

## [A Daily Analysis of Physical Activity and Satisfaction With Life in Emerging Adults](#)

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Maher, J. P., Doerksen, S. E., Elavsky, S., Hyde, A.L., Pincus, A.L, Ram, N., & Conroy, D.E. (2013). A daily analysis of physical activity and satisfaction with life in emerging adults. *Health Psychology*. 32(6):647-56.

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### Abstract:

**Objective:** Subjective well-being has well-established positive health consequences. During emerging adulthood, from ages 18 to 25 years, people's global evaluations of their well-being (i.e., satisfaction with life [SWL]) appear to worsen more than any other time in the adult life span, indicating that this population would benefit from strategies to enhance SWL. In these studies, we investigated top-down (i.e., time-invariant, trait-like) and bottom-up (i.e., time-varying, state-like) influences of physical activity (PA) on daily SWL. **Methods:** Two daily diary studies lasting 8 days (N = 190) and 14 days (N = 63) were conducted with samples of emerging adults enrolled in college to evaluate relations between daily PA and SWL while controlling for established and plausible top-down and bottom-up influences on SWL. **Results:** In both studies, multilevel models indicated that people reported greater SWL on days when they were more active (a within-person, bottom-up effect). Top-down effects of PA were not significant in either study. These findings were robust when we controlled for competing top-down influences (e.g., sex, personality traits, self-esteem, body mass index, mental health symptoms, fatigue) and bottom-up influences (e.g., daily self-esteem, daily mental health symptoms, daily fatigue). **Conclusions:** We concluded that SWL was impacted by people's daily PA rather than their trait level of PA over time. These findings extend evidence that PA is a health behavior with important consequences for daily well-being and should be considered when developing national policies to enhance SWL.

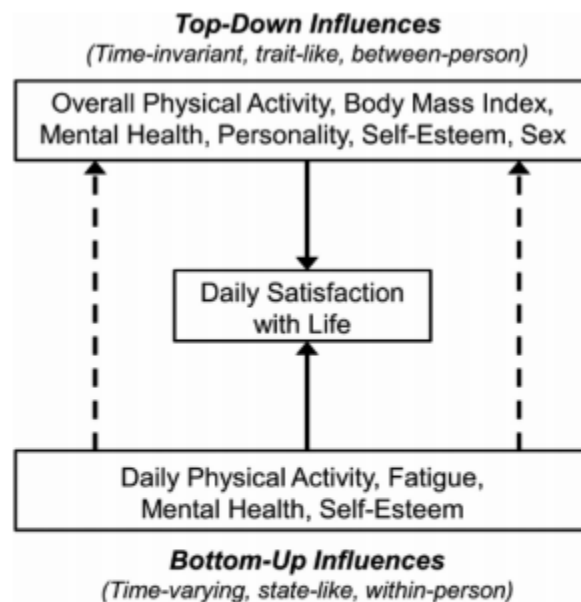
**Keywords:** well-being | exercise | intraindividual | daily diary

### Article:

Satisfaction with life (SWL) is related to peoples' physical and mental health and appears to be a key determinant of happiness throughout the life span (Diener & Chan, 2011; Pavot & Diener, 2008). Emerging adulthood is a particularly important stage for studying SWL because peoples' global evaluations of their well-being appear to worsen more from ages 18 to 25 years than any other time in the adult life span (Stone, Schwartz, Broderick, & Deaton, 2010). Understanding the factors that influence daily SWL is an important first step for explaining these age-related differences during emerging adulthood and may identify small, daily changes (i.e., being more active than usual) that emerging adults can make to enhance satisfaction. In this article, we report two daily diary studies that were conducted to evaluate emerging adults' daily SWL as a function of their daily physical activity (PA).

## SATISFACTION WITH LIFE AND PHYSICAL ACTIVITY

Subjective well-being is considered an umbrella term, consisting of both hedonic (i.e., affect) and evaluative (i.e., SWL) components (Diener, 1984). Contemporary research predominantly frames influences on SWL as either top-down or bottom-up (Diener, 1984). Figure 1 illustrates the conceptual structure of top-down and bottom-up influences on SWL. The majority of research on SWL focuses on top-down influences emphasizing dispositional (i.e., time-invariant, trait-level) correlates of SWL, such as personality or sex. Bottom-up influences of SWL reflect the impact that time-varying factors, such as daily life events, behaviors or states, may have on SWL. To the extent that daily influences accumulate to reflect dispositional tendencies, they may also produce a top-down effect on SWL.



*Figure 1.* A conceptual representation of top-down and bottom-up influences on SWL. Top-down and bottom-up influences can both directly influence SWL. Dashed arrows indicate that daily behaviors and experiences (i.e., bottom-up influences) may accumulate over time (e.g., repeated measures data), ultimately influencing overall tendencies or dispositions (i.e., top-down influences).

One factor that may have top-down or bottom-up influences on SWL is daily PA. Prospective studies on older adults show that engaging in regular PA is indirectly associated with improved SWL (Elavsky et al., 2005; Elavsky & McAuley, 2005; McAuley et al., 2008). Although it is tempting to attribute this association to the physical health benefits of PA that can slow age-related decline, both cross-sectional and longitudinal data indicate that PA indirectly enhances SWL through its influence on affect, physical self-worth, self-efficacy, and mental health (Elavsky et al., 2005; Elavsky & McAuley, 2005; McAuley et al., 2008). These mechanisms may also be influential during emerging adulthood, a life stage characterized by relatively poor self-evaluations and heightened affective lability compared with midlife and older adulthood (Robins, Trzesniewski, Tracy, Gosling, & Potter, 2002; Röcke, Li, & Smith, 2009). Throughout emerging adulthood, both the level and intensity of PA decline (Troiano et al., 2008), and those changes may help to explain the decrease in SWL during this developmental period; however, it is not presently clear whether the PA–SWL association found in older adults generalizes to emerging adults.

## **INFLUENCES ON SATISFACTION WITH LIFE**

Although PA has been linked with enhanced SWL, it is presently unclear whether PA influences SWL through top-down or bottom-up pathways (or both; Diener, 1984). A health behavior like PA may have both top-down and bottom-up influences on SWL. For example, overall PA may result in improved physical health, whereas daily PA may result in decreased anxiety or improved self-esteem—both chronic and acute PA may enhance SWL.

### **Top-Down Influences**

From a top-down or trait perspective, people who are more active in general should report greater SWL in general (i.e., a between-person association). This finding would imply that efforts to increase SWL should focus on accumulating high levels of PA over time and may implicate fitness-related adaptation as a mechanism for relations between PA and SWL. Many established top-down correlates of SWL are also associated with PA, and it is possible that PA–SWL relations are artifacts of third variables such as self-esteem or personality traits.

Self-esteem is one of the strongest top-down correlates of SWL, presumably because the perceptions that underlie self-esteem derive from progress in the pursuit of important life goals which are also the basis for SWL (Diener, 1984; Diener & Diener, 1995). Self-esteem has also been implicated as a correlate of PA (e.g., Ekeland, Heian, & Hagen, 2005).

Likewise, personality traits can influence SWL by impacting the ways that people interpret situations as well as where they direct their attention (e.g., on positive or negative events; Gray, 1990; Mischel & Shoda, 2008). SWL is associated with high levels of extraversion and low levels of neuroticism (Diener & Lucas, 1999; Mroczek & Spiro, 2005; Schimmack, Diener, & Oishi, 2002); and people high in extraversion and low in neuroticism also tend to be more physically active (Rhodes & Smith, 2006). Thus, personality traits may explain the between-person relation between PA and SWL.

Given this complex web of associations, it would be risky to draw conclusions about relations between PA and SWL without controlling for the top-down influence of self-esteem and personality traits on SWL. We hypothesized that people who were more physically active in general would report greater daily SWL on average, even after controlling for these top-down correlates.

### **Bottom-Up Influences**

Bottom-up influences have received considerably less attention in the literature compared with top-down influences (Heller, Watson, & Ilies, 2006; Schwarz & Strack, 1999). From a bottom-up or state perspective, being more or less physically active than usual on a particular day should influence a person's SWL that day (i.e., a within-person association). This finding would imply that PA has acute effects on SWL and the mechanism for this relationship does not involve changes in fitness. We hypothesized that people would report greater SWL on days when they were more physically active than usual.

Although we described self-esteem as a top-down influence earlier, self-evaluations fluctuate over time and may therefore exert a bottom-up influence on SWL as well. For example, desirable and undesirable daily events can alter both self-esteem and SWL (Diener, Suh, Lucas, & Smith, 1999; Greenier et al., 1999). Self-esteem is a strong predictor of SWL at the between-person level, so deviations in daily self-esteem may be responsible for acute changes in SWL. In this study, we hypothesized that people would report greater SWL on days when they were more physically active than usual, even after controlling for daily self-esteem.

### **THE PRESENT STUDIES**

Two daily diary studies were conducted to evaluate top-down and bottom-up associations between PA and SWL and to determine if these associations were robust after controlling for other potential top-down and bottom-up influences. These studies were designed to accomplish four specific objectives. First, we sought to characterize the relative proportion of between- and within-person variability in daily SWL. On the basis of recent findings that indicated that SWL can change within people over time (Heller et al., 2006), we expected substantial within-person variability in ratings of daily SWL. This finding would indicate the need to differentiate between top-down and bottom-up influences on SWL.

Our second objective was to establish whether there was an association between PA and SWL in emerging adults. Research evaluating this association has been heavily skewed toward the second half of the life span. We expected that a positive association between PA and SWL would be evident in emerging adults.

Our third objective was to establish whether PA and SWL were linked through top-down (i.e., between-person, trait-level) or bottom-up (i.e., within-person, state-level) processes, or both. The existing research on older adults is consistent with a top-down association between PA and SWL (i.e., a between-person hypothesis); however, in the context of emerging adulthood, we believe that the acute effects of PA may have bottom-up effects on SWL (i.e., a within-person

hypothesis). We hypothesized that both overall PA and daily PA would be positively associated with SWL.

Finally, we sought to determine whether the association between PA and SWL is robust after controlling for a variety of top-down and bottom-up influences. In Study 1, we controlled for the top-down or trait influences of self-esteem and personality traits, as well as the potential bottom-up or state influence of daily self-esteem. We also controlled for sex because of established sex differences in both PA and SWL (Stone et al., 2010; Troiano et al., 2008). We hypothesized that both overall PA and daily PA would be positively associated with SWL after controlling for these top-down and bottom-up covariates.

## **STUDY 1**

### **Method**

#### *Participants and procedures*

Participants were 190 university students ( $M$  age = 19.3 years,  $SD$  age = 2.8) enrolled in introductory psychology courses who participated in a study of daily experiences for course credit. The sample was composed of predominantly White (83%) women (66%) who were in their first or second year of schooling at the university (86%).

At an introductory session, participants were familiarized with the study protocol and completed baseline questionnaires. Participants were also provided with eight diary booklets to provide information on daily evaluations and behaviors (e.g., SWL, self-esteem, PA). The first diary booklet was completed during the evening introductory session, and participants were instructed to complete the remaining booklets before going to bed each evening for the duration of the study. The campus mail system was used for participants to return completed diary booklets each day.

Participants provided data for a total of 1,506 of the 1,520 possible person days (99% response rate), and 96% of participants ( $n = 183$ ) reported on all 8 days of the 8 day study (no. of days:  $Mdn = 8$ ,  $M = 7.92$ ,  $SD = 0.49$ ). The local institutional review board approved all study protocols, and prior to data collection, all participants gave informed consent and permission for their data to be used for research purposes.

#### *Measures*

Personality was assessed during the baseline assessment. SWL, PA, and self-esteem were assessed during daily assessments.

##### *Personality*

Personality was assessed using the Big Five Inventory short form (BFI-10; Rammstedt & John, 2007). Participants rated 10 items (assessing five dimensions of personality) on a 1 (*strongly disagree*) to 5 (*strongly agree*) scale, with extraversion, agreeableness, conscientiousness,

neuroticism, and openness scores each calculated as the average of two items. The trait scores from the BFI-10 have been shown to correlate significantly with the full 44-item version of the Big Five Inventory (Rammstedt & John, 2007).

### *Satisfaction with life*

Daily SWL was measured using the 5-item Satisfaction with Life Scale (SWLS; Diener, Emmons, Larsen, & Griffin, 1985), modified for daily administration. Prompted with instructions to “Look back on everything that happened to you today and consider the day as a whole,” participants rated each item (e.g., “In most ways today was close to ideal”) on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). These items were found to be reliable ( $\alpha = .90$ ). Item responses were averaged to obtain a reliable daily SWL score.

### *Physical activity*

Daily PA was measured by using a modified version of the Godin Leisure Time Exercise Questionnaire (LTEQ; Godin, Jobin, & Bouillon, 1986; Godin & Shephard, 1985), a validated measure of adult PA (Jacobs, Ainsworth, Hartman, & Leon, 1993). Participants were instructed to indicate how many times they engaged in (a) strenuous (e.g., running, vigorous swimming), (b) moderate (e.g., fast walking, volleyball), and (c) mild exercise (e.g., easy walking, yoga) for at least 10 min throughout their free time during the day. Using the LTEQ scoring procedure, responses were weighted by standard metabolic equivalents (MET; vigorous PA = 9 MET, moderate = 5, mild = 3) and summed to create a daily MET or energy expenditure score. Higher scores were indicative of more PA energy expenditure.

### *Self-esteem*

Daily self-esteem was assessed using the Single-Item Self-Esteem Scale (Robins, Hendin, & Trzesniewski, 2001). Prompted with instructions to “Look back on everything that happened to you today and consider the day as a whole,” participants rated the extent to which they had high self-esteem that day on a scale ranging from 1 (*not very much like me*) to 5 (*very much like me*). The Single-Item Self-Esteem Scale correlates strongly with the Rosenberg Self-Esteem Scale, and the two measures have a similar pattern of convergent and discriminant relations with other measures (Robins et al., 2001).

### *Data analysis*

Multilevel models (Snijders & Bosker, 1999) were used to examine between- and within-person associations between PA and SWL, while accommodating the nested nature of the data (days nested within persons). Models were estimated using SAS 9.2 PROC MIXED (Littell, Miliken, Stoup, & Wolfinger, 1996), with the small amount of missing observations (<1%;  $n$  observations = 12) treated as missing completely at random. The final sample consisted of 1,494 daily reports from 186 persons. In accordance with standard multilevel modeling practice, pseudo- $R^2$ , the additional proportion of variance explained by the predictors (e.g., daily PA), compared with a baseline model was considered as an indicator of effect size (see Snijders & Bosker, 1999).

## Data preparation

To separately test between- and within-person associations, daily ratings of PA and self-esteem were person centered (Bolger, Davis, & Rafaeli, 2003; Schwartz & Stone, 1998). For example, person  $i$ 's overall level of PA (Overall PA $_i$ ) was calculated as the within-person mean of her daily responses across the 8 days and each person's daily level of PA (Daily PA $_{di}$ ) was calculated as the deviation of day  $d$ 's score from the individual mean. Therefore, all constructs referred to at the daily level (i.e., daily PA, daily self-esteem) are daily deviations from the individual's average across days. For the purpose of this study, we considered within-person mean scores across the 8 days as indicative of top-down factors (i.e., differentiating more or less active people) and daily deviations as indicative of bottom-up factors (i.e., differentiating more or less "active than usual" days).

## Associations between physical activity and satisfaction with life

Daily SWL (SWL $_{di}$ ) was regressed on overall and daily PA, controlling for individual differences in personality, overall self-esteem, and daily deviations in self-esteem. The model was specified as

$$\text{Level 1: SWL}_{di} = \beta_{0i} + \beta_{1i}(\text{Daily PA}_{di}) + \beta_{2i}(\text{Daily Self-Esteem}_{di}) + e_{di} \quad (1)$$

$$\begin{aligned} \text{Level 2: } \beta_{0i} = & \gamma_{00} + \gamma_{01}(\text{Overall PA}_i) + \gamma_{02}(\text{Overall Self-Esteem}_i) \\ & + \gamma_{03}(\text{Agreeableness}_i) + \gamma_{04}(\text{Conscientiousness}_i) \\ & + \gamma_{05}(\text{Extraversion}_i) + \gamma_{06}(\text{Neuroticism}_i) \\ & + \gamma_{07}(\text{Openness}_i) + \gamma_{08}(\text{Sex}_i) + u_{0i} \end{aligned} \quad (2)$$

$$\beta_{1i} = \gamma_{10} + u_{1i} \quad (3)$$

$$\beta_{2i} = \gamma_{20} + u_{2i} \quad (4)$$

where  $\gamma_{01}$  to  $\gamma_{08}$  represent the top-down trait influences of PA, self-esteem, personality, and sex (between-person effects) on SWL;  $\gamma_{10}$  and  $\gamma_{20}$  represent the average strength of the bottom-up influences of state PA and self-esteem (average within-person effects) on SWL; and  $u_{0i}$ ,  $u_{1i}$ , and  $u_{2i}$  are individual-level residual deviations that are uncorrelated with the day-level residuals  $e_{di}$ . Of particular interest for our research questions are the  $\gamma_{01}$  and  $\gamma_{10}$  parameters quantifying the top-down and bottom-up associations between PA and SWL, controlling for the other top-down and bottom-up factors.

## Results and Discussion

Participants reported moderate SWL on average ( $M = 4.10$  on a 1 to 7 scale,  $SD = 0.77$ ) and ratings fluctuated considerably within people (intraclass correlation [ICC] = 28% between-persons variance). On average, participants overall level of PA ( $M = 12.67$ ,  $SD = 8.67$ ) was equivalent to participation in slightly more than two moderate-intensity bouts (>10 min) of activity per day. Both PA and self-esteem were characterized by substantial between- and within-person variability (ICCs = 59% and 47% between-person variance, respectively).

Two types of bivariate correlations were estimated for descriptive purposes—one was insensitive to within-person dependencies in ratings and the other was insensitive to within-person variation in ratings. In these analyses, PA and SWL had a weak positive association ( $r_s = .15$  and  $.13$ ), whereas self-esteem and SWL had a moderate-to-strong positive association ( $r_s = .53$  and  $.49$ ). At the between-person level, mean SWL had a weak positive association with agreeableness ( $r = .07$ ) and openness ( $r = .10$ ) and a weak negative association with neuroticism ( $r = -.14$ ).

Results from the multilevel model examining top-down (trait-level) and bottom-up (state-level) associations between PA, self-esteem, personality, sex, and SWL are given in Table 1. Our hypotheses concerning the association between PA and SWL received mixed support. From a bottom-up or state perspective, on days when people were more physically active than usual, they reported greater SWL ( $\gamma_{10} = 0.02, p = .0003$ ). However, top-down, between-person differences in overall trait levels of PA were not associated with SWL ( $\gamma_{01} = 0.01, p = .07$ ). Of note, the random effect for the within-person association was not statistically significant ( $\sigma_{u1}^2 = 0.01, p = .22$ ), indicating that this association was highly similar across individuals. As indicated by the pseudo- $R^2$ , the model accounted for approximately 26% of the variance in SWL, with daily PA accounting for 16% of the explained variance. Looking at the other factors, we found that, as expected, between-person differences in people’s overall levels of self-esteem were positively associated with SWL on average (top-down,  $\gamma_{02} = 0.50, p < .01$ ); and on days when people had greater self-esteem than usual, they reported greater SWL (bottom-up,  $\gamma_{20} = 0.68, p < .01$ ). The random effect for the association between daily self-esteem and SWL was significant ( $\sigma_{u2}^2 = 0.08, p < .01$ ), indicating that this within-person association varied between people. Contrary to expectations, we did not find evidence of significant top-down influences for personality traits or sex ( $ps > .05$ ).

Table 1  
*Study 1: Multilevel Models of Daily SWL as a Function of Physical Activity, Self-Esteem, Personality, and Sex*

Variable	Parameter estimate (SE)
<b>Fixed effects</b>	
Intercept, $\gamma_{00}$	4.10 (0.05)
Overall physical activity, $\gamma_{01}$	0.01 (0.01)
Daily physical activity, $\gamma_{10}$	0.02* (0.01)
Global self-esteem, $\gamma_{02}$	0.50* (0.07)
Daily self-esteem, $\gamma_{20}$	0.68* (0.04)
Agreeableness, $\gamma_{03}$	0.06 (0.05)
Conscientiousness, $\gamma_{04}$	0.04 (0.06)
Extraversion, $\gamma_{05}$	-0.05 (0.05)
Neuroticism, $\gamma_{06}$	-0.04 (0.05)
Openness, $\gamma_{07}$	0.05 (0.05)
Sex, $\gamma_{08}$	0.04 (0.11)
<b>Random effects</b>	
Variance intercept, $\sigma_{u0}^2$	0.32 (0.05)
Variance physical activity, $\sigma_{u1}^2$	0.01 (0.01)
Variance self-esteem, $\sigma_{u2}^2$	0.08* (0.03)
Covariance, $\sigma_{u1u0}$	0.01 (0.01)
Covariance, $\sigma_{u2u0}$	-0.04 (0.03)
Covariance, $\sigma_{u2u1}$	-0.01 (0.01)
Residual, $\sigma_e^2$	0.87*
-2LL	4383.0
AIC	4397.0

*Note.* Unstandardized estimates and standard errors. Model is based on 8 occasions nested within 186 participants for a total of 1,494 observations. AIC = Akaike Information Criterion; -2LL = -2 log likelihood. \*  $p < .05$ .



Of note, our model is based on our assumption that daily PA influences end-of-day SWL (as obtained by our assessment protocol)—behavior influencing subsequent evaluation of well-being. It is also possible that PA was influenced by the previous end-of-day's SWL—evaluations of well-being influencing subsequent behavior. To rule out this alternative temporal sequence (i.e., previous day's SWL influencing subsequent day's PA), we tested a second model where daily PA was regressed on previous day's SWL. The association was not significant ( $\gamma_{10} = 0.28, p = .15$ ). Thus, we concluded that the within-person association between PA and SWL more likely reflected behavioral influences on evaluation rather than evaluative influences on behavior.

We also conducted an additional analysis to control for the threat of reactivity (i.e., daily SWL changing systematically over the course of the study as a function of self-monitoring). We included day in the study (a continuous variable representing the sequence of days) and day of week (a series of six dummy-coded variables representing differences from the starting day of the study as a reference day) variables in our original model as part of Equation 1. After controlling for reactivity, our key conclusions about PA and SWL were unchanged.

In sum, the results of Study 1 supported our hypothesis that PA and SWL would be positively associated at the within-person level (i.e., bottom-up, state influence) but did not support our hypothesis that this association would also exist at the between-person level (i.e., top-down, trait influence). This analysis, which controlled for top-down influences of personality, self-esteem, and sex, as well as the bottom-up influence of daily self-esteem, contributed initial evidence of a link between daily PA and SWL in emerging adults.

## **STUDY 2**

Having obtained mixed support for our hypotheses, we sought to replicate and extend those findings in a separate sample. Study 2 was designed as an even more conservative test of the hypotheses concerning the influence of PA on SWL by (a) controlling for a different and broader set of plausible bottom-up (i.e., state) influences on SWL, which are also associated with PA (i.e., mental health symptoms and fatigue); and (b) controlling for additional top-down (i.e., trait) influences on SWL that might have suppressed between-person relations between PA and SWL.

Mental health, as a between-person difference, has an established top-down association with SWL (e.g., McAuley et al., 2006). Mental health symptoms can also vary from day-to-day within people (Ong, Bergeman, & Bisconti, 2005). Shifts in depression, anxiety, and stress reflecting the interaction of people's motivation with the changing contexts of their daily life should likely impact people's SWL at a given point in time. PA is also associated with fewer mental health symptoms (Landers & Arent, 2007), so it is possible that these associations are redundant. We expected that people who report greater overall levels of depression, anxiety, and stress would report lower SWL and that on days when people reported greater mental health symptoms, they would report lower SWL.

Energy resources can influence daily SWL because of their impact on a person's ability to pursue and accomplish their goals. Feelings of energy and vigor are linked to SWL in cross-sectional and longitudinal research (Fujita & Diener, 2005; Pilcher, 1998). Less is known about

the effects of daily fatigue on SWL—two possibilities exist. First, fatigue has been cited as both a barrier to engaging in PA as well as a consequence of PA (Brownson, Baker, Housemann, Brennan, & Bacak, 2001; Dishman, Sallis, & Orenstein, 1985). From this perspective, daily fatigue would be expected to reduce SWL. On the other hand, PA can have a revitalizing effect that invigorates goal pursuit and SWL (Puetz, O'Connor, & Dishman, 2006). In this study, we expected that PA would influence SWL above and beyond any negative influence of fatigue.

Individuals classified by the body mass index (BMI) guidelines as either overweight or obese tend to experience less satisfaction in specific domains such as work, family relationships, partner–spouse relationships, and social activities (Ball, Crawford, & Kenardy, 2004). BMI also has a strong negative association with PA (Strath, Holleman, Ronis, Swartz, & Richardson, 2008). We expected that individuals with greater BMI would report less SWL but that BMI would not suppress an association between PA and SWL.

To summarize, Study 2 was designed to determine whether the within-person association between PA and SWL in emerging adults could be replicated in an independent sample and to evaluate whether this association was robust when controlling for a different set of top-down (i.e., trait) and bottom-up (i.e., state) correlates of SWL. Our central hypothesis was that the within-person association between PA and SWL would be robust with controls for mental health, fatigue, and BMI included in the model. To test this hypothesis, we conducted a 14-day daily diary study. In addition to extending the duration of the sampling period, we used different measures of PA and SWL to reduce the possibility that Study 1 findings were due to idiosyncrasies of those measures.

## ***Method***

### *Participants and procedures*

Participants were 63 university students ( $M$  age = 21.0 years,  $SD$  age = 0.9) enrolled in two upper level courses who completed the study as part of class projects. The sample (60% female) was predominantly non-Hispanic or Latino (97%) and White (87%; unknown for  $n = 1$ ).

At an introductory session, participants provided informed consent, and a research assistant measured their height and weight twice (a third measure was taken if the two measures differed by more than 0.4 cm or 0.3 kg). The research assistant also trained participants how to log onto a password-protected website every evening between 7 p.m. and 4 a.m. for 14 days to complete a brief questionnaire about their behavior and feelings about the day as a whole. Participants provided data for a total of 771 of the 882 possible persons days (87% response rate) with 75% ( $n = 47$ ) reporting on more than 11 days over the course of the 14 day study (no. of days:  $Mdn = 12$ ,  $M = 12.2$ ,  $SD = 1.7$ ). The local institutional review board approved all study protocols, and all participants gave permission for their data to be used for research purposes.

## *Measures*

Participants provided data at their initial lab visit (i.e., demographics, height, weight) and daily through the web-based interface. Unless otherwise stated, participants rated items on a scale ranging from 1 (*not at all*) to 7 (*extremely*).

### *Satisfaction with life*

Daily SWL was assessed using a single item from the SWLS (Diener et al., 1985), modified for daily administration to “I was satisfied with my life today.” This item was selected because it had the strongest association with a latent SWL factor in a factor analysis of SWLS items from Study 1 (pattern coefficient = .90).

### *Physical activity*

Daily PA was assessed with a version of the International Physical Activity Questionnaire (IPAQ; Booth, 2000; Sjöström et al., 2002) modified to focus on daily instead of weekly PA. Participants reported the total amount of time that they had spent engaged in different intensity physical activities (vigorous, moderate, walking) for at least 10 min at a time that day. Standard data processing procedures for the IPAQ were used to convert duration of activity into MET (Sjöström et al., 2005). Activity times were weighted by standard metabolic equivalents (vigorous PA = 8, moderate PA = 4, walking = 3.3) and summed to create a PA MET·minutes/day score (Sjöström et al., 2005), and subsequently rescaled (simple division by 1000) to facilitate interpretation of model coefficients.

### *Mental health*

Three aspects of daily mental health were assessed: depression, anxiety, and stress. Daily depression (“Today, how much did you feel sad, blue, or depressed?”) and anxiety (“Today, how much did you feel worried, tense, or anxious?”) were assessed using modified single items from the Health-Related Quality of Life Questionnaire (Hennessy, Moriarty, Zack, Scherr, & Brackbill, 1994). Stress was assessed on a 1 (*not at all*) to 4 (*very often*) scale using a modified single item from the Perceived Stress Scale, “Today, I felt difficulties were piling up so high that I could not overcome them” (Sheldon, Cohen, Kamarck, & Mermelstein, 1983). This item was selected because it had the strongest association with a latent perceived stress factor in a factor analysis of the Perceived Stress Scale items from Study 1 (pattern coefficient = .80).

### *Fatigue*

Daily fatigue was assessed using a single item, “I felt very fatigued today,” on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). This item was created for this study and was based on a recent review of adult determinants of PA participation in which fatigue was cited as a factor associated with PA participation in adults (Troost, Owen, Bauman, Sallis, & Brown, 2002).

## *BMI*

Individuals' BMI was computed from height and weight measurements (i.e., kg/m<sup>2</sup>). The majority of the sample (86%) was classified as normal or overweight, based on BMI ( $M = 25.8$ ,  $SD = 4.4$ , range = 19.3–39.3).

## *Data analysis*

Data were prepared, analyzed, and interpreted in the same manner as in Study 1. Data were partitioned into overall (within-person means), and daily deviation scores. Multilevel models parallel to those given in Equations 1 to 4 but with one small change (residual variances for within-person predictors other than PA were removed to accommodate the small sample size) were then used to examine between- and within-person associations between PA and SWL. The very small amount of missing data (<1%;  $n$  observations = 2) were treated as missing completely at random. The final sample consisted of 769 daily reports from 63 persons.

## *Results and Discussion*

Participants' daily lives were characterized by moderate-to-high SWL ( $M = 5.36$  on a 1 to 7 scale) that varied considerably within people from day to day (ICC = 40% between-person variance). On average, the sample's PA levels ( $M = 0.55$ ,  $SD = 0.48$ ) were equivalent to participation in more than one bout (i.e., 10 min or more) of moderate-intensity activity per day. None of the putative influences on SWL (e.g., mental health symptoms, energy resources) exhibited more than moderate amounts of between-person variance (ICCs = 28–50% between-person variance).

As in Study 1, we estimated bivariate correlations and interpreted these coefficients descriptively rather than inferentially. Daily SWL was weakly but positively associated with PA ( $r_s = .04$  and  $.10$ ). High SWL was moderately-to-strongly associated with low levels of mental health symptoms (i.e., depression,  $r_s = -.72$  and  $-.51$ ; anxiety,  $r_s = -.62$  and  $-.38$ ; and stress,  $r_s = -.53$  and  $-.35$ ) and fatigue ( $r_s = -.35$  and  $-.28$ ).

Results from the multilevel model that examined top-down (trait) and bottom-up (state) associations between PA, mental health symptoms, fatigue, sex, BMI, and SWL are given in Table 2. As in Study 1, our hypotheses concerning the association between PA and SWL received mixed support. From a bottom-up or state perspective, on days when people were more physically active than usual, they reported greater SWL ( $\gamma_{10} = 0.21$ ,  $p = .03$ ). In contrast, top-down, between-person differences in overall levels of PA were not significantly associated with SWL ( $\gamma_{01} = 0.50$ ,  $p = .12$ ). Of note, the random effect for the within-person association between daily PA and SWL was not statistically significant ( $\sigma_u^2 = 0.01$ ,  $p = .47$ ), indicating that this association was highly similar across people. As indicated by the pseudo- $R^2$ , the model accounted for approximately 17% of the variance in SWL, with daily PA accounting for 24% of the explained variance.

Table 2  
*Study 2: Multilevel Models of Daily SWL as a Function of Physical Activity, Mental Health, Fatigue, Sex, and BMI*

Variable	Parameter estimate (SE)
<b>Fixed effects</b>	
Intercept, $\gamma_{00}$	5.38* (0.08)
Overall physical activity, $\gamma_{01}$	0.50 (0.31)
Daily physical activity, $\gamma_{10}$	0.21* (0.10)
Overall depression, $\gamma_{02}$	-0.84* (0.21)
Daily depression, $\gamma_{20}$	-0.43* (0.07)
Overall anxiety, $\gamma_{03}$	-0.21 (0.19)
Daily anxiety, $\gamma_{30}$	-0.01 (0.06)
Overall stress, $\gamma_{04}$	0.12 (0.25)
Daily stress, $\gamma_{40}$	-0.23* (0.08)
Overall fatigue, $\gamma_{05}$	-0.12 (0.09)
Daily fatigue, $\gamma_{50}$	-0.11* (0.03)
Sex, $\gamma_{07}$	0.01 (0.18)
BMI, $\gamma_{08}$	0.01 (0.02)
<b>Random effects</b>	
Variance intercept, $\sigma_{\gamma_{00}}$	0.20* (0.06)
Variance physical activity, $\sigma_{\gamma_{01}}$	0.01 (0.11)
Covariance, $\sigma_{\gamma_{01}\gamma_{00}}$	0.06 (0.07)
Residual, $\sigma^2_{\epsilon}$	0.97*
-2LL	2044.5
AIC	2052.5

*Note.* Unstandardized estimates and standard errors. Model is based on 14 occasions nested within 63 participants for a total of 771 observations. AIC = Akaike Information Criterion; -2LL = -2 log likelihood. \*  $p < .05$ .

With respect to mental health, people who were generally more depressed reported less SWL on average ( $\gamma_{02} = -0.84, p = .0002$ ); and on days when people felt more depressed than usual, they reported less SWL ( $\gamma_{20} = -0.43, p = .0001$ ). Anxiety was not significantly associated with SWL at either the between-person or within-person levels. On days when people felt more stressed than usual, they reported less SWL ( $\gamma_{40} = -0.23, p = .003$ ), but stress was not related to SWL at the between-person level ( $\gamma_{04} = 0.12, p = .62$ ). With respect to energy resources, on days when people felt more fatigued than usual, they reported less SWL ( $\gamma_{50} = -0.11, p = .0001$ ), but fatigue was not related to SWL at the between-person level ( $\gamma_{05} = -0.12, p = .17$ ). Neither sex nor BMI were significantly associated with people's average levels of daily SWL in this model.

As in Study 1, additional analyses were conducted. The first analysis evaluated the possibility of an alternative temporal sequencing for the within-person association between SWL and PA. Again, we found no evidence that daily PA was associated with the previous day's end-of-day SWL reports ( $\gamma_{10} = 2.77, p = .85$ ). The second analysis controlled for potential reactivity threats (i.e., daily values changing systematically over the course of the study either as a function of the overall sequence of days or properties of specific days). As well, we found no evidence of reactivity (i.e., daily values changing systematically over the course of the study either as a function of the overall sequence of days or properties of specific days). We also conducted a third additional analysis in Study 2 in which we dichotomized BMI (i.e., BMI >30 [obese] and BMI <30 [not obese]). Obese individuals tend to be less physically active and experience less satisfaction so results may differ depending on BMI category (Ball et al., 2004; Strath et al., 2008). We found no association in our data between dichotomized BMI and SWL ( $\gamma_{08} = .01, p = .70$ ), and there was no difference in the within-person association between PA and SWL when accounting for dichotomized rather than continuous BMI.

In sum, this study replicated the key finding from Study 1 that the association between PA and SWL was a within-person (bottom-up or state) and not a between-person (top-down or trait) phenomenon. Moreover, this association was not an artifact of within-person changes in day-to-day mental health symptoms or fatigue.

## **GENERAL DISCUSSION**

The two studies reported here established relations between daily PA and SWL in emerging adults. In both studies, this association existed at the within-person (bottom-up or state influences), but not the between-person level (top-down or trait influences) and was robust after controlling for a variety of potential bottom-up confounds (e.g., daily variation in self-esteem, depression, anxiety, stress, fatigue) and use of different measures of PA and SWL. The absence of a top-down effect was not due to suppression by a number of plausible third variables including self-esteem, personality traits, overall mental health symptoms, or overall fatigue.

### ***Variability in Daily Satisfaction With Life***

These studies were unique in that they sampled daily SWL as opposed to general evaluations of SWL each day. This approach revealed that no more than 40% of the variance in daily SWL could be attributed to between-person differences. In contrast, previous daily diary studies have concluded that more than 80% of the variance in SWL could be attributed to between-person differences (Heller et al., 2006). Unlike those studies and other longitudinal studies which indicated that SWL is stable across people and over time (e.g., Fujita & Diener, 2005), our SWL measures were modified to emphasize the daily nature of SWL (e.g., “I was satisfied with my life *today*” [emphasis added]). National panel studies (e.g., German Socio-Economic Panel Study, British Household Panel Study, U.S. Health and Retirement Study) using measures of SWL with specific time frames of reference (e.g., SWL over the past week or year) have also indicated considerably less between-person variability (.55, .47, .49, respectively) compared with general evaluations of SWL (Gerstorf et al., 2010). At this point, it is unclear whether daily and general evaluations of life satisfaction have different influences on the variability in SWL ratings but this may help to explain (a) why SWL had only moderate between-person variance, and (b) why PA and SWL were associated at the within- but not between-person level in our studies.

### ***Influences on Daily Satisfaction With Life***

Our intensive sampling of PA and SWL allowed us to partition PA into time-varying and time-invariant components and draw more precise conclusions about the within-person nature of this association. These findings may explain why so many studies have found only indirect associations between PA and SWL—a direct link only exists at the within-person level and previous studies have focused on between-person differences (Elavsky et al., 2005; Elavsky & McAuley, 2005; McAuley et al., 2008). It may be that once researchers include PA at the within-person level in analyses, the between-person effect of PA on SWL will be washed out.

In addition to establishing the within-person association between PA and SWL, these studies extended our understanding of other top-down and bottom-up influences on SWL. In Study 1,

self-esteem exhibited significant top-down and bottom-up associations with SWL. This finding replicated previous findings that self-esteem is a strong top-down influence on SWL (Diener, 1984). It also extended that finding by documenting that self-esteem has an additional bottom-up influence. Future research will need to determine whether this finding generalizes across the life span or simply reflects the salience of identity development as a developmental task in emerging adulthood.

In Study 2, daily SWL was associated with depression and stress but not anxiety. These mental health symptoms were strongly correlated in the present sample so we hesitate to rule out anxiety as a possible influence on SWL. These results extend previous work which has demonstrated top-down influences of mental health on SWL (e.g., McAuley et al., 2006) by providing the first evidence that daily variation in mental health symptoms can influence people's SWL. Daily mental health symptoms can adversely affect an individual's ability or willingness to pursue valued life goals, the successful pursuit of which forms the basis for SWL. This motivational mechanism was also indicated by our findings that linked daily SWL with perceived fatigue. Previous research has established links between SWL and daily feelings of energy (Fujita & Diener, 2005; Pilcher, 1998). By linking SWL with daily feelings of fatigue (at the within-person level), it appears that feelings of fatigue influence people's perceptions of the resources that they have available for goal pursuit. In emerging adulthood, when independence and personal responsibility are increasing, a person's ability to effectively and diligently pursue goals of interest appears to be crucial for their life satisfaction.

Several established top-down correlates of SWL, such as sex and personality trait differences (Diener & Lucas, 1999; Stone et al., 2010), failed to replicate in this study. It is possible that previous findings which established top-down correlates of SWL were the product of unmeasured PA differences between people. Alternatively, the present strategy of examining top-down and bottom-up correlates of SWL simultaneously may have provided a more conservative perspective than is typical in the SWL literature.

The present studies extended the literature on PA and SWL to the developmental stage of emerging adulthood. This stage is marked by distinctive challenges as people strive to develop unique identities and assume increasing responsibilities (Arnett, 2000). Longitudinal studies showing the high level of affective lability during this stage of life and cross-sectional studies demonstrating differences in self-evaluative and attributional tendencies from the beginning to end of the stage combine to suggest that emerging adulthood is taxing and can exert a toll on people's well-being (Orth, Robins, & Soto, 2010; Robins et al., 2002; Röcke et al., 2009). The present results suggest that daily PA promotion, or making small changes in daily PA, may be one way to offset diminished SWL during emerging adulthood. Small changes in daily life (i.e., taking the stairs instead of the elevator, walking to class instead of taking the bus) may have a greater impact on SWL as opposed to more dramatic changes (i.e., adopting a new exercise regimen). These small changes may be more manageable and easier to incorporate into daily life. By enhancing SWL, such efforts may help to reduce mental illness symptoms (e.g., depression, anxiety) or the risky behaviors that emerging adults often use to cope with dissatisfaction with life, such as alcohol use (Mata et al., 2012; Murphy, McDevitt-Murphy, & Barnett, 2005). Similarly, it would be a worthwhile endeavor for future research to evaluate the impact that daily

changes, which influence daily SWL, have as they accumulate over long periods of time, ultimately influencing overall SWL.

### ***Limitations***

Results from the two studies reported here enhanced our understanding of the link between PA and SWL in emerging adulthood; however, a few limitations must be recognized. First, we sampled a fairly homogeneous population with respect to their age, ethnicity, education, and physical ability (i.e., none had any physical or functional limitations). Research on more diverse populations, including the “forgotten half” of emerging adults who are not pursuing a college education (William T. Grant Foundation Commission on Work, Family, & Citizenship, 1988), will be valuable.

Second, self-report measures of PA were used in both studies. Self-reported measures of PA tend to overestimate the amount of PA participants engage in compared with objective measures of PA (Adamo, Prince, Tricco, Conner-Gorber, & Tremblay, 2009; Prince et al., 2008). Self-report measures also differ from objective measures of PA (Troiano et al., 2008) because they tend to emphasize leisure time PA and often neglect other important sources of PA such as occupational or transportation-related PA (e.g., walking to class, taking the stairs). We used modified versions of the LTEQ and IPAQ to reflect daily PA as opposed to total activity time throughout the week. Although we are unaware of any studies that have validated these adaptations of the measures, we are confident that the modifications do not adversely impact the validity of our score interpretations. Indeed, we believe that the most likely consequence of these modifications is increased score validity due to the reduced threat of retrospective recall bias. Either way, future research should seek to make use of both objective and subjective measures of daily PA. In addition, self-monitoring is known to influence behavior and thoughts (Michie, Abraham, Whittington, McAteer, & Gupta, 2009). It could be that as a result of participating in our study, participants altered their PA; however, our results suggest that any reactivity to study procedures did not change relations between PA and SWL.

Third, these data were intended to be collected at the end of each day. In Study 1 participants returned daily diaries through the campus mail system, which because it was closed on the weekends, resulted in daily diaries from Friday, Saturday, and Sunday night being returned in clusters on Monday or Tuesday. Therefore, although we tracked the data for severe deviations from protocol, we were unable to discern the exact time daily diaries were completed. We attempted to rectify this situation in Study 2 by having participants complete end-of-day questionnaires online that were available between 7 p.m. and 4 a.m. and were time stamped on submission. In addition, that participants completed questionnaire at the end of each day may have impacted results due to fatigue or circadian processes (e.g., melatonin, cortisol, blood pressure). Therefore, it may be valuable to sample SWL, as well as PA, at different times throughout the day to further untangle the association between PA and SWL. Such a study could use current technology (i.e., smartphones) to assess PA and SWL on other time scales (e.g., event contingent recording).

Fourth, because of the nonexperimental nature of these data, we cannot draw conclusions about causality. We tested and ruled out an alternative causal sequence across days to strengthen



confidence in our conclusion, but future experimental work is needed to determine the causal role that PA plays in changing SWL. We also attempted to control several plausible third variables that could suppress or account for associations between PA and SWL, but a number of other plausible influences were not controlled (e.g., feelings of competence, perceived control). It is possible that one of the variables that we did not control is driving the association between PA and SWL.

Finally, these studies did not examine the influence of affect in the relation between PA and SWL. The evaluative (i.e., SWL) and hedonic (i.e., affect) components of well-being overlap considerably (Diener, 1984). Although we did not disentangle the overlapping relation between SWL and affect, these studies establish the first evidence that daily PA can improve evaluative aspects of well-being in emerging adults.

## CONCLUSION

In closing, these studies showed a robust association between daily deviations in PA and SWL in two samples of emerging adults. These findings add to the accumulating evidence that PA is a behavior with important consequences for daily health and well-being (e.g., Physical Activity Guidelines Advisory Committee, 2008). Considering the important role that has emerged for SWL in national policy objectives (e.g., Healthy People 2020, Organization for Economic Cooperation and Development Better Life Initiative), these findings strengthen the case for making PA promotion a basic pillar of national policy.

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