### Title
Real-Time Associations Between Engaging in Leisure and Daily Health and Well-Being.




### Journal
Annals of behavioral medicine : a publication of the Society of Behavioral Medicine, 49(4)

### ISSN
0883-6612



### Authors
Zawadzki, Matthew J
Smyth, Joshua M
Costigan, Heather J



### Publication Date
2015-08-01

### DOI
10.1007/s12160-015-9694-3

Peer reviewed

ann. behav. med. (2015) 49:605–615
DOI 10.1007/s12160-015-9694-3

ORIGINAL ARTICLE

# Real-Time Associations Between Engaging in Leisure and Daily Health and Well-Being

**Matthew J. Zawadzki, Ph.D. · Joshua M. Smyth, Ph.D. · Heather J. Costigan, B.S.**

Published online: 28 February 2015


**Abstract**
***Background*** Engagement in leisure has a wide range of beneficial health effects. Yet, this evidence is derived from between-person methods that do not examine the momentary within-person processes theorized to explain leisure's benefits.
***Purpose*** This study examined momentary relationships between leisure and health and well-being in daily life.
***Methods*** A community sample ($n$=115) completed ecological momentary assessments six times a day for three consecutive days. At each measurement, participants indicated if they were engaging in leisure and reported on their mood, interest/boredom, and stress levels. Next, participants collected a saliva sample for cortisol analyses. Heart rate was assessed throughout the study.
***Results*** Multilevel models revealed that participants had more positive and less negative mood, more interest, less stress, and lower heart rate when engaging in leisure than when not.
***Conclusions*** Results suggest multiple mechanisms explaining leisure's effectiveness, which can inform leisure-based interventions to improve health and well-being.

**Keywords** Leisure · Mood · Stress · Ecological momentary assessment · Multilevel modeling

M. J. Zawadzki (✉)
Psychological Sciences, University of California,
Merced, CA 95343, USA
e-mail: mzawadzki@ucmerced.edu

J. M. Smyth (✉) · H. J. Costigan
Department of Biobehavioral Health, The Pennsylvania State University, State College, PA 16802, USA
e-mail: jms1187@psu.edu

Leisure activities are generally self-selected, self-rewarding behavioral pursuits that take place during non-work time [1, 2]. Studies have shown a wide range of positive effects of leisure—more leisure engagement is associated with greater positive mood, well-being, or life satisfaction [3–5], less negative or depressed mood [3, 6, 7], less stress and/or more stress-coping [8–10], and better cardiovascular health [11–13]. Although these results demonstrate a consistent positive relationship, much less is known as to how—or through what process—leisure exerts these effects. This lack of knowledge is due in part to leisure being primarily tested with between-person methods (i.e., those engaging in leisure are those that show a particular outcome), which are unable to assess the in-the-moment responses that engaging in leisure are proposed to have on health (i.e., the within-person processes linking leisure engagement to positive outcomes). Testing whether leisure has momentary or within-person effects is a necessary step toward understanding the mechanisms for leisure's benefits and ultimately to informing interventions employing leisure to improve health. To this end, this study examines the within-person effect of engaging in leisure on positive and negative mood, interest/boredom, stress (self-reported and cortisol), and heart rate.

## Contrasting Between- and Within-Person Effects

Many reasons have been proposed for why leisure has beneficial health effects (e.g., improving stress coping, reducing stress, promoting relaxation responses, reducing boredom). Although the specifics of these theories vary, a common element that many share is proposing transactional or in-the-moment effects of leisure. That is, these theories propose within-person explanations for its effects; for example, stress is reduced because leisure confers some positive relaxation benefit *when a person engages in leisure*; importantly, such benefit is not present or conferred when that same person is not engaging in leisure. However, most of the studies testing the effects of leisure on health are cross-sectional in nature (e.g., one time assessments of engagement in leisure and health whether via surveys or interviews) and/or have been analyzed using between-person statistics (e.g., bivariate correlations, linear regressions, non-repeated measures ANOVAs). These between-person data and analyses test a separate question than within-person data and analyses. In brief, one can think of between-person analyses testing a "who" question—are those individuals who engage in more leisure the same individuals who report less stress, better mood, etc. In contrast, a within-person approach tests a "when" question—what happens when an individual engages in leisure, relative to when that same individual is not engaged in leisure. A vital attribute of this distinction is that a relationship between two variables may be different at the between-person and within-person levels. A classic example that shows the difference of between- and within-person approaches concerns exercise and heart rate. Between-person research has demonstrated that individuals who have the highest levels of exercise engagement tend to have the lowest resting heart rates [14]. Yet, within-person examinations of exercise and heart rate reveal that when an individual engages in exercise, his or her heart rate increases compared to when that same individual is not engaging in exercise [15, 16]. Thus, we see a negative association between exercise and heart rate at the between-person level and a positive association at the within-person level. Although not all examples of within- and between-person approaches produce seemingly "opposite" relationships (recall that they test separate questions and thus may either agree or disagree), this example highlights the ecological fallacy [17, 18]. The ecological fallacy states that relationships between variables at one level (e.g., between individuals) cannot be assumed to exist at the same magnitude and direction at another level (e.g., within individuals) (for discussion of the different applications of between- and within-person models, see [19]). Thus, returning to leisure, it cannot be assumed (despite the plausibility of such a perspective) that the between-person data and analyses suggesting positive effects of leisure on health indicate support for the theorized in-the-moment, within-person associations that are proposed to underlie leisure's positive effects.

## Ecological Momentary Assessment

Much of the work on leisure has relied on global and/or retrospective self-report assessments of leisure and health. These types of retrospective reports may be subject to recall biases, for example, participants overestimating the number of health symptoms experienced over the recall period [20]. Biases may arise because long-term retrospective reports tend to tap more into global semantic judgments and beliefs rather than actual dynamic experiences [21, 22]. Thus, to reduce the potential of recall biases affecting estimates and to test the proposed within-person effect of leisure, a data capture approach that provides more fine-grained ambulatory information is needed to elucidate the pathways by which leisure impacts health and well-being in the dynamic flow of daily life [22, 23].

One strategy that facilitates this measurement precision is ecological momentary assessment (EMA). EMA allows the examination of repeated measures in real-time, measuring psychological and physiological processes for a person as they occur in the natural environment. This allows researchers the opportunity to assess events and/or perceptions closer to their real-life occurrence, thus reducing biases associated with longer term recall [23]. For leisure, it would be possible to measure whether or not a person reported engaging in leisure at a particular moment and to concurrently assess mood, stress, and other physiological markers of health, a process that would be repeated multiple times within and across days, thus providing multiple assessments of both leisure and non-leisure moments. This approach, and other related approaches, has been specifically advocated to help understand the effects of leisure [24], as they enable the researcher to track how patterns of leisure engagement within an individual affect health and well-being over time for that person. Nevertheless, despite such advocacy, little work has been conducted to examine the within-person effects of leisure.

## Dynamic Indices of Health

When examining health in momentary processes, it is necessary to assess health-relevant variables that are likely to vary over the periods of measurement (e.g., hours/days), rather than more stable indicators of health (e.g., disease status). As such, in the present analysis, we focus on mood and interest levels, stress (both self-reported stress and a biomarker of stress, cortisol), and heart rate. Mood states vary significantly throughout the day [25, 26], with momentary negative mood related to health complaints [27]. Interest also varies as a function of the activity one engages in and was assessed in the present study as a (negative) indicator of one's boredom levels. Prior work has linked greater levels of boredom with poor health behaviors, including greater drug use [28, 29] and eating [30, 31]. Moreover, those who report more boredom during leisure time also report greater engagement in smoking, drinking, and self-induced vomiting than non-bored individuals [32] and more sensation-seeking behaviors in general [33]. Finally, the stress biomarker, cortisol, is highly responsive to environmental stressors over short time frames in daily life [34]. Although measured at the momentary level, these moods, interest, stress, and heart rate variables are important to examine as they have been shown to be related to longer term health.

For example, daily stressors have been associated with both concurrent and subsequent health problems [35], and daily negative affect has been associated with engagement in more negative health behaviors [36]. Moreover, higher resting [37] and ambulatory [38] heart rate levels have been shown to predict poor cardiovascular health and mortality.

As this study is an initial test of the within-person effects of leisure on daily health, we compared leisure to exercise—an activity that has been established to have an in-the-moment influence on health-related processes. When individuals engage in exercise, compared to when they do not, their heart rate increases [15, 16]; exercise has also shown positive effects on improving positive mood, decreasing negative mood, and lowering stress [39–41]. For example, negative mood decreased and vigor increased after an aerobic exercise dance class compared to 15 min before the exercise [41]. Thus, including engagement in exercise in our analyses allowed us to examine whether leisure has an independent effect to that observed for exercise.

## The Present Research

The present research used EMA methods to examine the within-person relationships between real-time reported engagement in leisure and momentary health indicators, including positive and negative mood, interest, stress, and heart rate. Positive mood was assessed as levels of happiness, while negative mood was assessed as levels of sadness. Interest was assessed as a (negative) indicator of one's boredom levels. Stress was measured using subjective assessments and salivary cortisol. Finally, heart rate was a measure of cardiovascular functioning. We hypothesized that when a person was engaging in leisure they would report (1) more positive mood, (2) less negative mood, (3) more interest, and (4) lower stress and would have (5) lower cortisol and (6) lower heart rate—each relative to when that person was not engaging in leisure.

## Method

### Participants

As part of a larger study examining work parameters, participants ($n$=115) recruited from the greater metropolitan area of a mid-sized city in the Northeast US were eligible to participate if they were (1) over the age of 18, (2) currently employed Monday through Friday with regular working hours between 6:00 am and 7:00 pm, (3) not employed on weekends, (4) able to come into the research laboratory on a Wednesday evening and the following Monday, (5) fluent in English, (6) free of psychiatric therapy or drug treatment changes in the past 3 months, and (7) not pregnant. The sample was primarily female (75.8 %) with an average age of 41.21 ($SD$=11.62; range: 19–63). The majority of the sample was White (77.1 %), had a range of incomes (19.8 % had an income <$30,000; 53.5 %≥$30,000 and<$75,000; and 26.7 %≥$75,000), with most participant's education level including some college (10.1 % had a high school degree or less, 42.0 % some college, and 47.9 % at least a college degree).

### Measures

#### *Baseline Questionnaires*

Demographic information assessed included sex, age, race, income, and education. To reduce the number of levels across each demographic, the variables were recoded in the following ways: Race was recoded as White or non-White. Income was broken into three categories based on the following nine response options from which participants indicated their income level: low (less than $10,000; $10,000–19,999; or $20,000–29,999), middle ($30,000–39,999; $40,000–49,999; or $50,000–74,999), and high ($75,000–99,999; $100,000–150,000; or greater than $150,000). Finally, education was assessed as the highest level of completed education that was then recoded as high school or less (either high school but did not graduate or high school degree/GED), some college (either vocational certificate, associate's degree, or some college), and B.A. or higher (either graduated college or went to graduate school). A number of other measures were included in this study but were not relevant to the present analyses.

#### *Ecological Momentary Assessment (EMA)*

EMA self-report surveys assessed current engagement in leisure, exercise, and social interactions and mood, interest, and stress. Each survey was automatically dated and time-stamped. EMA data was collected via Palmpilot Z22 handheld computers (Palm Inc., Sunnyvale, CA) programmed using a free, open-source software package called Experience Sampling Program (http://www.experience-sampling.org/; see [42]). Participants were contacted at six semi-random times each day in 3-h intervals. Across participants, 1733 momentary assessments were collected.

As has been done in previous research [43], engagement in leisure and exercise were assessed with the following item: "At the time of the prompt, what were you doing?" From a list of possibilities, participants indicated if they were engaging in "socializing, relaxing, leisure" and/or "sports, exercise, recreation"; participants could indicate more than one option. Across all responses, participants indicated engaging in leisure 32.2 % of the time (range=0 to 14, $M$=5.21, $SD$=2.93) and exercise 4.1 % of the time (range=0 to 5, $M$=0.67, $SD$=1.07).

It should be noted that our measure of leisure also included socializing as part of the question stem, which is in line with research describing leisure as a social activity [44]. As we were interested in identifying whether leisure itself conferred benefits separate from social interactions, however, an additional item (to the one assessing leisure) was included that asked participants if they were engaging in social interactions: "At the time of the prompt, were you having any social interaction?" Including both the leisure and social interaction items in analyses allowed us to control for any potential benefits that may be conferred by a social interaction and thus identify the independent effect of leisure above socializing. Across all responses, participants engaged in social interactions 48.5 % of the time (range=0 to 16, $M$=7.82, $SD$=3.48).

Again following prior research [45, 46], positive and negative mood was assessed by asking how happy and sad participants were feeling at the time of the prompt on a 0 (*not at all*) to 6 (*very much*) scale (across participants, happy: $M$=4.35, $SD$=0.75; sad: $M$=0.73, $SD$= 0.76). Participants also indicated how interested and stressed they were using the same scale (across participants, interested: $M$=3.87, $SD$=0.90; stressed: $M$=1.30, $SD$=0.88). Finally, a second measure of subjective stress was assessed with four items modified from the 4-item Perceived Stress Scale [PSS] to assess if participants were currently feeling stressed (e.g., "At the time of the prompt, did you feel difficulties piling up so you cannot overcome them?" [47, 48]). Participants responded using a 0 (*not at all*) to 4 (*very much*) scale (across participants, PSS: $M$=1.81, $SD$=0.48). To differentiate the two stress measures in the analyses and discussion below, the single item stress measure is labeled as "stressed", whereas the modified 4-item PSS is labeled as "PSS".

### *Ambulatory Cortisol*

Participants provided saliva samples for cortisol analysis using standard salivettes (Sarstedt AG & Co, Nümbrecht, Germany) six times each day. Salivettes are small plastic tubes containing synthetic material that participants place in their mouths for approximately 90 second (or until saturated with saliva) and then replace in the tube. Participants were provided three prepared bags, each containing six salivettes designated for 1 day of use. At the end of each EMA survey, participants were reminded to provide a saliva sample and then labeled the salivette with the date and time. The saliva samples were sent to a technical lab (Dresden, Germany) to assay cortisol using standard methods. Given the non-normal distribution observed in cortisol, cortisol values were log-transformed prior to analysis. Across all samples and all participants, mean (SD) log-cortisol values (nmol/l) were 0.53 (0.19).

### *Heart Rate*

Heart rate was assessed using ambulatory Actiheart monitors (Mini Mitter Company, Inc., OR, USA), which were worn by participants at all times during the 3 days of ambulatory data collection except during activities that could cause the devices to get wet (the device connects to the electrodes by snapping on and thus can easily be removed and reattached with little difficulty or threat to data consistency). An Actiheart consists of a single-piece heart rate monitor connected by two standard ECG electrodes which are worn on the upper sternum and upper left pectoral muscle [49]. The Actiheart measures the electrocardiogram signal at 128 Hz over 15-s epochs. At the end of each epoch, a trimmed mean of the last 16 R-R intervals is calculated by ignoring values outside ±25 % of the initial mean. This signal is then converted to beats per minute (the manufacturer's specified measurable range is 31 to 250 beats per minute). Across all observations and all participants, mean (SD) heart rate beats per minute were 88.74 (16.54).

## Procedures

All procedures were in accordance with the ethical standards for the responsible conduct of human subject research. Potential participants were recruited via random calls from a local telephone directory and from public listings on a university e-mail news alert and local event websites. Each individual contacted, regardless of method, was provided the same information about participating in the study. Potential participants who met eligibility criteria were scheduled for an initial laboratory visit. At the initial visit, all participants gave informed consent and completed baseline materials at the laboratory on Wednesday evenings. Participants were provided EMA devices and trained to complete EMA self-report surveys by practicing in the presence of a trained research assistant. Actiheart monitors were checked individually by trained research assistants to ensure functionality, and participants received instruction on how to properly wear and adjust the devices to ensure that a clear signal was being obtained. They were also instructed to remove the devices before entering water and reattach them upon exiting (e.g., when taking a shower). Finally, participants were provided salivettes and trained how to properly collect and store saliva samples.

For the ensuing 3 days (i.e., Thursday through Saturday), EMA self-report surveys were gathered using the Palmpilot devices which participants carried at all hours between waking and sleeping (with wake and sleep times pre-specified by participants). Auditory alarms signaled participants to complete six surveys each day at semi-random intervals, stratifying waking hours into six roughly equal intervals with one measurement occurring randomly within each interval excluding the first and last 15 min of the interval. Participants were also provided an on-screen reminder at the end of each EMA assessment to collect a saliva sample. HR was assessed in an ongoing fashion with the Actiheart. During the return visit (Monday), participants returned all study materials. Daily self-reported assessments, Actiheart, and saliva samples were checked for completion. Compensation of $100 was dispensed for completing the study protocol, and an additional $20 was awarded for completing ~94 % (at least 17 out of 18) EMA surveys.

### Analytic Plan

As the collected EMA data have a two-level structure, with observations (level 1) nested within individuals (level 2), multilevel analyses were performed using the PROC MIXED command in SAS 9.3. Although the data were collected over similar time periods with the same number of proposed measurement per day, levels of compliance in EMA and cortisol differed slightly across participants resulting in differing levels of missing data. In general, multilevel approaches are robust to missing data and are recommended for analyzing EMA data [50].

Our multilevel models tested whether within-person (level 1) levels of engagement in leisure were associated with within-person (level 1) mood, interest, subjective stress, cortisol, and heart rate. We tested each outcome in a separate model to identify the unique relationship between leisure and the outcome of interest; because we had a priori hypotheses for each outcome, we did not adopt any error correction. These models reveal the *within-person* effect of leisure; the models can be interpreted as estimating the influence of engaging in leisure on mood, interest, stress, cortisol, and heart rate levels for a person relative to when that same person was not engaging in leisure. In other words, by way of example, we are testing whether variations in mood or stress for particular moments over time for a particular individual can be attributed to whether or not that particular person engaged in a leisure activity in that moment.

For all models, we examine both a base model and a second extended covariate model. In the base model, we controlled only for time of day and whether it was a workday or not. Although these variables were not the specific focus of this paper, statistically controlling for them allowed us to rule out time or day effects that could account for the results. Time of day was recoded into six 3-hour blocks, ranging from 1 to 6, coinciding with the window of time each EMA prompt took place (i.e., higher values correspond to later times in the day when the EMA was taken). In the second extended covariate model, we additionally included sex, age, race, income, and education, as these variables may impact the extent to which a person is able to engage in leisure. When including these demographic variables in the covariate model, the interpretation changes slightly. Results for the extended covariate model reveal the independent effect of when a person engages in leisure, compared to when that person does not, above any effects due to that person's demographics.

Finally, we performed two sets of planned follow-up analyses. First, we tested whether engagement in exercise has differential effects to engagement in leisure. Second, we tested a model in which we controlled for engagement in social interactions so as to rule out that any positive effects due to leisure were in fact due to one's social relationships (i.e., to test if social interactions that occur during leisure activities may be driving any observed effects).

## Results

### Leisure Only Model

We first tested a series of models examining the effect of engaging in leisure on mood, interest, stress, cortisol, and heart rate. We tested both a base model, controlling only the time-related variables (i.e., whether or not it was a workday and time of day), and an extended covariate model that also controlled for participant demographics (i.e., sex, age, race, income, and education). A similar pattern of results was found for both the base and extended covariate models, and thus, the results reported immediately below are for the extended covariate model only (due to space concerns, only the results relevant to leisure are presented below, but results related to the controls are available upon request and follow a similar pattern as presented in Table 1 that includes engagement in exercise in the models). Leisure had a consistent effect; when people reported engaging in leisure, they reported more happiness ($b$=.38, $SE$=.06, $p$<.001), trended toward less sadness ($b$=−.09, $SE$=.06, $p$=.091), more interest ($b$=.20, $SE$=.08, $p$=.011), less stress (stressed, $b$=−.40, $SE$=.08, $p$<.001; PSS, $b$=−.06, $SE$=.03, $p$=.046), and lower heart rate ($b$=−2.85, $SE$=1.26, $p$=.023) than when those same people reported that they were not engaging in leisure. In contrast to our hypothesis, leisure was unrelated to salivary cortisol ($b$=−.01, $SE$=.02, $p$=.617). Cortisol data, in general, did seem to fall within expected values and function; for example, cortisol values demonstrated the expected diurnal rhythm (see [34]), with decreasing values across the day ($b$=−.14, $SE$=.01, $p$<.001).

### Exercise and Leisure Model

We next added in whether or not participants were engaging in exercise at the time of the prompt to the models reported above. Estimates for the multilevel models are presented in Table 1, whereas means for each outcome by engagement in leisure and exercise are presented in Table 2. For both the base and extended covariate models, when a participant reported that they were engaging in exercise, they reported more

**Table 1** Estimates (standard errors) for leisure and exercise models on mood, interest, stress, cortisol, and heart rate

| | | Happy | | Sad | | Interest | | Stressed | | PSS | | Cortisol | | Heart rate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base | Extended | Base | Extended | Base | Extended | Base | Extended | Base | Extended | Base | Extended | Base | Extend |
| Intercept | | 3.99*** (.11) | 3.92*** (.32) | .77*** (.10) | 1.06** (.33) | 3.59*** (.13) | 3.18*** (.42) | 1.34*** (.12) | 1.68*** (.41) | 1.80*** (.06) | 1.96*** (.23) | 1.06*** (.03) | 1.09*** (.09) | 98.85*** (2.31) | 109.17*** (9.45) |
| Workday | | −.04 (.07) | −.04 (.07) | .05 (.06) | .06 (.06) | .0004 (.08) | .001 (.08) | .30*** (.07) | .29*** (.07) | −.02 (.03) | −.03 (.03) | −.05** (.02) | −.05** (.02) | −2.71* (1.09) | −2.91* (1.16) |
| Time of day | | .06*** (.02) | .06** (.02) | −.01 (.02) | −.004 (.02) | .04$^{+}$ (.02) | .03 (.02) | −.03 (.02) | −.02 (.02) | .01 (.01) | .02$^{+}$ (.01) | −.14*** (.01) | −.14*** (.01) | −.36 (.35) | −.28 (.37) |
| Sex | | – | −.23 (.16) | – | .19 (.16) | – | .02 (.21) | – | .11 (.21) | – | −.03 (.12) | – | −.01 (.04) | – | 8.60$^{+}$ (4.65) |
| Age | | – | .01$^{+}$ (.01) | – | −.01* (.01) | – | .02* (.01) | – | −.02$^{+}$ (.01) | – | −.004 (.004) | – | .0001 (.002) | – | −.38* (.17) |
| Race | | – | −.39* (.15) | – | .24 (.16) | – | −.45* (.20) | – | .54** (.20) | – | .16 (.11) | – | −.03 (.04) | – | −5.12 (4.55) |
| Income | Low | – | .47* (.20) | – | −.32 (.21) | – | .64* (.26) | – | −.50$^{+}$ (.26) | – | −.17 (.15) | – | .03 (.06) | – | 2.20 (5.75) |
| | Middle | – | .01 (.15) | – | .12 (.16) | – | .01 (.20) | – | −.04 (.20) | – | −.05 (.11) | – | −.04 (.04) | – | 6.42 (4.44) |
| Education | HS or less | – | .43$^{+}$ (.22) | – | −.29 (.23) | – | .13 (.29) | – | −.16 (.29) | – | −.05 (.16) | – | .01 (.06) | – | −.96 (6.55) |
| | Some College | – | −.05 (.14) | – | −.08 (.14) | – | −.42* (.18) | – | −.22 (.18) | – | −.10 (.10) | – | .002 (.04) | – | −.11 (4.01) |
| Exercise | | .52*** (.13) | .52*** (.13) | −.20$^{+}$ (.12) | −.17 (.12) | .73*** (.16) | .70*** (.16) | −.28$^{+}$ (.16) | −.27 (.17) | −.004 (.07) | −.01 (.07) | −.09* (.04) | −.12** (.04) | 7.72** (2.66) | 7.81** (2.84) |
| Leisure | | .43*** (.06) | .41*** (.06) | −.14** (.05) | −.11$^{+}$ (.06) | .25*** (.07) | .24** (.08) | −.42*** (.08) | −.42*** (.08) | −.07* (.03) | −.06* (.03) | −.01 (.02) | −.02 (.02) | −1.98$^{+}$ (1.19) | −2.41$^{+}$ (1.26) |

Workday (0 = non-workday, 1 = workday), sex (0 = male, 1 = female), race (0 = non-White, 1 = White), exercise (0 = not engaging at time of prompt, 1=engaging in at time of prompt), and leisure (0 = not engaging at time of prompt, 1 = engaging in at time of prompt) are dichotomous variables. Time of day is coded to indicate the EMA interval ranging from 1 to 6. Age is continuous. Both income (1 = low, 2 = middle, 3 = high—reference category) and education (1 = HS graduate or less, 2 = some college, 3 = college degree or more—reference category) are categorical variables with three levels, the highest of which is the reference group. Cortisol is log-transformed

*PSS* Perceived Stress Scale

$^{+}p<.10$, $^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

**Table 2** Means (standard errors) of engaging in exercise or leisure on mood, interest, stress, cortisol, and heart rate derived from the extended covariate model

| | | Happy | Sad | Interest | Stressed | PSS | Cortisol | HR |
|---|---|---|---|---|---|---|---|---|
| Exercise | No | $4.57^{a}$ (.09) | $0.57^{a}$ (.09) | $4.00^{a}$ (.11) | $1.17^{a}$ (.11) | $1.77^{a}$ (.06) | $0.54^{a}$ (.02) | $94.19^{a}$ (2.51) |
| | Yes | $5.10^{b}$ (.16) | $0.40^{a}$ (.15) | $4.69^{b}$ (.19) | $0.90^{a}$ (.20) | $1.76^{a}$ (.09) | $0.42^{b}$ (.05) | $102.00^{b}$ (3.70) |
| Leisure | No | $4.63^{a}$ (.10) | $0.54^{a}$ (.10) | $4.23^{a}$ (.13) | $1.24^{a}$ (.13) | $1.80^{a}$ (.07) | $0.49^{a}$ (.03) | $99.30^{a}$ (2.80) |
| | Yes | $5.04^{b}$ (.12) | $0.44^{b}$ (.11) | $4.47^{b}$ (.15) | $0.82^{b}$ (.15) | $1.73^{b}$ (.07) | $0.47^{b}$ (.03) | $96.89^{b}$ (2.99) |

Different subscripts indicate that moments with and without exercise or leisure significantly differed from each other. Means and standard errors are derived from the extended covariate model and thus reveal the effect of engaging in exercise and leisure on mood, interest, stress, cortisol, and heart rate whilst controlling for time and participant demographics

*PSS* Perceived Stress Scale, *HR* heart rate

happiness (*p*s<.001), more interest (*p*s<.001), and had higher heart rates (*p*s<.006), but had lower cortisol (*p*s<.020), than when those same individuals were not engaging in exercise. Effects of exercise on sadness and feeling stressed were marginal in the base model (*p*s<.088) but not significant in the extended model (*p*s>.115); no significant effects were observed for PSS (*p*s>.907). The addition of exercise to these models left all the observed patterns reported above for leisure relatively unchanged. Again, leisure had a consistent effect such that, in both the base and extended covariate models, when people reported engaging in leisure, they reported more happiness (*p*s<.001), less sadness (*p*s<.062), more interest (*p*s<.002), less stress (stressed, *p*s<.001; PSS, *p*s<.047), and marginally lower heart rate (*p*s<.097) than when those same people reported that they were not engaging in leisure; again, no significant relationships were observed with cortisol (*p*s>.393).

## Controling for Social Interactions

As aforementioned, the question stem for leisure contained the word "socializing" along with "relaxing" and "leisure." However, we were interested in the independent effect of leisure beyond potential positive effects due to socializing (e.g., social support). As a result, we re-ran the extended covariate model testing for the effect of leisure only but included an additional variable in the analyses assessing whether or not the participant was engaging in a social interaction at the time of the prompt. Thus, by including this variable in our models, we can control for the effect of engaging in social interactions and identify the unique effect of leisure. Even with social interactions included as a variable in the models, the effect of engaging in leisure continued to remain significant in all the ways previously reported, except for sadness. Specifically, results for the effect of leisure in the extended covariate model (including socializing) are as follows: happy ($b$=.33, *SE*=.06, $p$<.001), interest ($b$=.13, *SE*=.08, $p$=.088), stress (stressed: $b$=−.41, *SE*=.08, $p$<.001; PSS: $b$=−.06, *SE*=.03, $p$=.052), cortisol ($b$=−.01, *SE*=.02, $p$=.485), and heart rate ($b$=−3.07, *SE*=1.27, $p$=.016). For sadness, the effect of leisure is marginal in the base model ($b$=−.10, *SE*=.06, $p$=.066), which becomes non-significant in the extended covariate model sad ($b$=−.08, *SE*=.06, $p$=.138).

Separately, we also examined the effect of leisure for those moments when a participant reported no social interactions (i.e., the participant indicated that they were engaging in leisure, but not social interactions, at the time of the prompt). Again, leisure remained significant in all the ways previously reported for the extended covariate models, except for interest. Specifically, results for the effect of leisure in the extended covariate model are as follows: happy ($b$=.28, *SE*=.10, $p$=.003), sad ($b$=−.16, *SE*=.09, $p$=.070), stress (stressed: $b$=−.50, *SE*=.12, $p$<.001; PSS: $b$=−.11, *SE*=.05, $p$=.029), cortisol ($b$=.01, *SE*=.03, $p$=.772), and heart rate ($b$=−3.99, *SE*=2.02, $p$=.048). For interest, leisure was no longer significant ($b$=.05, *SE*=.13, $p$=.677).

## Exploratory Analyses

We were interested in the extent to which the effects of leisure and exercise carried over from one moment to the next (also known as lagged analyses). Unfortunately, for the EMA variables and cortisol, the data was not collected at a high enough density, and the differences in time between successive measures were too variable within and across participants, to permit these analyses. (Recall that participants completed an EMA and collected cortisol at random times within each of six roughly equal time intervals throughout; thus, measurements ranged from being minutes—for example, if the EMAs occurred at the end of one interval and the beginning of another—to hours apart.) Heart rate, however, was an exception as this data was collected in an ongoing fashion; thus, we could test the effect of engaging in leisure and exercise on heart rate in the specific subsequent hours to reporting on leisure and exercise. Therefore, we repeated the analyses reported in Table 1, but we tested lagged heart rate variables rather than contemporaneous variables with separate lags being created for each day. In the next hour, after an EMA, heart rate was marginally higher if a person had engaged in exercise in the previous hour compared to if that person did not ($b$=4.80, $SE$=2.88, $p$=.096) but lower if a person had engaged in leisure in the previous hours compared to if that person did not ($b$=−2.59, $SE$=1.30, $p$=.047). By the second hour after an EMA, these effects dissipated such that no significant differences emerged for engaging in exercise or not ($b$=2.12, $SE$=2.77, $p$=.444) or leisure or not ($b$=1.92, $SE$=1.29, $p$=.138).

## Discussion

Many of the theories speculating as to why leisure is beneficial point to transactional or in-the-moment effects, such as proposing that when a person engages in leisure, their stress levels decrease compared to when that person is not engaging in leisure. Yet, research examining leisure has been conducted with between-person data and analyses that provide a test of a different question (i.e., are those who generally engage in more leisure generally happier or less stressed than those that engage in less leisure), rather than a within-person test that evaluates if engaging in leisure is related to better mood or less stress in the moment relative to when not engaging in leisure. Using EMA to capture real-time assessments of leisure and psychological and physiological processes as they occur within the natural environment, we were able to examine this within-person "when" question directly. Doing so, we identified relatively clear patterns of within-person benefits of leisure such that when a person reported engaging in leisure he/she had better mood, more interest, lower stress, and lower heart rate than when he/she was not engaging in leisure.

Importantly, we found benefits of leisure on a range of outcomes, including self-reported mood and stress, and an objective measure of cardiovascular functioning (i.e., heart rate). Leisure impacted both positive and negative mood, which have independent relationships with stress, pain, illness symptoms, and health care utilization [27, 51]. Moreover, leisure was associated with greater interest, which likely indicates lower boredom levels. As boredom and disengagement have been related to poor health behaviors, including drug and alcohol use, smoking, and greater eating [28–33], leisure activities may serve as protective factor on health behaviors. Extending beyond mood states, leisure was associated with lower reports of stress and lower objectively measured heart rate, suggesting that leisure may evoke a type of relaxation response [52]. Although more research is needed to understand other physiological responses as a result of leisure (e.g., blood pressure), these early results support engagement in leisure activities as a way to promote relaxation. Finally, the positive effects of leisure on heart rate suggest the potential for long-term health implications as higher heart rate levels have been shown to predict poor cardiovascular health and mortality [37, 38]. Overall, these results suggest a robust influence of leisure on psychological, emotional, and physiological effects.

Although we found positive results on both of the subjective stress measures, we did not observe the hypothesized association between leisure and cortisol. This may have been due to timing issues; cortisol has a delayed response, typically peaking 20–40 min after a stressor [53]. In this study, participants provided their salivary assessments immediately after they indicated whether or not they were currently engaging in leisure. If participants had just begun to engage in the leisure activity, for example, any possible effects due to leisure on cortisol could not be observed until well after cortisol was assessed in our study. We considered probing this temporal relationship using lagged analyses; however, subsequent measurements did not take place until an average of two and a half hours later, thus providing sufficient time for the effect of an initial stressor or leisure activity to wear off and/or another cortisol-influencing event to occur. Future studies may wish to build in a brief delay between EMA and collecting cortisol or slightly retrospectively assess leisure activities over the past 30 minutes, to better assess these relationships. Alternatively, leisure activities (or some subset thereof) may be unrelated to cortisol or may have competing effects (e.g., activities like doing puzzles or arts and crafts may have positive mood-inducing effects but also self-evaluative elements that may increase cortisol). Future work may wish to examine specific attributes of leisure (e.g., high versus low arousal; active versus passive; performance-based versus non-evaluative) to better examine leisure's effect on cortisol levels.

As with the cortisol data, timing issues also prevented us from testing the carryover (or lagged) effects of leisure on mood, interest, and stress. Yet, heart rate was an exception as it was assessed in an ongoing fashion throughout the study period (thus allowing us to generate average heart rate levels every hour). We found that in the hour following a leisure activity, participants' heart rate was lower than the hour following an EMA in which those participants did not engage in leisure; however, by 2 hours subsequent to leisure, this effect on heart rate had dissipated. This and the other heart rate results suggests that there are both contemporaneous and short-term benefits (up to about 1 hour) but that these effects wane within 2 hours following leisure activities. It will be of interest to examine whether this pattern holds for other measures or if the effects of leisure on mood and stress, for example, have shorter or longer term effects. Testing these relationships would require a higher density of measurements and/or more consistent timing between EMAs, so as to reliably model the length of the lag between leisure and mood.

Finally, these results held when controlling for demographics and engagement in exercise and social interactions. A large body of evidence shows that exercise can produce benefits on mood and stress [39–41]. We did not measure what specific activities participants were doing when they reported leisure, but research suggests that some of the participants' reported leisure activities may have been exercised-based [13]. As such, observed effects in our initial leisure only models may have been due partially to exercise rather than leisure. Yet, in the follow-up analyses, we included whether or not participants were engaging in exercise at the time of the prompt; including exercise did not impact the observed effects for leisure (assessed over the same time period). Likewise, leisure has been described as a social activity [44], which has been proposed to account for some of leisure's effects. Yet, even after controlling for whether or not a participant was engaging in leisure or only examining instances of leisure with no reported social interactions, we still observed a consistent pattern of positive effects for leisure. In sum, these results suggest a robust and independent effect of leisure on momentary indices of health.

## Implications

This study was an initial test of the within-person associations of leisure and health. In doing so, these results lend broad support to theories proposing why leisure is beneficial; although it should be noted that the purpose of this study was to examine the within-person associations in general and thus was not optimally structured to test each specific theory. For example, some work suggests that leisure improves health because it has stress-reducing benefits [8–10]. Leisure is proposed to help reduce individuals' current stress levels, such as by providing a break from stressful events or helping to restore normal routines disrupted by stressors [54], and/or improve the ability to cope with current or future stressful events [55]. In finding that engagement in leisure was associated with more positive mood, less negative mood, and less reported stress (on two measures, including a state version of the perceived stress scale that assesses perceived controllability and efficacy regarding stress [47, 48]), there is strong initial support for both immediate stress-reduction benefits and in improving one's capacity to cope with stress. Another set of theories suggest the importance of leisure in reducing boredom [56, 57]. Reducing boredom through leisure is proposed to improve mental and physical health and to reduce engagement in poor health behaviors [29]. Consistent with these theories, we found that when participants engaged in leisure, they reported more interest than when not engaging in leisure, thus suggesting that leisure may indeed reduce boredom. Overall, the observed pattern of results suggests that the processes by which leisure is effective may be multifaceted, and future work may benefit from examining a range of mechanisms underlying leisure's effects on health.

These results may have promise for considering leisure as an intervention activity. Although a range of psychosocial interventions have been identified as able to promote positive mood and reduce stress (e.g., formal relaxation training, meditation, etc.), many of these interventions are difficult to implement and/or have poor long-term adherence. For example, many intervention approaches typically require extensive training periods and alterations to daily routines, each of which can make the activity less enjoyable and may pose barriers to initial engagement and long-term adherence [58]. In contrast, a leisure-based intervention can capitalize on activities that participants likely already do and enjoy and thus may not face many of these barriers to engagement and adherence. Self-determination theory suggests that people can be motivated to engage in an activity and to integrate that activity into their personality, based on the basic human needs of competence, relatedness, and autonomy [59]. In this way, leisure has an advantage over other interventions as typically people engage in leisure activities that they are able to do and are good at (competence), that they and others like them enjoy (relatedness), and which they choose (autonomy). Thus, inherent to leisure are features that promote intrinsic motivation, which from an intervention standpoint may translate into enhanced long-term adherence. Although promising from an adherence standpoint, a leisure-based intervention will likely face its own barriers. For example, an additional predictor to engagement in an activity is the awareness of the benefits of the activity [59, 60]. At times, benefits may refer to whether the activity will be satisfying; in terms of an intervention, benefits may also include educating participants that leisure is not just momentarily pleasing but could have lasting salubrious psychological and physical health effects. In sum, leisure has the potential to be a highly rewarding, intrinsically motivated activity, but future work is needed to design the optimal ways to operationalize leisure as an intervention.

## Limitations and Future Directions

Although the study was novel in its use of EMA, cortisol, and heart rate assessments to test the benefits of leisure, this study has several limitations. To reduce participant burden, single items were used (albeit repeatedly) to assess positive mood, negative mood, and interest/boredom; this approach may reduce the potential reliability of these measurements, although similar measures have been employed in prior research [45, 46]. Our measure of leisure asked simply whether or not a person was engaging in leisure activity, but we have no measure of what specific activities people were doing. Some evidence suggests that certain leisure activities are more beneficial than others [3] and that matching activities to people's preferences or personality may be additionally effective [61]. In addition, we did not assess the duration of engagement in leisure, which may moderate the impact of leisure on health (and/or occlude any time-dependent relationships, such as with cortisol). Although having repeated measures obtained via EMA is a strength of the study, engagement in leisure (or not) and momentary health indicators were assessed at the same time. As such, we are unable to make strong causal claims (e.g., a third variable could explain both decisions to engage in leisure and better mood and lower stress). Different designs (e.g., experimental laboratory approaches) and different assessment strategies (e.g., more sophisticated lagged designs with greater temporal resolution) are needed to provide stronger direct evidence for a causal effect of leisure on health. Finally, participants in the sample were all employed and skewed predominantly female, white, and with (at least) some college education, which may reduce the generalizability of findings.

## Conclusion

In sum, leisure appears to have a consistent within-person benefit on a person's daily health and well-being; when individuals engaged in leisure, they also reported better mood, more interest, less stress, and exhibited lower heart rate than when they were not engaging in leisure activity. This extends prior work that has identified the co-occurrence of engaging in leisure activities and health indicators at the between-person level, in particular by identifying within-person relationships that may suggest mechanisms for why leisure is beneficial to health and well-being. Importantly, by demonstrating the within-person relationship, this study directly informs theories of leisure, as well as suggests the potential for using leisure as an intervention to improve health and well-being in daily life.

**Conflict of Interest Statement** The authors, Matthew J. Zawadzki, Joshua M. Smyth, and Heather J. Costigan, have no conflict of interest to disclose.

**Ethical Adherence Statement** The research was conducted in compliance with the American Medical Association and the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

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