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Enjoying nature, exercise, social interaction, and affect: A daily diary study

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Abstract

This study investigated the pathways linking daily nature enjoyment to affect by testing whether the associations would be fully explained by exercise and social interaction. Participants ($N = 782$; 55.6% female; age 25–74, $M_{age} = 47.9$) from the Midlife in the United States (MIDUS) refresher study completed surveys across 8 days. Multilevel models indicated that enjoying nature with others tended to predict affect at the within-person level, while enjoying nature alone did not. However, enjoying nature alone did predict affect at the between-person level. Lastly, many of these associations remained, even while controlling for exercise and social interaction.

Keywords

affect, exercise, lifestyle, social interaction, well-being

Lifestyle behaviors are an important contributor to physical health, mental health, and well-being. Important lifestyle behaviors include diet, exercise, sleep, social interaction, substance use, and enjoying nature. Along with the other lifestyle behaviors, enjoying nature, exercise, and social interaction have been linked to health (Booth et al., 2012; Holt-Lunstad et al., 2015; Mygind et al., 2019) and well-being (McMahan and Estes, 2015; Milek et al., 2018; Zhang and Chen, 2019). Theoretical and empirical research also indicates that these three behaviors are related to each other (Bratman et al., 2019; Kuo, 2015), raising some questions about the degree to which the different behaviors are associated with positive physical and emotional outcomes. Further, the associations between these lifestyle behaviors and emotional well-being or distress are often studied with cross-sectional designs, which limits understanding how they are related in daily life. This study seeks to build on the previous literature by exploring the associations between enjoying nature, physical activity, socializing, and positive and negative affect using a daily diary design.

Nature and affect

The influence of natural spaces on health and emotional well-being has received increasing investigation, due in part to the increasing urbanization of the world and concerns about loss of access to and interaction with natural

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environments. Currently, 55% of the global population live in urban areas and that number is expected to increase to 68% by 2050 (United Nations, 2019). As an increasing proportion of the world's population resides in urban areas, they may miss out on the benefits of engagement in natural settings, potentially reducing well-being, and impairing both physical and mental health. Research has shown that having nearby greenspace predicts reduced anxiety and depression longitudinally (Engemann et al., 2019). Further, spending time in nature predicts affect (Bakolis et al., 2018) as does enjoyment of nature (Anderson et al., 2018). Enjoyment of nature involves a positive experience with the natural environment, which may include aspects such as savoring (Sato et al., 2018) and nature connectedness (Capaldi et al., 2015), which in turn have been shown to predict affect. Thus while simply being in nature may have benefits, enjoying nature may have a special association with affect because of the positive engagement with the natural environment. These observational associations have led researchers to develop clinical interventions such as providing park prescriptions to increase engagement in natural environments (Müller-Riemenschneider et al., 2020).

Exercise and affect

Exercise has been implicated in various physical diseases such as diabetes, stroke, obesity, and heart disease (Booth et al., 2012), as well as mental health disorders (Ashdown-Franks et al., 2020). Exercise also seems to regularly predict well-being and affect, including a specific association with happiness as demonstrated by a recent systematic review (Zhang and Chen, 2019). The benefits of exercise are supported by longitudinal (Schuch et al., 2018) and intervention research designs (Goldstein et al., 2020). Scholars claim that mechanisms by which exercise may have an influence include reducing oxidative stress and inflammation, improved brain function through increased brain plasticity, regulation of the hypothalamic-pituitary-adrenal (HPA) axis, and increased self-esteem and self-efficacy (Kandola et al., 2019). Importantly, previous research using intensive longitudinal designs supported exercise's association with affect at the within-person level (Pemberton and Tyszkiewicz, 2016).

Social interaction and affect

As thoroughly social creatures, humans benefit from close social interaction and a sense of belonging (Feeney and Collins, 2015), and languish when lonely or unsupported (Cacioppo and Cacioppo, 2014). A lack, or perceived lack of social connection strongly predicts mortality (Holt-Lunstad et al., 2015) and depression (Cruwys et al., 2014). Mechanisms by which social interaction is expected to influence health and emotional well-being include provision of support during times of adversity and by encouraging engagement in positive activities (Feeney and Collins, 2015). Other research shows that activities are rated as more fun when engaged in with others (Reis et al., 2017).

Nature, exercise, and social interaction

Research has shown that healthy lifestyle behaviors and unhealthy lifestyle behaviors tend to cluster with each other (Anderson and Fowers, 2020; Meader et al., 2016), indicating that engagement in one healthy/risky lifestyle behavior is often associated with engaging in other healthy/risky lifestyle behaviors. Some of the research and theory indicates that the benefits of nature enjoyment are driven by the increased likelihood of engaging in physical activity and social interaction (Bratman et al., 2019; Kuo, 2015). In Bratman et al.'s (2019) review of the literature, they indicate that being in nature may have its salutary effects because it is accompanied by social interactions and physical activity (as well as stress reduction and cognitive resource replenishment). This aligns with research showing that some of the self-reported motivations to engage in outdoor leisure activities include a desire for social interactions and physical fitness (Manfredo et al., 1996). Kuo (2015) also makes the argument for exercise and social interaction

as key factors in nature's positive impact on health and well-being, although his model also makes room for other variables such as the benefits of natural sights and sounds, environmental biodiversity, and relaxation. Empirically, exercise and social interaction were not significant mediators in a recent four-site, albeit cross-sectional, study (Triguero-Mas et al., 2017). Overall, it is not clear whether enjoyment of nature has unique day-to-day associations with affect when accounting for exercise and social interaction, although the models by Kuo (2015) and Bratman et al., (2019) offer additional mechanisms by which nature could influence affect. If those other factors are important, then enjoyment of nature should have associations with affect above and beyond the effects of exercise and social interaction. As such, to assess whether daily enjoyment of nature is associated with affect above and beyond the social interaction and exercise, those behaviors could be controlled for in statistical analyses. One previous daily diary study found that exercise, nature and social interaction all positively predicted vitality when entered into a model together, indicating that each was associated with vitality while controlling for the others (Ryan et al., 2010). However, that study was limited by its use of a student population for the daily diary components and for its focus only on one narrow aspect of affect, vitality.

Methodological variety can help improve our understanding of these behaviors and their association with affect. For example, Beute et al. (2016) recommend experience sampling/daily diary studies to fill the gap between lab-based, short-term experimental studies and longitudinal approaches toward the associations between nature and health. Some of the arguments that support the use of daily diary or experience sampling approaches are that recall biases are reduced (i.e. participants report on exercise that day rather than average exercise in a given year), the behavior may more closely align with natural human functioning, and it allows for the investigation of within and between person associations with relevant outcomes. This means that one can, for example, see whether participants' average amount of time spent exercising is associated with affect (between-person association), while also assessing whether daily fluctuations in exercise around that average are associated with affect (within-person associations). This is important because associations in diary studies can differ by strength and in some cases even direction across levels of analyses.

The present study

Using a daily diary design, this study sought to answer a pair of research questions. First was whether within-person and between-person enjoyment of nature would be associated with daily positive and negative affect. Second, was whether enjoying nature would remain significantly positively associated with positive affect and negatively associated with negative affect at the within- and between-person levels, controlling for exercise and social interaction while enjoying nature. In response to those research questions, hypotheses were established for the study. Enjoying nature would be positively associated with positive affect and negatively with negative affect at the within-person (h1, h2) and between-person (h3, h4) levels. In a separate model controlling for social interaction and exercise during the period of enjoying nature, the same directions of associations were expected between enjoying nature and both positive (h5, h6) and negative affect (h7, h8).

Methods

Participants

Publicly available, de-identified data were from the Midlife in the United States (MIDUS) Refresher study and a subsequent daily diary project (Ryff and Almeida, 2018). The Refresher study was a nationally representative telephone and mail study conducted between 2011 and 2014 focused on midlife development related to physical health, psychological well-being and social functioning. The purpose was to build off the original MIDUS study by refreshing the sample with a new cohort. The main refresher sample included 3577 participants aged

23–76 years old. Of those, a random sub-sample were invited to participate in a daily diary survey with 782 individuals actually participating. Participants provided informed consent for both the refresher study and for the daily diary study. The sample characteristics of the daily diary sub-sample and the larger sample were similar (see Surachman et al., 2019). The participants completed interviews for eight consecutive evenings where they responded to a number of questions related to their day. Details for the procedures for the data collection can be found on the MIDUS website (http://midus.wisc.edu). The response rate to the survey was generally high, with a total of 5849 days' worth of surveys across the sample out of 6256 total possible days (93.50% response rate).

Measures

Enjoying nature. Participants responded to the following question: "Since this time yesterday did you spend any time enjoying or viewing nature?" They also reported at what time this occurred. This was used to create a dummy coded variable for enjoying nature, as the duration of the nature experience was not asked. Participants only reported on a maximum of one bout of enjoying nature. The item was person-centered, and the sum of days of enjoying nature across the duration of the study for each participant was centered on the grand mean. Descriptive statistics can be seen in the Supplemental Materials.

Exercise. Participants reported how much time they engaged in vigorous physical activity since the same time yesterday and also reported what time they began exercising. The time of day when the participant reported enjoying nature was compared to the time interval of their exercise bout. If the time of the experience of enjoying nature was contained within the period of exercise, this exercise duration was used to create an exercise while enjoying nature variable. The other exercise bouts were used to create another variable representing exercise while not enjoying nature. These variables were person-centered and the person means of these behaviors were centered on the respective grand means.

Social interaction while enjoying nature. When responding to the question about spending time enjoying nature, participants also reported whether their nature experience was with another person, and if so, who it was. Using this response, two dummy coded variables were created: One for days when the participant enjoyed nature alone and one for days when the participant enjoyed nature with others. These variables were person-centered and the person means of these variables were centered on the respective grand means.

Positive and negative affect. Each day, participants responded to 13 positive affect items and 14 negative affect items, indicating how much of the day they felt those emotions. Item responses were on a five-point continuum ranging from 0 to 4 (0=None of the time, 1=A little of the time, 2=Some of the time, 3=Most of the time, and 4=All the time). A composite variable was created for each set of items and then standardized across all occasions of measurement. These scales have been regularly used to assess affect (e.g. Leger et al., 2016) and using the procedures from Bonito et al., (2012) reliability coefficients were calculated at the daily and person levels for the positive affect (day=.73; person=.96) and negative affect (day=.68; person=.90) scales.

Time. To account for changes in positive and negative affect over the course of the study, time was entered into the model, representing the day of the participant's survey, ranging from 0 to 7. Also included in the model was whether the day of assessment was a weekday ("0") or weekend ("1").

Covariates. To account for other variables that might influence affect and the likelihood of enjoying nature or exercising, the participants' self-reported daily number of stressors and daily number of physical symptoms were also included as covariates. For daily number of stressors, participants were provided with seven

prompts asking if they had experienced six specific stressful experiences and one additional open-ended stressful experience. For daily number of physical symptoms, participants indicated whether they experienced a series of 28 possible physical symptoms (e.g. headache, backache, dizziness) on that day. The number of daily stressors and daily symptoms endorsed by the participants were person-centered while the person-means were centered on the grand mean.

Analysis plan

The analysis used multilevel models to analyze the nested data (days within-persons) so that within-person and between-person associations could be assessed. All models were analyzed using R statistical software with the *lme4* (Bates et al., 2015) and *robustlmm* (Koller, 2016) packages. The initial goal for the analyses was to analyze the data with traditional mixed effects linear models, but diagnostic plots indicated the presence of outliers and non-normality in the residuals of the negative affect models. As such, robust linear mixed effects models were more appropriate for those models (see Field and Wilcox, 2017). Preparatory data management included recoding the variables from text to numeric format, calculating time and time intervals, and centering the variables. ICC values for the binary items were calculated using the random intercept logistic regression method described by Wu et al. (2012).

To test the study hypotheses, two pairs of models were run. Following the recommendation of Barr et al. (2013), a maximal random effects structure was modeled for the positive affect models, but due to extreme computational burdens of random slopes in robust models, only random intercepts were estimable for the negative affect models. The first pair of models included enjoyment of nature to test associations with positive and negative affect (h1–h4). The second pair of models investigated whether enjoying nature alone was still associated with affect, controlling for exercise (h5–h8).

Data sharing statement

Are de-identified individual participant data available (including data dictionaries)? Yes, from the Inter-university Consortium for Political and Social Research (https://www.icpsr.umich.edu/web/ICPSR/studies/37083). What data in particular are shared? All of the individual participant data collected during the study were made available, after de-identification. What other documents are available? The author's script for running the data cleaning and analysis in R, analyses output, and an overview of the supporting documentation.

Results

Forty-six percent of days included some amount of exercise and 43% of days involved spending time enjoying nature. Of the days spent enjoying nature 19% involved engaging in exercise and 77% involved enjoying nature with another person. The relatively high proportion of nature days in which people enjoy nature with others indicates that enjoyment of nature and social interaction cluster together in this sample.

Direct effects of enjoying nature

The first pair of models indicated that past-24-hour enjoyment of nature was associated with ratings of positive affect (b=.10, 95% CI [0.06, 0.13]) and negative affect (b=−0.03, 95% CI [−0.06, −0.004]) at the within-person level. At the between-person level, enjoyment of nature was associated with positive affect (b=.08, 95% CI [.05, .10]) and negative affect (b=−.01, 95% CI [−0.02, −0.01]). See Table 1 for full results.

Enjoying nature controlling for exercise and social interaction exercising

To test whether nature had associations with affect beyond any concurrent social interaction and exercise, a second pair of models were fitted to the data including these variables. At the within-person level enjoying nature with others

Table 1. Fixed effects for models 1 and 2 predicting positive and negative affect.

	Positive affect						Negative affect					
	Model 1			Model 2			Model 1			Model 2		
	Est	SE	95% CI	Est	SE	95% CI	Est	SE	95% CI	Est	SE	95% CI
Fixed effects												
Intercept	0.09	0.03	0.02, 0.14	0.08	0.03	0.02, 0.14	−0.08	0.01	−0.10, –0.05	−0.08	0.01	−0.10, –0.05
Time	−0.02	0.00	−0.03, –0.02	−0.02	0.004	−0.03, –0.02	−0.01	0.00	−0.02, –0.01	−0.01	0.00	−0.02, –0.01
Weekend	0.07	0.02	0.04, 0.10	0.07	0.02	0.04, 0.10	−0.05	0.01	−0.08, –0.03	−0.05	0.01	−0.08, –0.03
Phys symptoms_w	−0.05	0.01	−0.05, –0.03	−0.05	0.01	−0.06, –0.04	0.07	0.00	0.06, 0.08	0.07	0.00	0.06, 0.08
Phys symptoms_b	−0.12	0.01	−0.15, –0.09	−0.12	0.01	−0.15, –0.10	0.13	0.01	0.11, 0.14	0.13	0.01	0.12, 0.14
Stressors_w	−0.13	0.01	−0.15, –0.11	−0.13	0.01	−0.15, –0.11	0.25	0.01	0.23, 0.26	0.25	0.01	0.23, 0.26
Stressors_b	−0.40	0.06	−0.52, –0.27	−0.37	0.06	−0.49, –0.24	0.53	0.03	0.48, 0.58	0.52	0.03	0.47, 0.57
Nature_w	0.10	0.02	0.06, 0.13				−0.03	0.01	−0.08, –0.03			
Nature_b	0.08	0.01	0.05, 0.10				−0.01	0.00	−0.02, –0.01			
Nature alone_w				0.05	0.03	−0.02, 0.11				−0.03	0.03	−0.08, 0.02
Nature alone_b				0.10	0.02	0.06, 0.13				−0.02	0.01	−0.03, –0.01
Nature social_w				0.11	0.02	0.07, 0.15				−0.03	0.01	−0.06, –0.00
Nature social_b				0.06	0.01	0.03, 0.09				−0.01	0.01	−0.02, –0.00
Ex nature_w				0.02	0.01	0.00, 0.04				0.00	0.01	−0.02, 0.02
Ex nature_b				−0.01	0.06	−0.14, 0.11				0.04	0.03	−0.01, 0.09
Ex other_w				0.04	0.01	0.02, 0.05				−0.00	0.01	−0.01, 0.01
Ex other_b				0.12	0.03	0.06, 0.18				−0.03	0.01	−0.05, –0.01
Model fit												
AIC	9851.9			9869.3			-			-		
BIC	10058.2			10115.6			-			-		

Within-person effects for nature, exercise, stressors and physical symptoms were person-centered, while between-person effects for those variables were centered on the grand mean. Ex = exercise, which was duration of exercise in minutes. Variables followed by "_w" are at the within-person and those followed by "_b" are at the between-person level. Random effects structure for the positive affect models are available in Supplemental Materials.

was associated with positive affect (b=0.11, 95% CI [0.07, 0.15]), while enjoying nature alone was not (b=0.05, 95% CI [−0.02, 0.11]). However, at the between-person level, both enjoying nature with others (b=0.06, 95% CI [0.03, 0.09]) and while alone (b=0.10, 95% CI [0.06, 0.13]) were associated with positive affect. Interestingly, time exercising during bouts of enjoying nature was not associated with positive affect at the within- (b=0.02, 95% CI [−0.003, 0.04]) or between-person (b=−0.01, 95% CI [−0.14, 0.11]) levels, although exercise while not enjoying nature was associated with positive affect at the within- (b=0.04, 95% CI [0.02, 0.05]) and between-person (b=0.12, 95% CI [0.06, 0.18]) levels.

For the negative affect model, associations with negative affect were found for within-person fixed effects of enjoying nature with others (b=−0.03, 95% CI [−0.06, −0.004]), but not enjoying nature alone (b=−0.03, 95% CI [−0.08, 0.02]). At the between-person level, there were associations for enjoying nature with others (b=−0.01, 95% CI [−0.02, −0.001]) and enjoying nature alone (b=−0.02, 95% CI [−0.03, −0.01]). Interestingly, of all the exercise variables, only exercise while not enjoying nature at the between-person level was negatively associated with negative affect (b=−0.03, 95% CI [−0.05, −0.01]).

Discussion

This study aimed to explore the association of daily enjoyment of nature with positive and negative affect. The study utilized a daily diary design and multilevel modeling to analyze the data with days nested within persons. The findings generally support the association between daily experiences of enjoying nature and both positive and negative affect in a large sample of U.S. adults, spanning geographic location and age. The first model showed associations between enjoying nature and positive and negative affect at the within- (h1, h2) and between- (h3, h4) person levels. However, when controlling for time spent exercising and social interaction while enjoying nature, enjoying nature alone was associated with positive (h7) and negative affect (h8) at the between-person level, but not the within person level (h5, h6). Thus, at the within-person level enjoying nature is not a significant predictor, when accounting for the other lifestyle behaviors of social interaction and exercise.

The finding that enjoying time in nature shows associations with affect is an important addition to the literature because much of the previous research has relied on cross-sectional data, or large interval longitudinal day to examine the relations between spending time in nature and health and well-being outcomes. Although other diary studies have investigated nature experiences (e.g. Anderson et al., 2018; Ryan et al., 2010; Sato and Conner, 2013), they are relatively rare relative to cross-sectional studies, and none have been conducted on a sample that approaches representability of the U.S. population. The greater generalizability of these findings further substantiates the associations of daily enjoyment of nature with positive and negative affect, which in turn have important associations with overall physical health (Boehm and Kubzansky, 2012). Of note, the within-person association with negative affect has been particularly lacking in previous diary or experience sampling research. These findings from experience sampling studies are important because they demonstrate associations at the daily or momentary level, rather than asking for global aggregated reports of time in nature and affect. These findings can be supported by continued experimental work to help clarify causal relations between enjoying nature and both positive and negative affect.

Some theory indicates that exercise and social interaction are core factors which co-occur with enjoying nature and which explain the relationship between enjoying nature and emotional well-being (e.g. Hartig et al., 2014; Kuo, 2015). Despite not being related at the within-person level when controlling for social interaction and exercise, the between-person associations between enjoying nature and affect are important evidence for the potential benefits of nature enjoyment above and beyond exercise and social interaction. These other benefits might be accounted for by the biophilia hypothesis and the ways that natural environments

support attentional restoration and stress reduction (Baxter and Pelletier, 2019; see below). The lack of within-person findings are similar to a network analysis, which showed that while associated with exercise and social interaction at the within-person level, time enjoying nature was not associated with well-being (Anderson and Fowers, 2020). The lack of within-person associations in these studies contrasts with Ryan et al.'s (2010) daily diary study, which found that enjoying nature predicted vitality, controlling for physical activity and social interaction at the within-person level. Differences in measurement of the lifestyle behaviors and this study's utilization of a broader range of affect in the dependent variables, including negative affect, may explain the null findings. Importantly, the present study demonstrated some negative associations between enjoyment of nature and negative affect, which indicates that nature experiences may not only be associated with positive affect, but also associated with less negative affect. Together, this study and the Ryan et al., (2010) study offer some evidence that nature's association with affect is due to other factors beyond co-occurring exercise and social interaction.

The unique benefits of nature might be explained by stress-reduction properties which have been shown to mediate the relationship between nearby greenspace and affect (de Vries et al., 2013). Further, many of the purported benefits of enjoying time in nature, ranging from antimicrobial compounds given off by plants, to the beauty of scenic views, to improved air quality are theorized to have a unifying pathway to health through improved immune functioning (Kuo, 2015). Individual differences in experiences of nature may also moderate the nature-affect association. For example, connectedness to nature (Capaldi et al., 2015) and savoring (Sato et al., 2018) may explain the positive associations between enjoying nature and affect. Also, the well-being that accompanies the activity of enjoying nature may depend on the circumstances which the person finds themselves and their purpose for pursuing the activity. For example, while some may be seeking enjoyment and pleasurable experiences in nature which are further amplified by the company of other people, other individuals may use nature experiences as an escape, a time for contemplation and reflection, or a time to experience reduced stress alone (Manfredo et al., 1996). It will be important for future research to investigate the potential mediating and moderating factors that can explain how, for whom, and under what circumstances enjoying nature might be beneficial.

Although this study has strengths such as a relatively large sample of participants for a daily diary survey, there are some limitations. First and most generally, these data were not collected with these hypotheses in mind and thus some aspects of measurement were limited. The ability to thoroughly assess the associations between the enjoyment of nature and affect was limited by the use of a binary measurement of nature enjoyment, with its inclusion of "viewing" nature experiences, which could have occurred without necessarily being in nature. While self-reported exercise is only modestly correlated with objectively measured actigraph assessments of exercise (Prince et al., 2008), other research indicates that self-reported exercise is the stronger predictor of affect (McLean et al., 2018). Some research has used GPS data from smart phones to objectively measure distance to nature and degree of naturalness. Of particular note is MacKerron and Mourato's study (2013) which tracked over 21,000 British adults' location using GPS and their momentary affect, resulting in over a million data points across a 6-month period. What they found is that when individuals were objectively closer to natural environments, they reported greater happiness. Also, in calculating the binary variables of exercising while enjoying nature versus exercise in other settings, there is likely some measurement error that was introduced into the study when the exercise interval (start to end of exercise) was assessed for overlap with time of enjoying nature. It is possible that an individual could have reported spending time in nature around 8 am, which continued until 10 am, with a bout of exercise going from 9 am to 10 am. If that were the case,

this bout would have been coded as not occurring while enjoying nature.

Future research would benefit from a few additions. A more comprehensive and systematic assessment of the time spent in nature versus in human-built environments would reduce the complications of using overlapping time intervals in this study. Other outcome variables might be important to consider beyond positive and negative affect, including other forms of well-being and physiological variables. Lastly, some research indicates that it is the quality of the nature experience and not just the quantity that is important (Sato and Conner, 2013), so future research should assess the types, quantity, and quality (e.g. naturalness, beauty, biodiversity) of nature experiences, in conjunction with other related lifestyle behaviors such as social interaction and exercise.

Conclusion

This study provides support for enjoying nature alone, enjoying nature with someone else, and exercise as lifestyle behaviors associated with positive and negative affect in a daily diary study design. Although enjoying nature has not traditionally been a central focus in health psychology, these findings can help inform future experimental manipulation of these behaviors, which may in turn support the development of lifestyle medicine and related lifestyle approaches to improve health and emotional well-being. With global shifts toward urban living, lifestyle medicine approaches need to continue to explore how the relationship between time spent in nature and affect is affected by environmental circumstances and individual differences.

Author's note

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Supplemental material

Supplemental material for this article, including the data description, R code, and output, is available online: https://osf.io/y9djw/.

References

Anderson AR and Fowers BJ (2020) Lifestyle behaviors, psychological distress, and well-being: A daily diary study. *Social Science & Medicine* 263: 113263.

Anderson CL, Monroy M and Keltner D (2018) Awe in nature heals: Evidence from military veterans, at-risk youth, and college students. *Emotion* 18(8): 1195–1202.

Ashdown-Franks G, Firth J, Carney R, et al. (2020) Exercise as medicine for mental and substance use disorders: A meta-review of the benefits for neuropsychiatric and cognitive outcomes. *Sports Medicine* 50(1): 151–170.

Bakolis I, Hammoud R, Smythe M, et al. (2018) Urban mind: Using smartphone technologies to investigate the impact of nature on mental well-being in real time. *BioScience* 68(2): 134–145.

Barr DJ, Levy R, Scheepers C, et al. (2013) Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language* 68(3): 255–278.

Bates D, Mächler M, Bolker B, et al. (2015) Fitting linear mixed-effects models using lme4. *Journal of Statistical Software* 67(1): 1–48.

Baxter DE and Pelletier LG (2019) Is nature relatedness a basic human psychological need? A critical examination of the extant literature. *Canadian Psychology/Psychologie canadienne* 60(1): 21–34.

Beute F, de Kort Y and IJsselsteijn W (2016) Restoration in its natural context: How ecological momentary assessment can advance restoration research. *International Journal of Environmental Research and Public Health* 13(4): 420.

Boehm JK and Kubzansky LD (2012) The heart's content: The association between positive psychological well-being and cardiovascular health. *Psychological Bulletin* 138(4): 655–691.

Bonito JA, Ruppel EK and Keyton J (2012) Reliability estimates for multilevel designs in group research. *Small Group Research* 43(4): 443–467.

Booth FW, Roberts CK and Laye MJ (2012) Lack of exercise is a major cause of chronic diseases. *Comprehensive Physiology* 2(2): 1143–1211.

Bratman GN, Anderson CB, Berman MG, et al. (2019) Nature and mental health: An ecosystem service perspective. *Science Advances* 5(7): eaax0903.

Cacioppo JT and Cacioppo S (2014) Social relationships and health: The toxic effects of perceived social isolation. *Social and Personality Psychology Compass* 8(2): 58–72.

Capaldi CA, Passmore H-A, Nisbet EK, et al. (2015) Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing* 5(4): 1–16.

Cruwys T, Haslam SA, Dingle GA, et al. (2014) Depression and social identity: An integrative review. *Personality and Social Psychology Review* 18(3): 215–238.

de Vries S, van Dillen SME, Groenewegen PP, et al. (2013) Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine* 94: 26–33.

Engemann K, Pedersen CB, Arge L, et al. (2019) Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. *Proceedings of the National Academy of Sciences* 116(11): 5188–5193.

Feeney BC and Collins NL (2014) A new look at social support: A theoretical perspective on thriving through relationships. *Personality and Social Psychology Review* 19: 113–147.

Field AP and Wilcox RR (2017) Robust statistical methods: A primer for clinical psychology and experimental psychopathology researchers. *Behaviour Research and Therapy* 98: 19–38.

Goldstein E, Topitzes J, Brown RL, et al. (2020) Mediational pathways of meditation and exercise on mental health and perceived stress: A randomized controlled trial. *Journal of Health Psychology* 25: 1816–1830.

Hartig T, Mitchell R, Vries S de, et al. (2014) Nature and Health. *Annual Review of Public Health* 35(1): 207–228.

Holt-Lunstad J, Smith TB, Baker M, et al. (2015) Loneliness and social isolation as risk factors for mortality: A meta-analytic review. *Perspectives on Psychological Science: A Journal of the Association for Psychological Science* 10(2): 227–237.

Kandola A, Ashdown-Franks G, Hendrikse J, et al. (2019) Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. *Neuroscience and Biobehavioral Reviews* 107: 525–539.

Koller M (2016) robustlmm: An R package for robust estimation of linear mixed-effects models. *Journal of Statistical Software* 75(6): 1–24.

Kuo M (2015) How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology* 6: 1093.

Leger KA, Charles ST, Turiano NA, et al. (2016) Personality and stressor-related affect. *Journal of Personality and Social Psychology* 111(6): 917–928.

MacKerron G and Mourato S (2013) Happiness is greater in natural environments. *Global Environmental Change* 23(5): 992–1000.

Manfredo MJ, Driver BL and Tarrant MA (1996) Measuring leisure motivation: A meta-analysis of the recreation experience preference scales. *Journal of Leisure Research* 28(3): 188–213.

McLean DC, Nakamura J and Csikszentmihalyi M (2018) Reconsidering the experience machine: Self-reported versus objective measures of physical activity to increase positive affect. *Journal of Health Psychology* 25: 2428–2439.

McMahan EA and Estes D (2015) The effect of contact with natural environments on positive and negative affect: A meta-analysis. *The Journal of Positive Psychology* 10(6): 507–519.

Meader N, King K, Moe-Byrne T, et al. (2016) A systematic review on the clustering and co-occurrence of multiple risk behaviours. *BMC Public Health* 16: 657.

Milek A, Butler EA, Tackman AM, et al. (2018) "Eavesdropping on happiness" revisited: A pooled, multisample replication of the association between life satisfaction and observed daily conversation quantity and quality. *Psychological Science* 29(9): 1451–1462.

Müller-Riemenschneider F, Petrunoff N, Yao J, et al. (2020) Effectiveness of prescribing physical activity in parks to improve health and well-being - the park prescription randomized controlled trial. *International Journal of Behavioral Nutrition and Physical Activity* 17(1): 42.

Mygind L, Kjeldsted E, Hartmeyer RD, et al. (2019) Immersive nature-experiences as health promotion interventions for healthy, vulnerable, and sick populations? A systematic review and appraisal of controlled studies. *Frontiers in Psychology* 10: 943.

Pemberton R and Tyszkiewicz MDF (2016) Factors contributing to depressive mood states in everyday life: A systematic review. *Journal of Affective Disorders* 200: 103–110.

Prince SA, Adamo KB, Hamel ME, et al. (2008) A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity* 5: 56.

Reis HT, O'Keefe SD and Lane RD (2017) Fun is more fun when others are involved. *The Journal of Positive Psychology* 12(6): 547–557.

Ryan RM, Weinstein N, Bernstein J, et al. (2010) Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology* 30(2): 159–168.

Ryff CD and Almeida D (2018) Midlife in the United States (MIDUS Refresher): Daily Diary Project, 2012-2014. Inter-university Consortium for Political and Social Research [distributor]. DOI: 10.3886/ICPSR37083.v1.

Sato I and Conner TS (2013) The quality of time in nature: How fascination explains and enhances the relationship between nature experiences and daily affect. *Ecopsychology* 5(3): 197–204.

Sato I, Jose PE and Conner TS (2018) Savoring mediates the effect of nature on positive affect. *International Journal of Wellbeing* 8(1): 18–33.

Schuch FB, Vancampfort D, Firth J, et al. (2018) Physical activity and incident depression: A meta-analysis of prospective cohort studies. *The American Journal of Psychiatry* 175(7): 631–648.

Surachman A, Wardecker B, Chow S-M, et al. (2019) Life course socioeconomic status, daily stressors, and daily well-being: Examining chain of risk models. *The Journals of Gerontology: Series B* 74(1): 126–135.

Triguero-Mas M, Donaire-Gonzalez D, Seto E, et al. (2017) Natural outdoor environments and mental health: Stress as a possible mechanism. *Environmental Research* 159: 629–638.

United Nations: Department of Economic and Social Affairs (2019) World urbanization prospects: 2018 highlights. United Nations. Retrieved from https://population.un.org/wup/Publications/Files/WUP2018-Highlights.pdf (accessed on 10 January 2020).

Wu S, Crespi CM and Wong WK (2012) Comparison of methods for estimating the intraclass correlation coefficient for binary responses in cancer prevention cluster randomized trials. *Contemporary Clinical Trials* 33(5): 869–880.

Zhang Z and Chen W (2019) A systematic review of the relationship between physical activity and happiness. *Journal of Happiness Studies* 20(4): 1305–1322.