary lapse), participants also rated their current level of several dimensions of negative affect using items modeled on the PANAS (Watson, Clark, & Tellegen, 1988). Specifically, participants rated their current loneliness, anger/irritation, boredom, sadness, and stress. Each dimension of negative affect was rated using a 5-point scale (1 = *not at all* to 5 = *extremely*). See Forman et al. (2017) for additional details about the EMA protocol.

Mean level of negative affect was calculated by averaging responses across domains of negative affect at each EMA prompt and then averaging these composite scores across each day. Variability in negative affect was calculated as the mean squared successive difference (MSSD). Daily MSSD was calculated for each of the five affect constructs (loneliness, irritation/anger, boredom, sadness, and stress) and these five measurements were then averaged for each day to provide a single daily composite negative affective variability score. This method is similar to other studies utilizing EMA methods to evaluate daily affect (e.g., (Dunton et al., 2014; Maher, Dzubur, et al., 2018; Simons, Wills, & Neal, 2014; Spindler, Stopsack, Aldinger, Grabe, & Barnow, 2016; Weinstein & Mermelstein, 2013). An alternative strategy, averaging negative affect ratings at each time point before calculating MSSD, was considered; however, using this strategy, variations in different affect constructs could be missed (e.g., a decrease in sadness from Time 1 to Time 2 and an equivalent increase in stress from Time 1 to Time 2 would result in no variation). The selected strategy would allow for evaluation of the average change across any given affect construct.

Data analysis

Data were analyzed using R version 3.5.1. For a day to be included in analyses, activity data had to be available for at least 10 hours and at least three EMA surveys had to be filled out; for a participant to be included in analyses, they had to provide at least two valid days. Of the 190 individuals in the study, 141 provided at least one valid day of activity data and 162 provided at least one valid day of EMA data; 139 individuals provided both activity and EMA data for at least two days and were included in analyses. Multilevel models with participant-level random intercept and slope effects (where the addition of random slopes improved model fit using likelihood-ratio tests) were built to test the association between MVPA and negative affect (i.e., mean and variability). For variability in negative affect and MVPA, between-subject (i.e., the daily mean for each person) and within-subject (i.e., the individual's daily deviation from their own mean) variables were created. Engagement in MVPA (defined dichotomously for each day as engaging in one or more bouts or engaging in no bouts) was evaluated using generalized linear mixed models with a binomial distribution (using the glmer function in the 'lme4' package; (Bates, Sarkar, Bates, & Matrix, 2007)). Time spent in MVPA and negative affect had a non-normal distribution such that many individuals had many days with zero or low time in MVPA and zero or low negative affect and variability in negative affect; thus, compound Poisson mixed models were used for analyses (using the cpglmm function in the 'cplm' package; (Zhang, Zhang, & Matrix, 2018)). Because treatment condition could feasibly impact affect and/or MVPA, condition was included as a covariate in all analyses. Additionally, compliance (surveys completed and hours of accelerometer wear), BMI, age, gender, and weekend vs. weekday. Finally, the number of dietary lapses reported each day was included as a covariate given that lapsing from dietary goals could have impacted affect or variability in affect.

Results

Participants (n = 139) were predominantly White (71.2%, 22.7% Black or African-American, 3.1% Hispanic/Latino, 1.2% Asian), female (82.5%), had an average BMI of 32.57 ± 6.16 kg/m^2 and had an average age of 52.04 ± 9.78 years. Participants excluded from the present analyses (n = 51) for insufficient MVPA or EMA data did not significantly differ in demographic variables, percent weight loss, or baseline levels of affect or MVPA compared to those included in the present analyses. Participants completed an average of 5.72 ± 0.98 surveys on days included in analyses, and provided data for an average of 6.12 ± 1.56 days. Intraclass correlations for average affect and variability in affect were .64 and .33 respectively. Thus, disaggregating between- from within-person effects was appropriate for variability in negative affect; average level of negative affect was not disaggregated given the relative stability of the construct within-individuals, which is consistent with prior literature (Maher, Huh, Intille, Hedeker, & Dunton, 2018). Participant-level variability in MVPA engagement was high; while the participant-average was approximately 45% of days engaged in at least one bout of MVPA, participants ranged from never engaging in a bout of MVPA during the 7-day assessment window to engaging in at least one bout of MVPA each day (see Table 1). Intraclass correlations for engagement in MVPA and time spent in PA were .22 and .32 respectively; thus, disaggregating between- from within-person effects was appropriate for each variable. Between-subjects, average negative affect was significantly associated with engagement in PA and time spent in PA, while variability in negative affect was not (see Table 2).

Associations between negative affect and engagement in MVPA

Significant negative between-subjects associations existed between engagement in MVPA (vs. non-engagement) and mean level and variability in negative affect across the assessment period such that individuals who engaged in more frequent MVPA had lower negative affect (Estimate = −0.18, $p = .004$) and lower variability in negative affect (Estimate = −0.64, $p = .02$) compared with those who engaged in less frequent MVPA. There were not significant relationships between engaging in MVPA and daily affect within-subjects (Estimate = −0.01, $p = .33$ and Estimate = 0.08, $p = .32$ for average negative affect and variability in negative affect respectively; see Table 3); thus, controlling for participant's mean MVPA level across the assessment period, there were not significant differences in daily affect (mean level or variability) between days with or without MVPA.

Associations between negative affect and time spent in MVPA

Similarly, significant negative between-subjects associations existed between time spent in MVPA and mean level (Estimate = −0.003, $p = .006$) and variability (Estimate = −0.01, $p = .02$) in negative affect such that individuals who engaged in MVPA for longer periods had lower average negative affect and lower variability in negative affect across the assessment period compared to individuals who engaged in MVPA for shorter periods of time. There were not significant relationships between engaging in MVPA and daily affect within-subjects (Estimate = 0.00, $p = .10$ and Estimate = 0.001, $p = .55$ for average negative affect and variability in negative affect respectively; see Table 3); thus, controlling for participant's mean daily time spent in MVPA across the assessment period, there were not significant differences in daily affect (mean level or variability) when an individual spent longer or shorter amounts of time in MVPA than was typical for that individual.

Negative affect predicting next-day MVPA

Effects were not observed for average level of affect predicting engagement in MVPA (Estimate = −0.06, SE estimate = −0.07, $z = -0.88$, $p = .38$), but were for time spent in MVPA (Estimate = −0.36, $p = .03$) on the following day. Lower variability in affect on one day (controlling for average variability in affect) significantly predicted engagement in MVPA (Estimate = −0.48, SE estimate = 0.24, $z = -1.99$, $p = .046$) and time in MVPA (Estimate = −0.42, $p = .006$; see Table 4) on the next day.

MVPA predicting negative next-day affect

Engagement in MVPA on one day (controlling for a person's average level of engagement) was not significantly related to average level of negative affect (Estimate = 0.00, SE estimate = 0.01, $z = -0.04$, $p = .97$) or variability in negative affect (Estimate = 0.08, SE estimate = 0.11, $z = 0.72$, $p = .47$) on the next day. Time spent in MVPA on one day (controlling for a person's average daily time spent in MVPA) was not significantly related to average level of negative affect or variability in negative affect (Estimate = 0.00, $p = .46$ and Estimate = 0.00, $p = .81$ respectively) on the next day (see Table 5).

Discussion

This study was among the first to (1) examine the relationship between MVPA and average negative affect, and (2) examine the relationship between MVPA and variability in negative affect, among adults in a weight loss program that prescribes a high level of physical activity. Results of this study indicate that, between individuals, lower average daily negative affect was associated with engaging in MVPA on more days and for longer periods. Additionally, on days where an individual's variability in affect is lower than their own average daily level, he or she is more likely to engage in MPVA on the following day. These results provide important information for understanding the relationship between daily MVPA and negative affect.

Several recent studies have highlighted the bidirectional nature of the relationship between MVPA and affective states (Emerson et al., 2018; Liao, Chou, Huh, Leventhal, & Dunton, 2017; Niermann, Herrmann, von Haaren, van Kann, & Woll, 2016; Schöndube, Kanning, & Fuchs, 2016). These studies have shown that engagement in MVPA has the potential to increase positive affect and to reduce negative affect, and that higher positive affect increases the likelihood and duration of subsequent MVPA while negative affect appears to deter MVPA (Emerson, 2017). Results of the present study suggest that lower average levels of negative affect (across several days) are associated with engaging in MVPA on more days and for longer periods of time. Importantly, however, there were not significant relationships between deviations from one's own average negative affect and MVPA on the same day. Thus, individuals with lower negative affect or lower variability in negative affect generally may engage in greater MVPA, but a single day of lower negative affect (or variability) may not be associated with improved engagement. It is possible that lower typical negative affect allows individuals to establish consistent patterns of MVPA, while a single day of lower negative affect fails to engender an immediate behavioral response. Alternatively, it is possible that consistent engagement in MVPA lowers negative affect while a single bout of MVPA fails to immediately reduce average daily negative affect. Finally, it is also possible that this relationship could be explained by another construct that leads to better psychological functioning and engagement in goal-directed behavior.

Importantly, engagement in MVPA on one day was not associated with negative affect on the next day. Thus, the present study offers no evidence that free-living MVPA reduces negative affect the following day. Several prior studies have similarly observed no acute effects of MVPA on negative affect (Liao et al., 2015). While some studies have observed significant temporal associations between MVPA and negative affect, it is important to note that these have often used bipolar affect scales (e.g., a Likert scale anchored by "good" and "bad") rather than separating positive and negative affect; thus, these may reflect increases in positive affect rather than decreases in negative affect. It is also possible that there was a floor effect of negative affect ratings given that average and variability in negative affect were relatively low across the study, rendering it difficult to establish a within-person relationship between negative affect and MVPA. It may be that relationships would emerge within individuals engaged in weight loss who have higher negative affect ratings (e.g., those with clinically-relevant levels of depression) or greater variability in negative affect. Alternatively, negative affect in this study was comprised of several separate ratings of possible negative affective states; it is possible that MVPA is related only or more strongly to a specific negative affective state (e.g., related to anxiety but not to loneliness). Finally, it is possible that the effects of MVPA on negative affect are cumulative over time (e.g., regular engagement in MVPA over many months decrease negative affect) or differs based on an individual's BMI status.

Effects of negative affect on one day predicting MVPA the next yielded significant within-subjects effects for variability in affect. Thus, when an individual has lower variability in affect compared to their own average, he or she is likely to engage in greater MVPA on the following day. This finding adds to the current literature by indicating that variability in affect may be an important predictor of activity. Literature increasingly indicates that affect is an important predictor of physical activity (Emerson et al., 2018). Additionally, research with other health behaviors similarly indicates that increased variability in affect is temporally associated with engagement in unhealthy behaviors (e.g., (Weinstein, Mermelstein, Shiffman, & Flay, 2008). Variability in affect is also associated with weight gain over time (Dunton, 2018), perhaps through a combination of reduced engagement in MVPA or engagement in unhealthy eating. Thus, variability in affect may be especially important for individuals attempting to lose weight or to maintain weight losses. It is possible that higher variability is related to having greater levels of stress or emotional instability (thus, individuals may have less time to devote to weight control due to other cognitive or emotional demands). Understanding how variability in affect impacts salient outcomes, and whether it is possible to reduce variability in affect with treatment, will be important future research.

Several important aspects of measurement warrant particular attention. Within this study, only one type of activity was considered (i.e., aerobic activity of at least moderate intensity for at least 10 minutes at a time). Whether other types of activity, such as leisure activity, strength training, or aerobic activity less than 10 minutes in duration, has similar or different associations is unclear. Given some evidence that individuals with overweight or obese BMIs may find activity at lower self-selected paces to be more enjoyable, it is possible that individuals derive more affective benefit from such activity. Future research should continue to disentangle how negative affect is related to physical activity among individuals in an intervention program designed to increase activity. Additionally, all variables were aggregated at the daily level. Thus, results cannot be generalized to intraday relationships or to large timescales. Notably, research has not consistently supported immediate effects of MVPA on negative affect; thus associations at the day level may constitute an important extension of previous work. Recent research also indicates that variability in MVPA may have important associations with psychological outcomes, particularly among adults with higher BMIs (Maher, Huh, et al., 2018). Whether relationships exist between variability in MVPA and average levels of affect or variability in affect is unknown. Additionally, variability in affect can be measured in many different ways. While one prior study attempted to utilize location-scale modeling to evaluate similar relationships, non-normal distribution of the MVPA and negative affect data precluded the ability to generate results (Maher, Dzubur, et al., 2018). Approaches to conceptualizing and measuring variability include location-scale modeling, intraindividual variance, and MSSD, among others. The advantages and limitations to each method have been discussed previously (Jahng, Wood, &

Trull, 2008; Wang, Hamaker, & Bergeman, 2012); while evaluating several indices of variability was outside the scope of this study, research should continue to explore how to best conceptualize intraindividual variability.

Strengths of the current study include use of a relatively large sample with overweight/ obesity actively participating in a behavioral weight loss program, allowing for examination of factors that are associated with MVPA in individuals attempting to follow a PA prescription (while also changing diet). Use of EMA allowed for momentary, rather than retrospective, report of affect, and thus a more ecologically valid measurement of negative affect. Additionally, this study evaluated several separate affective states (rather than evaluating affect as bipolar dimensions such as valence and arousal) in addition to affect variability. We also obtained objective MVPA estimates via the use of accelerometers and compliance with EMA and accelerometer protocols was high. However, findings from the current study must be interpreted within the context of certain study limitations. First, we were unable to measure or control for external situations in an individual's life that might have impacted MVPA, average affect, or affect variability (i.e., we could not ascertain the direct, isolated impact of MVPA on affect and vice versa). Secondly, we only captured a snapshot of physical activity (i.e., one week), which meant we were unable to evaluate relationships between affect and MVPA over more extended time. Additionally, this study evaluated bouts of ten or more minutes of MVPA rather than total (i.e., not within bouts) MVPA over the course of a day. Bouts of MVPA are consistent with previous national recommendations for physical activity (Health & Services, 2008) and recommendations within behavioral weight control programs, but it may be that affective effects of MVPA occur with shorter bouts of MVPA or activity that does not reach moderate intensity. Third, measures of affect were rated at each timed prompt as well as at any user-initiated prompts following dietary lapses, which may have targeted times of specific affect; thus, measured affect may have some degree of bias given that user-initiated surveys likely reflected dietary lapses (which may have increased negative affect). Additionally, random surveys could be completed up to 45 minutes following the survey prompt, which may have impacted affect ratings (e.g., waiting to complete a survey until higher negative affect has dissipated). Finally, while many studies use mean affect scores in a manner similar to the present study, it is possible that this measurement also captures how well individuals differentiate between affect states, as those who are unable to differentiate between affective states may have higher mean scores compared to those who are better able to differentiate. Affect differentiation has also been related to psychological and health outcomes (Demiralp et al., 2012; Kashdan, Ferssizidis, Collins, & Muraven, 2010; Pond Jr et al., 2012; Zaki, Coifman, Rafaeli, Berenson, & Downey, 2013). Future research should seek to understand the relationship between affective variability and differentiation and whether these independently relate to health outcomes.

Taken together, results indicate the presence of important relationships between daily average levels of negative affect and daily variability in negative affect and MVPA in individuals undergoing behavioral weight loss. Although additional research on the bidirectional relationship between MVPA and affective variability is needed, if future findings support that greater variability in negative affect predicts MVPA, physical activity interventions may wish to target negative affect in treatment (e.g., through teaching emotional regulation skills) to promote MVPA engagement. On the other hand, consistent MVPA could be a viable venue through which to decrease typical negative affect and affect variability. Future research should utilize experimental designs to disentangle these effects. Given that negative affect and negative affective variability predict weight gain (Dunton, 2018) and other poor health outcomes, reducing negative affect may improve weight loss maintenance. Future research should continue to understand the relationship between affect and health behaviors, as interventions may be improved both for psychological disorders or other chronic health conditions with the addition of MVPA and for MVPA promotion with the addition of skills to improve affect regulation.

Funding:

The authors acknowledge the National Institutes of Diabetes and Digestive and Kidney Diseases as the funding source (R01 DK095069; PI: Forman).

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Highlights

- Average levels physical activity are negative associated with negative affect
- Physical activity is negative associated with variability in negative affect
- Lower variability in affect is associated with greater physical activity the next day
- Negative affect may be important to address among those adopting physical activity

Table 1.

Sample characteristics

	Mean (SD)	Median	Range
Composite daily mean negative affect	1.34 (0.36)	1.22	1–3.08
Composite daily variability in negative affect	0.36 (0.36)	0.26	0–2.17
% of days engaged in physical activity	44.82 (31.43)	42.86	0–100.00
Mins/day engaged in physical activity	19.20 (18.62)	13.88	0–111.93

Table 2.

Between-subject correlations

	1.	2.	3.
1. Average negative affect			
2. Variability in negative affect	.66**		
3. Time spent in MVPA	−.18*	.12	
4. Engagement in MVPA	−.20*	−.14	.81**

Note.

* $p < .05$;

** $p < .001$

Table 3.

Within- and between-subjects associations between negative affect and engaging in a bout of MVPA

	Average affect				Variability in affect			
	Estimate	SE Estimate	z-value	p-value	Estimate	SE Estimate	z-value	p-value
Engaging in a bout of MVPA								
Intercept	2.21	0.17	13.01	<.001	−0.61	0.80	−0.76	.45
BMI	−0.01	0.003	−1.55	.12	−0.01	0.01	−0.87	.38
Sex	0.03	0.05	0.54	.59	0.19	0.22	0.87	.38
Age	−0.001	0.002	−0.71	.48	−0.01	0.01	−1.62	.11
Treatment condition	−0.06	0.04	−1.69	.09	−0.20	0.16	−1.27	.20
Weekend	−0.06	0.01	−5.12	<.001	−0.12	0.07	−1.69	.09
Accelerometer wear time	0.004	0.003	1.19	.24	0.05	0.02	2.80	.005
Surveys completed	−0.01	0.004	−2.47	.01	−0.05	0.03	−1.86	.06
Dietary lapses	0.00	0.01	−0.06	.95	0.10	0.04	2.53	.01
BS MVPA	−0.18	0.06	−3.11	.004	−0.64	0.28	−2.29	.02
WS MVPA	−0.01	0.01	−0.98	.33	0.08	0.08	0.99	.32
Time spent in MVPA								
Intercept	2.29	0.18	12.54	<.001	−0.67	0.82	−0.81	.42
BMI	−0.01	0.003	−1.42	.16	−0.01	0.01	−0.74	.46
Sex	−0.01	0.05	−0.21	.84	0.13	0.22	0.57	.57
Age	−0.003	0.003	−1.40	.16	−0.01	0.01	−1.65	.10
Treatment condition	−0.05	0.04	−1.42	.16	−0.17	0.16	−1.06	.29
Weekend	−0.06	0.01	−5.26	<.001	−0.12	0.07	−1.71	.09
Accelerometer wear time	0.003	0.003	0.99	.32	0.05	0.02	2.56	.01
Surveys completed	−0.01	0.004	−2.33	.02	−0.04	0.03	−1.48	.14
Dietary lapses	0.00	0.01	0.03	.97	0.09	0.04	2.43	.02
BS MVPA	−0.003	0.001	−2.76	.006	−0.01	0.01	−2.33	.02
WS MVPA	0.00	0.00	−1.63	.10	0.001	0.002	0.60	.55

Note. Models evaluating mean affect included random intercept effects; models evaluating MSSD included random intercept and slope effects.

Table 4.

Effects of affect on Day *T* on time spent in MVPA on Day *T+1*

	Average affect				Variability in affect			
	Estimate	**SE Estimate**	**z-value**	**p-value**	**Estimate**	**SE Estimate**	**z-value**	**p-value**
Intercept	5.97	0.80	7.45	<.001	5.69	0.79	7.25	<.001
BMI	−0.06	0.01	−4.52	<.001	−0.05	0.01	−4.34	<.001
Sex	−0.62	0.18	−3.37	.001	−0.62	0.18	−3.40	.001
Age	−0.01	0.01	−0.78	.44	−0.01	0.01	−0.91	.37
Treatment condition	0.04	0.15	0.28	.78	0.06	0.15	0.42	.68
Weekend	−0.34	0.12	−2.81	.005	−0.33	0.12	−2.69	.007
Accelerometer wear time	0.01	0.03	0.19	.85	0.01	0.03	0.30	.76
Surveys completed	−0.03	0.03	−1.01	.31	−0.06	0.04	−1.63	.10
Dietary lapses	0.05	0.07	0.65	.51	0.05	0.07	0.71	.48
Affect	−0.36	0.16	−2.22	.03	-	-	-	-
BS affect	-	-	-	-	−0.31	0.24	−1.28	.20
WS affect	-	-	-	-	−0.42	0.15	−2.77	.006

Note. Models evaluating mean affect included random intercept effects; models evaluating MSSD included random intercept and slope effects.

Table 5.

Effects of time spent in MVPA on Day *T* on affect on Day *T+1*

	Average affect				Variability in affect			
	Estimate	**SE Estimate**	**z-value**	**p-value**	**Estimate**	**SE Estimate**	**z-value**	**p-value**
Intercept	2.26	0.17	13.31	<.001	0.13	0.77	0.16	.87
BMI	−0.01	0.003	−1.74	.08	−0.02	0.01	−1.40	.16
Sex	0.01	0.05	.21	.83	0.07	0.21	0.34	.73
Age	−0.002	0.002	−0.91	.36	−0.01	0.01	−1.41	.16
Treatment condition	−0.01	0.04	−1.53	.13	−0.24	0.15	−1.54	.12
Weekend	−0.06	0.01	−6.02	<.001	−0.18	0.07	−2.55	.01
Accelerometer wear time	0.001	0.003	0.50	.62	0.02	0.02	0.97	.33
Surveys completed	−0.01	0.003	−2.05	.04	−0.06	0.03	−1.91	.06
Dietary lapses	−0.004	0.01	−0.66	.51	0.10	0.04	2.71	.007
BS MVPA	−0.003	0.001	−2.52	.01	−0.01	.01	−2.59	.01
WS MVPA	0.00	0.00	−0.74	.46	0.00	.001	−0.24	.81

Note. Models included random intercept effects.