Journal of Environmental Psychology 38 (2014) 1–9

Contents lists available at ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep

# The influence of urban green environments on stress relief measures: A field experiment

Liisa Tyrväinen [a], Ann Ojala [a,*], Kalevi Korpela [b], Timo Lanki [c], Yuko Tsunetsugu [d], Takahide Kagawa [d]

[a] Finnish Forest Research Institute Metla, Jokiniemenkuja 1, Box 18, FI-01301 Vantaa, Finland
[b] School of Social Sciences and Humanities/Psychology, University of Tampere, 33014 Tampere, Finland
[c] Department of Environmental Health, Environmental Epidemiology Unit, National Institute for Health and Welfare, P.O. Box 95, FI-70701 Kuopio, Finland
[d] Department of Wood Engineering, Forestry and Forest Products Research Institute, 1 Matsunosato, Tsukuba, Ibaraki 305-8687, Japan

ARTICLE INFO

*Article history:*
Available online 25 December 2013

*Keywords:*
Restoration
Stress
Well-being
Urban green environments
Field experiment

ABSTRACT

This study investigated the psychological (perceived restorativeness, subjective vitality, mood, creativity) and physiological (salivary cortisol concentration) effects of short-term visits to urban nature environments. Seventy-seven participants visited three different types of urban areas; a built-up city centre (as a control environment), an urban park, and urban woodland located in Helsinki, the capital of Finland. Our results show that the large urban park and extensively managed urban woodland had almost the same positive influence, but the overall perceived restorativeness was higher in the woodland after the experiment. The findings suggest that even short-term visits to nature areas have positive effects on perceived stress relief compared to built-up environment. The salivary cortisol level decreased in a similar fashion in all three urban environments during the experiment. The relations between psychological measures and physiological measures, as well as the influence of nature exposure on different groups of people, need to be studied further.



## 1. Introduction

The quality of urban environments is increasingly recognised to contribute to human health and well-being. The supply and maintenance of health-promoting areas and elements within urban areas such as green spaces are suggested to support residents' possibilities to cope with everyday stress and to have a beneficial effect on human health (Frumkin, 2001; Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006; Maller, Townsend, Pryor, Brown, & St Leger, 2005; Nilsson, Baines, & Konijnendijk, 2007). The continuing urbanisation process and pressures on existing green spaces, however, challenge the adequate provision of these areas. In urban planning processes, the health and well-being benefits of nature areas are not fully acknowledged and therefore, their provision is difficult to justify faced with competing land-use interests (e.g. Tyrväinen, Pauleit, Seeland, & de Vries, 2005).

In modern urbanised societies, acute and chronic stress, and insufficient recovery from stress, are recognised as an increasing problem and a cause for long-term effects on health (McEwen, 1998; Sluiter, Frings-Dresen, Meijman, & van der Beek, 2000). Stress is an important public health concern that is related to mental health problems such as burnout syndrome as well as cardiovascular, gastroenterological, immunological and neurological diseases (Nilsson, Sangster, & Konijnendijk, 2011). In Europe, for example, the main work-related problems include musculoskeletal problems (59.8%) followed by stress, depression or anxiety (13.7%) (Europe in figures – Eurostat Yearbook, 2011, p. 187). This suggests that stress control is a vital issue in maintaining good health and preventing stress-related diseases in urbanised societies. The current health care practices, however, are costly and often focus on the treatment of stress-related illnesses instead of preventing them.

Previous research shows that green spaces help to reduce stress, and generally enhance psychological recovery (e.g. Björk et al., 2008; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Herzog, Maguire, & Nebel, 2003; Laumann, Gärling, & Stormark, 2003). For physiological recovery, there is somewhat less evidence of an effect (Bowler, Buyung-Ali, Knight, & Pullin, 2010), but there are studies reporting positive effects of green spaces on stress relief

* Corresponding author. Tel.: +358 408015020.
*E-mail addresses:* liisa.tyrvainen@metla.fi (L. Tyrväinen), ann.ojala@metla.fi, annojala123@gmail.com (A. Ojala), kalevi.korpela@uta.fi (K. Korpela), timo.lanki@thl.fi (T. Lanki), yukot@ffpri.affrc.go.jp (Y. Tsunetsugu), kagawa@affrc.go.jp (T. Kagawa).

0272-4944/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jenvp.2013.12.005

(Lee et al., 2012; Li et al., 2008; Park et al., 2007; Tsunetsugu et al., 2007). There is also increasing interest in studying whether nature may assist both in preventing illnesses that are mediated by psychological processes, such as stress, and in curing stress-related diseases, such as burnout and depression. The economic implications of any positive contribution of urban green settings to health are likely to be substantial (Nilsson et al., 2011).

Many studies from Europe, North America and Asia report that compared to urban environments, natural environments improve human mood states (Hartig et al., 2003; Hartig, Mang, & Evans, 1991; Morita et al., 2007; Tsunetsugu et al. 2013) as well as concentration and performance (van den Berg, Koole, & van der Wulp, 2003; Hartig et al. 2003, 1991; Laumann et al., 2003). Research has shown that even exposure to photographic pictures of nature, compared to pictures of urban environments, has positive effects on emotional states and cognitive performance (Hartmann & Apaolaza-Ibáñez, 2010; Ulrich et al., 1991).

A number of studies focussing on physiological stress-releasing effects of one type of nature area (forest) visits compared to visits in the built environment have been conducted in Japan. The field experiments conducted in different parts of the country show that forest visits can lower blood pressure and pulse rate, reduce cortisol level, suppress sympathetic nervous activity, and enhance parasympathetic nervous activity (Lee et al., 2012; Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010; Tsunetsugu et al., 2013).

Cortisol concentration is a widely utilised stress marker in the studies above but also in various other scientific fields. Cortisol is released by the hypothalamic pituitary adrenal (HPA) axis in response to stress (Seplaki, Goldman, Weinstein, & Lin, 2004), and it is considered one of the major components of the physiological stress response in humans (Ockenfels et al., 1995). Cortisol can be measured in blood, urine or saliva. In psychobiological research, salivary measurements are often preferred because of their non-invasive nature. Salivary cortisol can be a convenient and reliable parameter of endocrine stress responses (Kirschbaum & Hellhammer, 1989), because its response to stress is immediate and it is highly associated with the free cortisol fraction in the blood (Kirschbaum & Hellhammer, 1994). Importantly, the sampling procedure does not affect cortisol values (Kirschbaum & Hellhammer, 1989). In response to a stressor, the excretion of cortisol usually increases, but there is considerable diurnal variability in cortisol levels, normally peaking in early morning and declining towards the evening (Levine, Zagoory-Sharon, Feldman, Lewis, & Weller, 2007). Therefore, standardisation of the timing of sampling is important in field studies.

Salivary cortisol response to psychological stress is considered to be influenced by gender, as the response is generally greater in men compared to women (e.g. Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004; Lovallo, Farag, Vincent, Thomas, & Wilson, 2006). Moreover, nicotine and alcohol intake may reduce cortisol responses (Lovallo, Dickensheets, Myers, Thomas, & Nixon, 2000; Rohleder & Kirschbaum, 2005). Field studies conducted mainly in Japan with young male participants have reported lowered salivary cortisol concentrations by viewing landscapes in forested areas as well as walking in forest environments compared to built-up areas in city centres (Lee et al., 2011; Park et al., 2008, 2010), but results are still somewhat mixed. In a recent study conducted in Portland, United States, the salivary cortisol concentration when viewing different urban settings (from very natural to very built) revealed no differences between four experimental sites (Beil & Hanes, 2013). In that study, only a small number of participants (15) were involved. The participants visited each site for a short period (20 min) and may not have given enough time to allow measurable changes in salivary cortisol to occur. These results show that there is a need to have stronger evidence about the effect of green areas on stress relief in urban environments.

In the previous experiments, emotional responses have been measured mainly by Profile of Mood States, POMS (e.g. Park et al., 2009, 2010; Tsunetsugu, Park, & Miyazaki, 2010) and Zuckerman Inventory or Personal Reactions, ZIPERS (e.g. Hartig et al., 1991), but other emotional measures have seldom been used. However, the most consistent evidence over several studies on the differences between the effects of natural and urban environments concerns emotional outcomes (Bowler et al., 2010). Natural environments evoke positive moods (tranquillity and energy) and decrease negative moods such as anger, sadness and fatigue. Thus, we decided to use as short a measure of mood as possible (the Positive and Negative Affect Scale PANAS) and concentrate more on other, less studied experiences. Thus, we used the Restoration Outcome Scale (ROS) that has been used mainly in favourite place studies (Korpela, Ylén, Tyrväinen, & Silvennoinen, 2008). Moreover, vitality is a distinct but related concept to restoration (Ryan et al., 2010) and deserves further study in different environments. Lastly, it has been argued that research in this field should also consider how the environment fosters not only emotions and energy but also ongoing personal development such as creativity (Newell, 1997). Consequently, we also measured feelings of creativity.

Little experimental research has so far investigated how different real-world environmental settings actually influence stress. This is why there is a need to study the adult working people after their work day.

Moreover, little is known about the amount of exposure to nature areas needed to gain health benefits. The study of Tyrväinen, Silvennoinen, Korpela, and Ylen (2007) showed that the positive feelings (concentration, eagerness, vigour) of urban citizens were stronger when green areas were used more than five hours per month in comparison to those who used areas less or not at all. More research evidence is also needed about the health benefits of the use of different types of nature areas in an urban context. The current study aims to increase our knowledge about the effects of these types. In a recent study conducted in Finland, restorative experiences in favourite urban woodlands together with exercise and activity outdoor areas and waterside environments were significantly stronger than in favourite parks or built urban settings (Korpela, Ylén, Tyrväinen, & Silvennoinen, 2010).

### 1.1. Objectives

The main objective of this study was to investigate the restorative effects of short-term visits in three different types of urban environments: a built-up area in a city and two types of green areas, a park and a woodland (forested area). Thus, we add to earlier studies by including two different types of green environment.

As an individual's response to stress is a result of a complex, temporal chain of psychophysiological and emotional responses, we use both physiological and psychological indices/measures. We are interested in how these changes emerge in different phases of the experiment that includes both a viewing and a walking phase. More specifically, the aim was to study the effect of viewing and walking on perceived restorativeness, subjective vitality, mood, creativity, and salivary cortisol concentration.

We expect that the green areas differ in terms of their restorative quality, so that the woodland is a more restorative environment than the urban park. We hypothesise that all dependent variables (restoration, vitality, positive mood states) show stronger stress relief in green environments compared to the built-up environment (control) after the experiment. We expect a decrease in negative mood states and cortisol levels in green environments. Moreover, we expect that positive feelings decrease and cortisol level and negative feelings increase or remain unchanged in the built-up environment (city centre). Because we included several novel measures, we cannot present any hypotheses of their relative differences during the experiment or indeed differences in creativity at the end of the experiment.

## 2. Method

### 2.1. Study sites

Participants were exposed on separate days to one of the three different environments situated in Helsinki, the capital of Finland, home to approximately 600,000 people. These three study environments were: 1) Alppipuisto, representing a constructed urban park; 2) Keskuspuisto, representing a large urban woodland; and 3) the city centre, representing a built-up urban environment.

Alppipuisto is one of the oldest urban parks in Helsinki, established in the 19th century and the size of the whole park area together with a neighbourhood park is 20 ha. It is situated next to an amusement park and the railway tracks leading to Helsinki's central railway station. The park is a well-designed green area with flower beds, water element, lawns, old park trees including facilities such as benches, and a performance stage for live music events. During the experiment, the participants first viewed the park and then walked four guided rounds in the park along recreational routes in the southern areas of Alppipuisto, the size of which is about 5 ha (see Fig. 1, a recreation of the actual experimental situation in Alppipuisto).

Keskuspuisto is the largest forested area in Helsinki with a total size of 1000 ha. It is ten kilometres in length and is widely used for outdoor recreation around the year. The park mainly consists of 60 to 100-year-old mixed and conifer forests. In Keskuspuisto, the participants viewed spruce-dominated mature forest stands in the northern parts of the area and were then guided for a walk along recreational trails in a forest environment from the viewing place to a destination point and back (see Fig. 2).

The control study site in the city centre was next to the main street (Mannerheimintie) with few single urban trees. In the experiment, the participants first viewed the little square along the main street while seated. Then the guided walk went along pavements to the shopping and traffic centre and back (see Fig. 3).

### 2.2. Sample

The sample consisted of 95 participants, of whom 82 visited all three study sites (eight participants visited two, and five participants visited only one study site). The final sample of this study consists of 77 participants from whom we have all measures from all time-points. The participants were 30 to 61-year-old ($M = 47.64$, SD $= 8.68$) healthy, non-smoking adults, of whom six were men. We chose participants whose place of work was in the Helsinki Metropolitan Area. The participants worked 39.25 h per week (SD $= 12.64$), on average; 83 per cent worked during the daytime, 3.9 per cent mainly at night and 11.7 per cent of the participants were employed in shift work. Most of the participants (80.5 per cent) were civil servants, 14.3 per cent were employees, and 5.2 per cent were entrepreneurs or freelancers.

**Fig. 2.** Walking session in Keskuspuisto (urban woodland).

### 2.3. Experimental design

#### 2.3.1. Timing of the experiment

We carried out the experiment during working days at three different periods; in the autumn of 2011 and 2012 from mid-August until mid-September, and in spring 2012 from the beginning of May until mid-June. The experiment was not run during the main summer vacation season from mid-June until the beginning of August. We ran the experiment during the early and late summer season when the expected air temperature is relatively warm and the nature is green. The experimental periods were conducted over 3.5–6 weeks each, depending on the total number of experimental groups per period. All experiments started at 3 pm, i.e. after a normal working day for most of the volunteers.

**Fig. 1.** Subjects filling in the questionnaires in Alppipuisto (urban park).

**Fig. 3.** Viewing session in Helsinki city centre.

*2.3.2. Recruitment*

We used several ways to recruit volunteers to our experiment. We contacted personnel managers of different governmental or municipal organisations, who helped to invite participants (local staff) through intranet or e-mail lists. The invitation letter was also published in the monthly bulletin of the University of Helsinki. In addition, the invitation letters were delivered directly to households located nearby the experimental meeting point at the National Institute for Health and Welfare.

The invitation letter consisted of a short description about the experiment and information on how to sign up for the experiment. The volunteers got an extended information package and the first background information questionnaire by post. In the information package, we presented a background to the study, procedure and risks of the experiment, voluntariness and confidentiality, funding information and contact information of the research personnel. The guiding sheet informed participants about how to prepare for each visit (no alcohol and tobacco consumption before the experiment, avoidance of hard physical training during the day of the experiment, and some guidance for clothing), how to find the meeting point, and the exact dates and times of all three visiting times.

*2.3.3. Materials of this study*

*2.3.3.1. Psychological measures.* During the experiment, we used several psychological scales to measure the participants' self-reported restorativeness, vitality and mood. To check whether the respondents focused their attention on the environment in comparison to, for example, other people or the activity itself (walking) we used a five-item Focus of Attention Scale (TFOAS) (McIntyre & Roggenbuck, 1998).

We used two scales to measure restorative experiences (Kaplan & Kaplan, 1989). These were the Restoration Outcome Scale (ROS) (Korpela et al., 2008) and the Perceived Restorativeness Scale (PRS) (Hartig, Korpela, Evans, & Gärling, 1997). The ROS scale has six items, of which three reflect relaxation and calmness ("I feel restored and relaxed", "I feel calm", "I have enthusiasm and energy for my everyday routines"), one reflects attention restoration ("I feel focused and alert"), and two reflect clearing one's thoughts ("I can forget everyday worries", "My thoughts are clear"). The 16 items of the PRS are based on the four restorative qualities defined by the attention restoration theory (ART): being away, fascination, coherence and compatibility. We calculated two subscales from the PRS, the General Restorativeness subscale (PRS Gen), consisting of twelve items (being away (e.g. "Spending time here gave me a break from my day-to-day routine"), fascination (e.g. "This place has fascinating qualities") and compatibility (e.g. "Being here suits my personality")), and incoherence (PRS Incoh), consisting of four items (e.g. "It is a confusing place").

The self-reported mood was measured by the Positive and Negative Affect Scale (PANAS) (Watson, Clark, & Tellegen, 1988). We calculated the PANAS POS from ten items indicating positive affect, high energy level, full concentration and pleasurable engagement, and the PANAS NEG from ten items, indicating negative affect, distress, and a variety of aversive mood states (nervousness, anger, guilt).

The self-reported perceptions of having energy and feelings of being alive were measured by four items (e.g. "I feel alive and vital", "I have energy and spirit") from the Subjective Vitality Scale (Ryan & Frederick, 1997).

The Creativity Scale includes four items designed for the purposes of the present study (e.g. "I got several new ideas", I felt especially creative after being outdoors") .All psychological items were measure using Likert scales from 1 (not at all) to 7 (completely).

*2.3.3.2. Physiological measures.* The saliva samples from each subject were obtained with a Salivette device (No. 51.1534; Sarstedt, Nuembrecht, Germany). All saliva samples were immediately handled on the same evening of each experimental day. The saliva samples were centrifuged for 2 min with 1000G for saliva separation, pipetted to eppendorf tubes and frozen to −20 °C. After the experiment, the saliva samples were sent to HUSLAB (accredited laboratory of the hospital district of Helsinki and Uusimaa), where cortisol concentrations were determined with liquid chromatography and tandem mass spectrometry.

*2.3.4. Experimental procedure*

Participants were divided into groups with a maximum of four people. The order of visiting each study site was randomised in order to eliminate the order effect. Participants were guided to visit each study site (Alppipuisto, Keskuspuisto and Helsinki city centre) once. There was at least one week between each visit. The groups were often not formed by the same people during all three visits. From the participants, 40 people belonged to the "physiological group" and the rest to the "psychological group". All groups wore ambulatory blood pressure monitors. The participants from the physiological groups additionally carried Holter monitors for ECG analyses. The physiological group also took one extra cortisol sample (after viewing). The researchers carried air temperature and humidity monitors during the experiment. In this paper we report the results of psychological measures as well as results concerning changes in cortisol levels.

The participants got an SMS reminder in the morning of each experimental day. After arrival, the participants were given an introduction to the experiment. On the first visit, participants also signed a written consent of their voluntary participation and returned questionnaires sent to them prior to the experiment. On each of the three visits, participants completed a short questionnaire concerning possible recent acute illnesses, medication use, and other factors possibly affecting cortisol concentrations. Then the participants themselves took the first set of blood pressure measurements (control measure). The ECG equipment was set for participants in physiological group and they also had 2 dl of juice and a cheese sandwich to guarantee the same basic energy level. Before leaving for the site, all participants rinsed their mouths with water for cortisol measures.

The trip to the experimental site took 20–30 min. After arrival, in order to diminish possible socialisation effects, the participants were asked not to talk to each other during the experiment. The first blood pressure measures were taken in the van (after sitting quietly for 3 min). Next, the participants completed the first questionnaire (the SVS, ROS and PANAS) and took cortisol samples. The first phase of the experiment was the viewing session for 15 min on-site. After this, the participants took a second set of blood pressure measurements, filled in a second questionnaire (the SVS and ROS), and took the second cortisol measure (phys. group only). The viewing session was followed by a 30-min walk led by a researcher to make sure that all groups took the same route and slow walking speed (no more than 4 km per hour). The order of activities (sitting and walking) was chosen in order to guarantee reliable physiological measures (ECG and blood pressure). The routes were predefined and were all approximately 2 km long. Another researcher walked behind the group, carrying equipment for the measurement of temperature and relative humidity (phys. group only). After walking, the participants went back to the van, sat quietly for 3 min and took the third set of blood pressure measurements, answered the third set of psychological questionnaires (the ROS, SVS, PANAS, PRS, and Creativity) and took the third cortisol measure. When the experiment was over, participants were given some iced coffee or juice and a snack. The whole experiment took approximately 3 h (see experimental plan in Fig. 4).

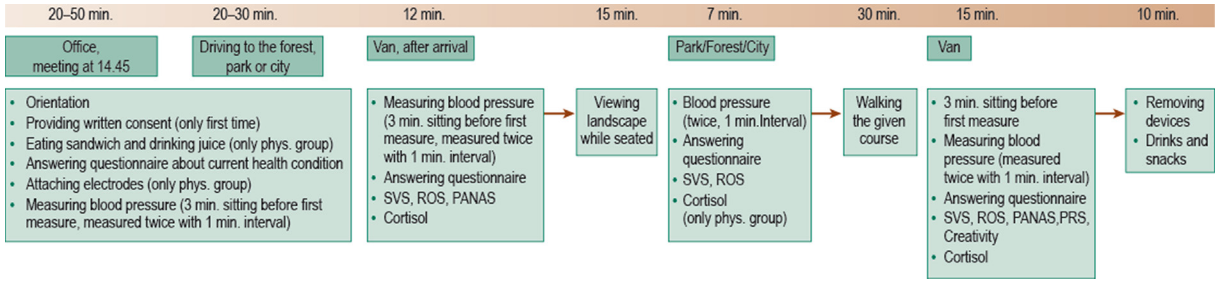


**Fig. 4.** Experimental plan.

During the whole experiment, only one visit was transferred to another day because of rain. However, we had a little rain on eight days of the experiment. The weather varied mostly from sunny to cloudy. Average temperatures varied between 23.1, 22.1, and 22.0 °C during the 2011 autumn, 2012 spring, and 2012 autumn experimental periods, respectively.

## 3. Results

### 3.1. Scale statistics

The scale statistic is presented in Table 1. All scales of psychological measures had good Cronbach's $\alpha$, ranging from .82 to .96, and only the PRS Incoh had a lower but acceptable reliability score in the forest after walking (Cron. $\alpha = .69$). For all psychological measures, the mean sum scores were calculated, taking into account some reverse items of the scales. The mean scores and standard deviations are presented in the table as well as the correlations in between all measures at all three time-points. The ROS, SVS and PANAS POS were significantly positively correlated in all places at all time-points. There was a non-significant correlation between PANAS POS and PANAS NEG. As expected, the PANAS POS was significantly positively correlated to the ROS, SVS, PRS Gen and Creativity and significantly negatively correlated to the PRS Incoh. The PANAS NEG was significantly negatively correlated to the ROS, SVS, PRS Gen and significantly positively correlated to the PRS Incoh, accordingly. There was a non-significant correlation between PANAS NEG and Creativity at all time-points. The Creativity measure was significantly positively correlated to all other measures, except one non-significant correlation between the PRS Incoh after the experiment in the forest setting (see Appendix A).

**Table 1**
Scale statistics of all psychological measures in three places during the experiment.

| Place | City | | | Park | | | Forest | | |
|---|---|---|---|---|---|---|---|---|---|
| Measures | Mean | SD | Cron $\alpha$ | Mean | SD | Cron $\alpha$ | Mean | SD | Cron $\alpha$ |
| *At the beginning* | | | | | | | | | |
| ROS | 4.56 | .89 | .89 | 4.68 | .80 | .88 | 4.60 | .84 | .89 |
| SVS | 4.57 | 1.02 | .86 | 4.68 | .88 | .85 | 4.65 | .99 | .86 |
| PANAS POS | 4.14 | .85 | .90 | 4.27 | .81 | .88 | 4.15 | .95 | .92 |
| PANAS NEG | 1.81 | .68 | .88 | 1.77 | .74 | .89 | 1.64 | .68 | .89 |
| After viewing | | | | | | | | | |
| ROS | 4.37 | .96 | .87 | 5.08 | .85 | .88 | 5.00 | .85 | .87 |
| SVS | 4.60 | .92 | .85 | 4.88 | .87 | .81 | 4.81 | .96 | .88 |
| *After walking* | | | | | | | | | |
| ROS | 4.20 | .97 | .88 | 5.04 | .95 | .91 | 5.16 | .82 | .88 |
| SVS | 4.41 | .95 | .82 | 5.00 | .88 | .85 | 5.05 | .88 | .88 |
| PANAS POS | 3.81 | .97 | .92 | 4.44 | .90 | .89 | 4.49 | .92 | .92 |
| PANAS NEG | 1.69 | .72 | .90 | 1.56 | .70 | .90 | 1.39 | .50 | .88 |
| PRS Gen | 3.81 | 1.19 | .96 | 4.63 | 1.00 | .94 | 5.25 | .82 | .93 |
| PRS Incoh | 3.74 | 1.35 | .88 | 2.94 | 1.21 | .85 | 2.07 | .83 | .69 |
| Creativity | 2.81 | 1.21 | .84 | 3.67 | 1.29 | .87 | 3.79 | 1.37 | .91 |

### 3.2. Results from the repeated-measures ANOVA

We conducted repeated-measures analyses of variance (ANOVA) to calculate the effects of intervention in three different environments in Helsinki. In the analysis we used three within-subjects factors (Helsinki city centre (City), Alppipuisto (Park) and Keskuspuisto (Forest)) and three testing time-points of intervention (at the start (T1), in the middle (T2) and at the end of the experiment (T3)) for the Restoration Outcome Scale (ROS) and the Subjective Vitality Scale (SVS). The testing time-points for the Positive and Negative Affect Scale (PANAS) and salivary cortisol were pre- post-test conditions (T1 and T3), and testing time-point for the Perceived Restorativeness Scale (PRS) and the Creativity measures were only at the end of the experiment (T3).

To get all possible contrasts and their combinations for the ROS and SVS, we ran four models with the following reference categories: City and T1; City and T2; Park and T1; and Park and T2.

For the ROS, there was a significant main effect of Place on ratings of the restorative outcome, $F(2, 152) = 21.77$, $p < .01$. Contrasts revealed that the Park and Forest were equally restorative and more restorative than the City, with a large effect size. There was also a significant main effect of Time on the restorative outcome $F(1.55, 117.63) = .8.54$, $p < .01$. Contrasts revealed that there was a significant, medium-sized effect between T2 and T1, and T3 and T1, but there was no significant effect between T3 and T2, indicating that the feelings of restoration change after sitting in the environment. The significant interaction effect between the Place and Time of the measures during the experiment ($F(3.04, 230,91) = .23.47$, $p < .01$) showed that the participants felt restoration in different ways depending on the place and time of the experiment. The interaction effect showed a significant difference between Park vs. City and Forest vs. City on T2 (after sitting) vs. T1 (in the beginning); and T3 (after walking) vs. T1; as well as Forest vs. City and Forest vs. Park on T3 vs. T2. This means that the participants already felt higher levels of restoration after 15 min of sitting in green areas, and the longer stay in the Forest and Park raised the restorative effect even more. There was significant interaction with medium-sized interaction effect between Park and Forest on T3 vs. T2, but there was no mean difference between the green places at the end of the experiment. (See Table 2 and Fig. 5).

For the SVS, there was a significant main effect of the Place on ratings on subjective vitality, $F(1.70,129.30) = 8.14$, $p < .01$. Contrasts revealed that ratings of Park and Forest were significantly higher compared to the City with medium effect sizes, whereas there was no significant differences of the subjective vitality effect between Park and Forest (see Table 2). There was also a significant main effect of Time on the subjective vitality measure during the experiment $F(1.59, 121.03) = 6.82$, $p < .01$. Contrasts revealed that there was a significant, medium-sized effect between T2 and T1 and T3 and T1, but there was a non-significant, small effect between T3 and T2. There was also a significant interaction effect between Place

**Table 2**
Results of simple contrasts in repeated-measures ANOVA, the *F* statistics (with degrees of freedom 1.76) and the effect size.

| Place | Time | Measure | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ROS | | SVS | | PANAS POS | | PANAS NEG | | PRS Gen | | PRS Incoh | | Creativity | | Cortisol | |
| | | *F* | *r*[1] | *F* | *r* | *F* | *r* | *F* | *r* | *F* | *r* | *F* | *r* | *F* | *r* | *F* | *r* |
| Park vs. City | | 29.76** | .53 | 11.73** | .37 | 17.30** | .43 | 1.85 | .15 | 29.85** | .53 | 19.31** | .45 | 24.32** | .49 | .12 | .04 |
| Forest vs. City | | 28.14** | .52 | 8.78** | .32 | 12.78** | .38 | 17.69** | .43 | 74.64** | .70 | 97.34** | .75 | 31.05** | .54 | 3.34 | .21 |
| Forest vs. Park | | .03 | .02 | .09 | .03 | .14 | .04 | 7.94** | .31 | 23.77** | .49 | 35.16** | .56 | .53 | .08 | 4.60* | .24 |
| | T2 vs. T1 | 15.82** | .42 | 7.60** | .30 | 1.42 | .14 | 23.02** | .48 | | | | | | | 133.55** | .80 |
| | T3 vs. T1 | 7.60** | .30 | 8.64** | .32 | | | | | | | | | | | | |
| | T3 vs. T2 | .20 | .05 | 1.71 | .15 | | | | | | | | | | | | |
| *Interaction* | | | | | | | | | | | | | | | | | |
| Park vs. City | T2 vs. T1 | 26.56** | .51 | 2.99 | .19 | 17.04** | .43 | 1.28 | .13 | | | | | | | 3.25 | .20 |
| | T3 vs. T1 | 29.82** | .53 | 10.71** | .35 | | | | | | | | | | | | |
| | T3 vs. T2 | 1.77 | .15 | 9.04** | .33 | | | | | | | | | | | | |
| Forest vs. City | T2 vs. T1 | 29.16** | .53 | 1.59 | .14 | 23.92** | .49 | 4.26* | .23 | | | | | | | .02 | .02 |
| | T3 vs. T1 | 51.01** | .63 | 20.69** | .46 | | | | | | | | | | | | |
| | T3 vs. T2 | 17.24** | .43 | 22.17** | .48 | | | | | | | | | | | | |
| Forest vs. Park | T2 vs. T1 | .02 | .02 | .23 | .05 | 2.83 | .19 | .40 | .07 | | | | | | | 3.61 | .21 |
| | T3 vs. T1 | 3.96 | .22 | .73 | .10 | | | | | | | | | | | | |
| | T3 vs. T2 | 7.63** | .30 | 2.02 | .16 | | | | | | | | | | | | |

Note. ***F* is significant at the .01 level. **F* is significant at the .05 level.
[1] – *r* is the effect size, the relationship between the independent and dependent variable, ranging from .00 to 1.00.

and Time on the measure during the experiment ($F(2.98, 226.64) = 8.83$, $p < .01$). The interaction effect showed a significant difference between Park and Forest vs. City on T3 (in the end) vs. T2 (after sitting); and T3 (after walking) vs. T1. The results show that the subjective vitality scores raise in the Park and Forest environments after spending a longer time in them compared to the City, where the vitality scores decrease (see interaction in Fig. 6).

The positive and negative emotions felt in all three study places were measured at the start and the end of the experiment using the PANAS scale. To get all possible combinations for the PANAS, we ran two models with the following reference categories: City and T1; and Park and T1.

There was a significant main effect of the Place on ratings on positive emotions, $F(2,152) = 10.30$, $p < .01$. Contrast revealed that there was a moderate effect on differences between Park and Forest compared to the City; but again, no significant difference between Forest and Park (see Table 2). There was no significant main effect of Time on positive emotions during the experiment $F(1, 76) = 1.42$, ns. The significant interaction effect between Place and Time on the measure of positive emotions during the experiment ($F(1.81, 137,70) = 16.54$, $p < .01$) showed a moderate effect between T3 vs. T1 in the Park and Forest compared to the City, showing that people had more positive emotions after the experiment in the green environments (see Fig. 7). For the negative emotions, there was a

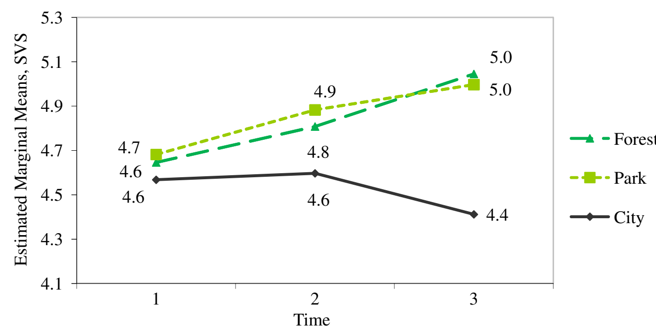


**Fig. 6.** Interaction graph for the Subjective Vitality Scale. The type of place is represented by the three lines on three time-points. *Note.* T1 = at the start, T2 = in the middle, and T3 = at the end of the experiment.

significant main effect of Place ($F(2,152) = 8.74$, $p < .01$). The medium effect size showed that people had fewer negative emotions in the Forest compared to the Park and the City. The small effect size indicated that there was no difference in the ratings on negative emotions in the Park compared to the City. Taking into account the moderate effect size of Time ($F(1,76) = 23.02$, $p < .01$), people felt fewer negative emotions at the end of the experiment compared to

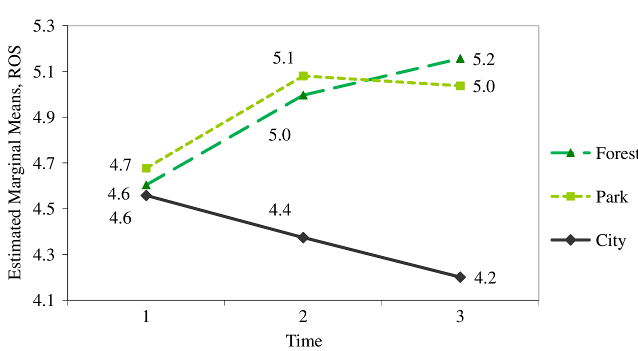


**Fig. 5.** Interaction graph for the Restoration Outcome Scale. The type of place is represented by the three lines on three time-points. *Note.* T1 = at the start, T2 = in the middle, and T3 = at the end of the experiment.

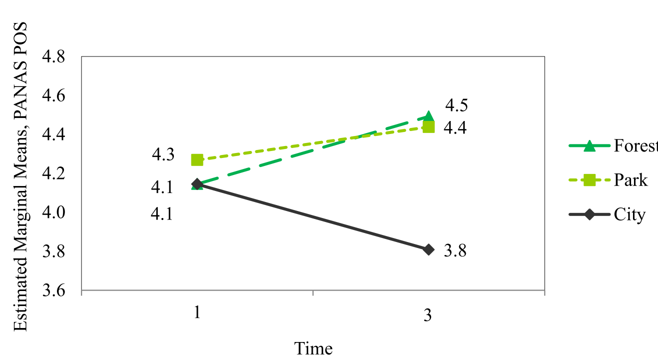


**Fig. 7.** Interaction graph for the PANAS POS. The type of place is represented by the three lines on two time-points. *Note.* T1 = at the start, and T3 = at the end of the experiment.

the start of the experiment. The interaction effect between Place and Time was non-significant ($F$(1,152) = 1.77, ns), (see Fig. 8).

The restorative effect of all three places was measured by the PRS scale divided into two subscales: the PRS Gen ("This place has fascinating qualities") and the PRS Incoh ("It is a confusing place"). We were also interested in the intervention effect of creativity measured by the Creativity scale.

There was a significant main effect of Place on ratings of the PRS Gen ($F$(1.82, 138.94) = 47.10, $p < .01$), PRS Incoh ($F$(2, 152) = 50.18, $p < .01$), and Creativity ($F$(2, 152) = 19.56, $p < .01$) (see Fig. 9 for the estimated mean scores of Place). There was a large effect size of Forest and Park compared to the City, and also a medium effect size of Forest compared to the Park on the ratings of the PRS (Gen and Incoh) scores (see Table 2). This means that people evaluated the Forest and the Park as more compatible to their needs compared to the City, and the Forest was evaluated as the most fascinating and compatible place at the end of the experiment. Feelings of incoherence were strongest in the City and at the lowest level in the Forest. The ratings on Creativity were higher in the Forest and the Park compared to the City, but there was no difference between the Park and the Forest at the end of the experiment.

There was a non-significant main effect of Place on ratings of the salivary cortisol, $F$(2,152) = 2.63, ns. There was a significant main effect of Time on the salivary cortisol $F$(1,76) = 133.55, $p < .01$. Contrasts revealed that there was a significant large effect between T3 (at the end of the experiment) and T1 (at the beginning of the experiment). There was a non-significant interaction effect between the Place and Time of the measures of salivary cortisol during the experiment ($F$(2, 152) = 2.23, ns.) (see Fig. 10). The results showed that the cortisol level decreased over time, independent of the place of the experiment.

## 4. Discussion and conclusions

In this study we investigated the restorative effects of short-term visits in different types of urban environments. We compared a built-up area and two different types of green environment, a constructed urban park and an extensively managed woodland, as opposed to most previous studies that compare a built-up environment to just one natural environment. In our experiment we combined psychological measures with the physiological one (salivary cortisol levels). Moreover, we had a large sample size of the adult (mainly female) working people as participants who arrived for the experiment after their working day. Previous experimental studies have had smaller sample sizes and students (often males) as participants (e.g. Park et al., 2008; Tsunetsugu et al., 2013). This allowed us to look at the effects of exposure to nature close to the environment the participants would have access to, and also close to their real-life situations, giving them opportunities for stress relief. However, recruiting healthy, middle-aged adults had some limitations. We contacted the chief personnel managers of various working places, but we had no control over who received the invitation letter. In the end our sample consisted of mainly female participants. We do not know if the invitation letters were sent to the working places with female domination in work force, or the women were more active to participate in this study. The literature suggests that women and men differ in their perceptions and usage of urban green space (e.g. Beil & Hanes, 2013; Richardson & Mitchell, 2010). However, we kept the few male participants in our study for two reasons: First, our males voluntarily participated in all three sessions and it would have been unethical to leave them out. Second, we calculated all the analyses with females only and we found two changes in psychological (not physiological) results. These differences were the changes of a significance level in two cases. The significance levels of the interaction effects between three environmental settings and three time-points during the experiment of subjective vitality scale increased from .01 to .05 with females only (the significant difference between urban park and urban woodland vs. city centre in the end of the experiment (after walking) vs. after sitting, and after walking vs. at the beginning of the experiment). The second case concerns the negative affect scale, where the interaction effect between the three urban environmental settings and the negative mood measure at two time-points during the experiment was non-significant (as mentioned in the results section), but there was a significant difference between urban woodland vs. city centre on time two (at the end of the experiment) vs. time one (at the start of

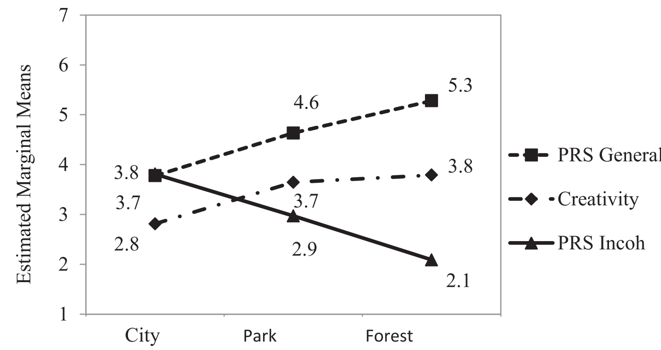


**Fig. 9.** Interaction graph for the PRS General, PRS Incoherence, and Creativity at the end of the experiment. The type of place is represented by the three lines.

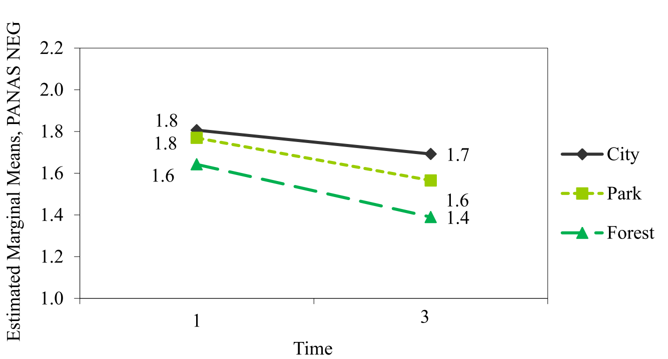


**Fig. 8.** Interaction graph for the PANAS NEG. The type of place is represented by the three lines on two time-points. *Note.* T1 = at the start, and T3 = at the end of the experiment.

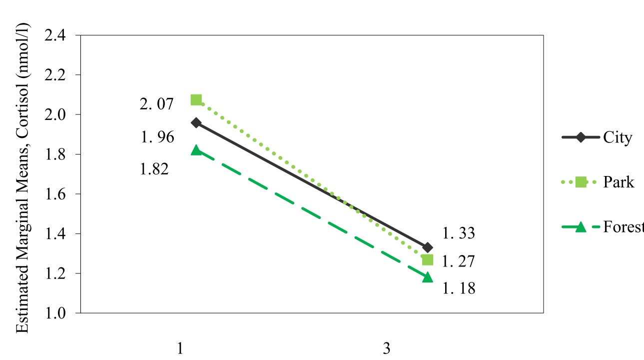


**Fig. 10.** Interaction graph for the salivary cortisol. The type of place is represented by the three lines on two time-points. *Note.* T1 = at the start, and T3 = at the end of the experiment.

the experiment), that disappeared when the sample consisted only females ($p < .04$ and $p = .10$, respectively). These differences of significance levels did not change the main results or the conclusions, and this is why we decided to keep our male participants in the analysis. We still think that the gender difference in nature perception is an important question that is worth more research and this is why it would be important to avoid gender imbalance in recruiting process if possible.

We studied the influence of three environmental settings on participants' feelings of restoration, vitality, mood, creativity and cortisol concentration by using several psychological measures (the Restoration Outcome Scale, Subjective Vitality Scale, Positive and Negative Affect Scale, Perceived Restorativeness Scale, feelings of creativity) and physiological salivary cortisol samples. The results of our field experiment are much in line with the findings from the previous correlational and experimental studies (e.g. Hartig et al., 1991; Hartig et al., 2003; Morita et al., 2007). The study confirmed the hypothesised increase of feelings of restoration, vitality, and positive mood in green environments and their decrease in a built urban setting. In addition, feelings of creativity were higher in green environments. The findings of the study also confirmed that experiential restoration can take place after a short period of nature exposure (e.g. Hartig et al., 2003; Tsunetsugu et al., 2013). However, an increase in the level of vitality in the green areas compared to the city shown by the interaction effect between places and time was evident only after walking. This is a novel finding, suggesting that a stay of longer than 15 min in the nature environment is needed to enhance feelings of vitality.

There is evidence that the natural settings may differ in terms of their restorative quality (Herzog et al., 2003; Korpela et al., 2010; Tyrväinen, Silvennoinen, et al., 2007; Tyrväinen, Mäkinen, & Schipperijn, 2007) and favourite woodlands have proved to be more restorative than favourite urban parks (Korpela et al., 2010). Our results show that the large urban woodland and extensively managed urban park both had positive influences on stress relief, but the differences between green areas were smaller than we hypothesised. There were only a few differences between these two urban green area types. The amount of negative feelings was smaller in the urban woodland compared to the two other places, and the overall perceived restorativeness was higher in the woodland after the experiment compared to urban park and urban woodland. The significant interaction effect with the moderate effect size between the urban park and the urban woodland at the end of the experiment compared to the middle of the experiment (after sitting) suggests that even though there was no mean difference between the green places at the end of the experiment, the longer stay in the urban woodland could have resulted in a higher restorative effect compared to the urban park. Thus, such urban woodland that was used in the present experiment might have more potential for stress release than the urban park we used.

The field experiment was conducted in built-up and green urban environments where disturbing noise and air pollution is present to some extent, even in woodlands. This may partially explain the findings that the two different types of urban green areas, the large urban park and the urban woodland, had relatively little differences in effects measured in the experiment. However, these suggestions need further analysis using the collected air quality and noise data during the experiment.

In this study we observed no consistent differences in salivary cortisol levels between visits to different types of environments. All of our experiments were conducted at the same time of day, and therefore in principle diurnal variability should not have masked the hypothesised effect of green space. The previous studies conducted in Japan report that the visits to green areas outside the city significantly reduce salivary cortisol concentration compared to city visits (Park et al., 2007; Tsunetsugu et al., 2007). In a study conducted in the United States in an urban setting, the salivary cortisol level, when viewing four different urban settings, revealed no differences between the sites (Beil & Hanes, 2013). In this study the visit to each site was only 20 min, which may be too short a time for physiological responses and measurable changes in salivary cortisol.

The results of our study showed that there were no differences in cortisol levels, even after spending somewhat longer periods of time – more than 45 min – in different urban environments. This finding suggests that the decrease in cortisol level might not appear if the differences between visiting areas are not sufficiently large (e.g. a very busy urban centre vs. a natural forest outside the city). Moreover, it is suggested that perceived stress is only moderately associated with salivary cortisol because of the complexity of pathways leading from the perception of stress to the activation of the hypothalamus—pituitary—adrenal axis, and in addition, factors such as oestrogen levels (gender, menstrual cycle, oral contraceptives) or medical conditions could affect cortisol binding (Hellhammer, Würst, & Kudielka, 2009). Therefore, it is possible that we did not observe any significant differences in salivary cortisol in our study because our participants consisted mainly of middle-aged females, which might be the least responsive group (Kudielka et al., 2004). Previous studies with a similar study design involved only young male participants and are therefore not directly comparable with the present study (e.g. Park et al., 2007; Tsunetsugu et al., 2007). We observed a time-course significant decrease in cortisol in all three environments. Thus it is likely that we reliably observed the normal diurnal variability of decreasing levels of cortisol towards the end of the afternoon. It is possible, however, that the salivary cortisol concentration is not a very good measure for capturing stress reduction in *short-time* nature exposure experiments for all types of participants.

The overall conclusion of our field experiment is that being in a built-up urban environment brings about perceptions of an incoherent environment and decreases feelings of restorativeness, feelings of vitality and positive mood, even if the activities themselves in this environment were rather relaxing (viewing and low-speed walking). On the contrary, the managed urban parks with old trees and natural views and the urban woodland were perceived as more coherent and were better environments for restoration and for having feelings of vitality and creativity. The results of our experiment suggest that the large urban parks (more than 5 ha) and large urban woodlands have positive well-being effects on urban inhabitants, and in particular for healthy middle-aged women. The results suggest that spending time in urban green areas after work has stress-reducing effects. This means that urban parks and woodlands should be easily accessible for residents. In the future, the relations between psychological measures and physiological measures, their link to other environmental qualities of green areas, such noise and air quality as well as the influence of nature exposure on different groups of people (e.g. young, elderly, those suffering from burnout), and the long-term effects of nature, need to be studied further.

## Acknowledgements

The authors wish to thank all the researchers and research assistants who helped to run the field experiment. We thank the City of Helsinki and Metsähallitus for their cooperation in the recruitment process. We are grateful for all the participants who took part in our experiment. This research was conducted as part of projects "Stress-reducing qualities of urban green areas" (Grant No. 139699) and "Green infrastructures for health in the future living environments (GreenHealth)" (Grant No. 255423), funded by the Academy of Finland.

## Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jenvp.2013.12.005

## References


Beil, K., & Hanes, D. (2013). The influence of urban natural and built environments on physiological and psychological measures of stress – a pilot study. *International Journal of Environmental Research and Public Health, 10*, 1250–1267. http://dx.doi.org/10.3390/ijerph1004125.

van den Berg, A. E., Koole, S. L., & van der Wulp, N. Y. (2003). Environmental preference and restoration: (How) are they related? *Journal of Environmental Psychology, 23*, 135–146.

Björk, J., Albin, M., Grahn, P., Jacobsson, H., Ardö, J., Wadbro, J., et al. (2008). Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. *Journal of Epidemiology & Community Health, 62*(4), e2.

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systemic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health, 10*, 456–465. http://dx.doi.org/10.1186/1471-2458-10-456.

Europe in figures–Eurostat yearbook. (2011). *Living conditions and social protection*. Eurostat, European Commission.

Frumkin, H. (2001). Beyond toxicity human: Health and the natural environment. *American Journal of Preventive Medicine, 20*, 234–240.

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology, 23*, 109–123.

Hartig, T., Korpela, K., Evans, G. W., & Gärling, T. (1997). A measure of restorative quality in environments. *Scandinavian Housing and Planning Research, 14*, 175–194.

Hartig, T., Mang, M., & Evans, G. W. (1991). Restorative effects of natural environment experiences. *Environment & Behavior, 23*(1), 3–26.

Hartmann, P., & Apaolaza-Ibáñez, V. (2010). Beyond savanna: An evolutionary and environmental psychology approach to behavioral effects of nature scenery in green advertising. *Journal of Environmental Psychology, 30*(1), 119–128.

Hellhammer, D. H., Würst, S., & Kudielka, B. M. (2009). Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology, 34*, 163–171.

Herzog, T. R., Maguire, C. P., & Nebel, M. B. (2003). Assessing the restorative components of environments. *Journal of Environmental Psychology, 23*, 159–170.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge: Cambridge University Press.

Kirschbaum, C., & Hellhammer, D. H. (1989). Salivary cortisol in psychobiological research: An overview. *Neuropsychobiology, 22*(3), 150–169.

Kirschbaum, C., & Hellhammer, D. H. (1994). Salivary cortisol in psychoneuroendocrine research: Recent developments and applications. *Psychoneuroendocrinology, 19*, 313–333.

Korpela, K., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2008). Determinants of restorative experiences in everyday favourite places. *Health & Place, 14*, 636–652.

Korpela, K., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2010). Favorite green, waterside and urban environments, restorative experiences and perceived health in Finland. *Health Promotion International, 25*(2), 200–209.

Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). HPA axis responses to laboratory psychosocial stress in healthy elderly adults, younger adults, and children: Impact of age and gender. *Psychoneuroendocrinology, 29*(1), 83–98.

Laumann, K., Gärling, T., & Stormark, K. M. (2003). Selective attention and heart rate responses to natural and urban environments. *Journal of Environmental Psychology, 23*, 125–134.

Lee, J., Li, Q., Tyrväinen, L., Tsunetsugu, Y., Park, B.-J., Kagawa, T., et al. (2012). Nature therapy and preventive medicine. In J. Maddock (Ed.), *Public health – Social and behavioral health* (pp. 325–350). InTechOpen. http://dx.doi.org/10.5772/37701.

Lee, J., Park, B. J., Tsunetsugu, Y., Ohira, T., Kagawa, T., & Miyazaki, Y. (2011). Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. *Public Health., 125*(2), 93–100.

Levine, A., Zagoory-Sharon, O., Feldman, R., Lewis, J. G., & Weller, A. (2007). Measuring cortisol in human psychobiological studies. *Physiology & Behavior, 90*, 43–53.

Li, Q., Morimoto, K., Kobayashi, M., Inagaki, H., Katsumata, M., Hirata, Y., et al. (2008). Visiting a forest, but not a city, increases human natural killer activity and expression of anticancer proteins. *International Journal of Immunopathology and Pharmacology, 21*, 117–128.

Lovallo, W. R., Dickensheets, S. L., Myers, D. A., Thomas, T. L., & Nixon, S. J. (2000). Blunted stress cortisol response in abstinent alcoholic and polysubstance-abusing men. *Alcoholism Clinical and Experimental Research, 24*(5), 651–658.

Lovallo, W. R., Farag, N. H., Vincent, A. S., Thomas, T. L., & Wilson, M. F. (2006). Cortisol responses to mental stress, exercise, and meals following caffeine intake in men and women. *Pharmacology Biochemistry and Behavior, 83*(3), 441–447.

Maas, J., Verheij, R. A., Groenewegen, P. P., de Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: How strong is the relation? *Journal of Epidemiology & Community Health, 60*, 587–592.

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine, 338*, 171–179.

McIntyre, N., & Roggenbuck, J. W. (1998). Nature/person transactions during an outdoor adventure experience: A multi-phasic analysis. *Journal of Leisure Research, 30*, 401–422.

Maller, C., Townsend, M., Pryor, A., Brown, P., & St Leger, L. (2005). Healthy nature healthy people: 'Contact with nature' as an upstream health promotion intervention for populations. *Health Promotion International, 21*(1), 45–54. http://dx.doi.org/10.1093/heapro/dai032.

Morita, E., Fukuda, S., Nagano, J., Hamajima, N., Yamamoto, H., Iwai, Y., et al. (2007). Psychological effects of forest environments on healthy adults: Shinrinyoku (forestair bathing, walking) as a possible method of stress reduction. *Public Health, 121*(1), 54–63.

Newell, P. B. (1997). A cross-cultural examination of favourite places. *Environment & Behavior, 29*, 495–514.

Nilsson, K., Baines, C., & Konijnendijk, C. C. (Eds.). (2007), *COST Strategic WorkshopHealth and the natural outdoors*. Final report http://www.umb.no/statisk/greencare/general/strategic_workshop_final_report.pdf.

Nilsson, K., Sangster, M., & Konijnendijk, C. C. (2011). Forest, tress and human health and well-being: Introduction. In K. Nilsson, M. Sangster, C. Gallis, T. Hartig, S. de Vries, K. Seeland, et al. (Eds.), *Forest, trees and human health* (pp. 1–19). Springer Science +Business Media.

Ockenfels, M. G., Porter, L., Smyth, J., Kirschbaum, C., Hellhammer, D. H., & Stone, A. A. (1995). Effect of chronic stress associated with unemployment on salivary cortisol: Overall cortisol levels, diurnal rhythm, and acute stress reactivity. *Psychosomatic Medicine, 57*, 460–467.

Park, B. J., Tsunetsugu, Y., Ishii, H., Furuhashi, S., Hirano, H., Kagawa, T., et al. (2008). Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in a mixed forest in Shinano Town, Japan. *Scandinavian Journal of Forest Research, 23*(3), 278–283.

Park, B. J., Tsunetsugu, Y., Kasetani, T., Hirano, H., Kagawa, T., Masahiko, S., et al. (2007). Physiological effects of shinrinyoku (taking in the atmosphere of the forest) using salivary cortisol and cerebral activity as indicators. *Journal of Physiological Anthropology, 26*, 12–38.

Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., & Miyazaki, Y. (2010). The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): Evidence from field experiments in 24 forests across Japan. *Environmental Health and Preventive Medicine, 15*(1), 18–26.

Park, B. J., Tsunetsugu, Y., Kasetani, T., Morikawa, T., Kagawa, T., & Miyazaki, Y. (2009). Physiological effects of forest recreation in a young conifer forest in Hinokage town, Japan. *Silva Fennica, 43*(2), 291–301.

Richardson, A. E., & Mitchell, R. (2010). Gender differences in relationships between urban green space and health in the United Kingdom. *Social Science & Medicine, 71*(3), 568–575.

Rohleder, N., & Kirschbaum, C. (2005). The hypothalamic-pituitary-adrenal (HPA) axis in habitual smokers. *International Journal of Psychophysiology, 59*(3), 236–243.

Ryan, R. M., & Frederick, C. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality, 65*(3), 529–565.

Ryan, R. M., Weinstein, N., Bernstein, J., Brown, K. W., Mistretta, L., & Gagné, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology, 30*, 159–168.

Seplaki, C. L., Goldman, N., Weinstein, M., & Lin, Y. H. (2004). How are biomarkers related to physical and mental wellbeing? *Journal of Gerontology: Biological Sciences, 59A*(3), 201–221.

Sluiter, J. K., Frings-Dresen, M. H. W., Meijman, T. F., & van der Beek, A. J. (2000). Reactivity and recovery from different types of work measured by catecholamines and cortisol: A systematic literature overview. *Occupational and Environmental Medicine, 57*, 298–315.

Tsunetsugu, Y., Park, B. J., & Miyazaki, Y. (2010). Trends in research related to "Shinrinyoku" (taking in the forest atmosphere or forest bathing) in Japan. *Environmental Health and Preventive Medicine, 15*(1), 27–37.

Tsunetsugu, Y., Lee, Y., Park, B. J., Tyrväinen, L., Kagawa, T., & Miyazaki, J. (2013). Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. *Landscape and Urban Planning, 113*, 90–93.

Tsunetsugu, Y., Park, B. J., Ishii, H., Hirano, H., Kagawa, T., & Miyazaki, Y. (2007). Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata prefecture, Japan. *Journal of Physiological Anthropology, 26*(2), 135–142.

Tyrväinen, L., Mäkinen, K., & Schipperijn, J. (2007). Tools for mapping social values of urban woodlands and other green areas. *Landscape and Urban Planning, 79*(1), 5–19.

Tyrväinen, L., Pauleit, S., Seeland, K., & de Vries, S. (2005). Benefits and uses of urban forests and trees. In K. Nilsson, T. B. Randrup, & C. C. Konijnendijk (Eds.), *Urban forests and trees in Europe: A reference book* (pp. 81–114). Springer Verlag.

Tyrväinen, L., Silvennoinen, H., Korpela, K., & Ylen, M. (2007). *Luonnon merkitys kaupunkilaisille ja vaikutus psyykkiseen hyvinvointiin* [*The importance of nature environment on urban inhabitants and their psychological well-being*]. In *Metlan työraportteja (FFRI Working papers), 52*; (pp. 57–77).

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*, 201–230.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS Scales. *Journal of Personality and Social Psychology, 54*, 1063–1070.