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Restoration and stress relief through physical activities in forests and parks

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Abstract

A field survey assessed the restorative effects of visiting an urban forest and a city park in Zurich, Switzerland. Respondents rated their headaches, level of stress, and how balanced they felt both prior to visiting the outdoor location and at the time of being interviewed. Suffering from headaches and stress decreased significantly, and feeling well-balanced increased significantly. The recovery ratio for stress was 87%, and the reduction in headaches was 52%, in terms of the possible improvements on five-point rating scales. With respect to feeling well-balanced, the observed changes amounted to 40% of the possible enhancement. Positive effects increased with length of visit, and individuals practising sports (e.g., jogging, biking, playing ball) showed significantly higher improvements than those engaged in less strenuous activities (e.g., taking a walk or relaxing). These findings support previous research on how exercise in green spaces promotes well-being and recovery from stress.

Keywords: Exercise; Headaches; Leisure activities; Sports; Urban green space; Well-being

Introduction

In contemporary western societies, many physical illnesses, including coronary disease and cancer, are strongly related to sedentary, physically inactive lifestyles, and chronic stress (Krantz and McCeney, 2002; Breckenkamp et al., 2004; Kopp and Réthelyi, 2004). Urban planners are thus challenged to improve the health and well-being of citizens by creating public spaces that facilitate recovery from stress and motivate people to become physically active. People tend to favour green spaces like nature reserves, woodlands, and urban parks for recovering from stress (Bell et al., 2005). This preference appears reasonable against the background of Ulrich's stress reduction theory (SRT; Ulrich, 1981, 1983; Ulrich et al., 1991) and Kaplan and Kaplan's attention restoration theory (ART; Kaplan and Kaplan, 1989; Kaplan, 1995), both of which hold that green spaces are especially conducive to restoration. ART is mainly concerned with cognitive processes and proposes that natural spaces facilitate the restoration of attention capacities that can be depleted by activities demanding prolonged, effortful attention (Kaplan, 1995). SRT is concerned with the emotional and physiological benefits of exposure to natural spaces and emphasizes the stress reduction associated with them (Ulrich et al., 1991). Referring to Baum et al.'s (1985) definition, Ulrich et al. (1991, p. 202) regard stress as the "process by which an individual responds

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psychologically, physiologically, and often with behaviours, to a situation that challenges or threatens well-being''. SRT proposes that being exposed to an unthreatening natural environment or even viewing natural elements like vegetation or water (e.g., on colour slides or on videotape; cf. Ulrich, 1979, 1981; Ulrich et al., 1991) activates a positive affective response, a behavioural approach orientation, and sustained, wakefully relaxed attention. As a consequence, stressed individuals can experience a decrease in stress, which involves reduced levels of negatively toned feelings, and reductions in physiological arousal from high to moderate levels (Ulrich, 1981, 1983). Biological preparedness for such a response pattern is said to be evolutionarily adaptive because natural elements like vegetation and water were critical for early humans' survival and well-being (Ulrich et al., 1991). To customarily display a stress response involving high levels of physical activation in face of an unthreatening natural setting would be maladaptive, since such ''physiological mobilization would have been fatiguing, and over a prolonged period would be linked with chronic cardiovascular and endocrine responses that adversely affected health'' (Ulrich et al., 1991, p. 226). On the contrary, an approach orientation and continuous attention towards rich and unthreatening environments seem biologically adaptive (e.g., by encouraging exploration for food or water resources). Since in phylogeny, human beings developed in natural environments and not in urban ones, a similarly innate biological preparedness to respond positively to urban environments could not develop.

According to ART, the restorative qualities of environments are determined by four components that facilitate recovery from mental fatigue: *being away*, *extent*, *compatibility*, and *fascination*. The last, *fascination*, is considered essential: a stimulus must have a fascinating quality to attract involuntary attention (which does not demand mental effort, as opposed to directed attention, which demands attention capacity that can be depleted). Nature is assumed to attract involuntary attention because of its fascinating qualities and therefore provides the opportunity for recovering from mental fatigue. Ulrich et al. (1991) see a biologically prepared, positively toned emotional reaction as central for the stress reduction achieved by the exposure to green environments. They argue that fascination in terms of the elicitation of involuntary attention cannot explain the restorative effects of natural environments: involuntary attention is also experienced by persons who are confronted with threatening stimuli and environments that are by no means restorative. Exposure to threatening stimuli (i.e., to stressors), such as spiders or snakes, attracts involuntary attention and at the same time elicits negatively toned emotions and an activation of the autonomic nervous system (Ulrich et al., 1991). Biological preparedness for such a stress response involving physiologic activation and involuntary attention is evolutionary rational: it arms an individual with the resources and information required to cope with dangerous situations. Elicitation of involuntary attention is therefore not considered crucial for stress reduction (Ulrich et al., 1991).

Kaplan (1995) emphasizes that ART regards fascination as a necessary but not sufficient aspect of restorative environments. Different types of fascination exist, such as ''the 'hard' fascination of watching auto racing and 'soft' fascination of walking in a natural setting'' (Kaplan, 1995, p. 172), and restorative environments require three further attributes. *Being away* refers to environmental characteristics that allow an escape from certain ordinary aspects of life, such as distractions, obligations, everyday hassles, and pursuits of purposes and thoughts. *Extent* means that to be highly restorative, an environment needs to be ''rich enough and coherent enough so that it constitutes a whole other world.'' *Compatibility* refers to a fit between the environment and ''what one is trying to do and what one would like to do'' (Kaplan, 1995, p. 173).

Consistent with Kaplan and Kaplan's (1989) theory, various studies have shown that natural green environments are perceived to possess all four attributes – fascination, being away, extent, and compatibility – to a larger extent than built environments (Laumann et al., 2001; Purcell et al., 2001; Herzog et al., 2002, 2003; Bodin and Hartig, 2003; Hartig et al., 2003). Moreover, walking in a natural environment has been found to have significantly better restorative effects than walking in urban surroundings (Hartig et al., 1991, 2003). Harte and Eifert (1995) examined the health benefits of physical activities in outdoor versus indoor settings and found that running on a campus reduced negative emotions but running on a treadmill in a laboratory did not. In a study by Pretty et al. (2005), participants running on an indoor treadmill while viewing a pleasant rural scene were found to have a higher degree of restorative effects than those exposed to unpleasant rural or urban scenes, suggesting that exercising in a pleasant green environment has a positive effect. Bodin and Hartig (2003) found a non-significant tendency for regular runners to have stronger positive emotional effects when running in a park than when running in an urban environment. The authors speculate that the non-significance of this tendency might be due to the small sample size of the study, but nevertheless, they observed that runners significantly preferred a park environment to an urban environment. Several other studies have also found that natural spaces are more attractive to people than built environments (cf. Ulrich, 1986; Hartig, 1993). Moreover, previous studies show that the preference for natural over urban environments is

closely related to higher expected benefits in terms of restorative outcomes (Herzog et al., 2003; Staats et al., 2003), which suggests that the restorative value of an environment could be an implicit frame of reference for judgments of general preference (Purcell et al., 2001). In addition, Van den Berg et al. (2003) show that experienced restoration mediates the greater preference for natural over built environments.

A considerable number of studies have shown that visiting green spaces and being exposed to natural elements can reduce psychological strain, increase psychological well-being, and support recovery from illness (Ulrich, 1984, 1986, 1993; Verderber, 1986; Parsons et al., 1998; Frumkin, 2001; Kaplan, 2001; Riediker and Koren, 2004). In the Netherlands for example, epidemiological studies showed that (1) residents of neighbourhoods with extensive green space enjoy, on average, better health than those in neighbourhoods without (De Vries et al., 2003). The mortality of elderly Japanese living in megacities is lower when there are green paths and spaces in the vicinity of their residences (Takano et al., 2002). In Sweden, the more often people use urban public green spaces, the less they suffer from stress (Grahn and Stigsdotter, 2003) Experiencing the restorative effects of nature and pursuing various activities in natural environments – including observing nature, taking a walk in natural surroundings, hiking, gathering berries and mushrooms, gardening, fishing and hunting, as well as working in the forest – correlate positively with the individual well-being of Estonians (Raudsepp, 2005). Other studies have shown that hiking and camping in the wilderness are a source of spiritual inspiration (Fredrickson and Anderson, 1999) and have investigated the mental health benefits of community gardening (Parr, 2005). However, research comparing the restorative benefits of engaging in various outdoor activities in different types of green and natural environments has hitherto been rare. Periurban forests and city parks are two types of urban green spaces that cover large areas and attract numerous visitors. The present study compares the restorative effects of four kinds of activities (doing sports, walking, relaxing, and observing nature) that are frequently undertaken in green spaces and distinguishes between a forest environment and a park setting. Against the background of previous studies showing the positive effects of exercise on well-being (Fox, 1999; Biddle et al., 2000; Bodin and Hartig, 2003) and the WHO (2006) recommendation on performing activities of at least moderate intensity, it was expected that practicing sports (ranging from moderate to vigorous in intensity) in green locations would have stronger restorative effects than taking a walk (light activity, according to Breckenkamp et al., 2004) and relaxing (very light activity). Additional purposes of the study were (1) to find out people's opinions on how best to recover from stress, (2) to identify the health benefits people expect from visiting forests and parks, and (3) to determine whether the positive effects actually experienced in a green space are correlated with people's beliefs in the restorative benefits of green spaces.

Method

Our assessment of restoration is based on two subjective measures of psychological distress (stress, headaches) as well as a subjective measure of well-being (feeling well-balanced). This is consistent with Massé et al.'s (1998) recommendation to use concomitant measures of psychological distress and well-being for the assessment of mental health in general (i.e., non-clinical) populations, which takes into account that "a low level of psychological distress does not mean automatically a high level of subjective well-being"; rather, these are "two different, though correlated, dimensions of a virtual concept of mental health" (p. 497). According to Massé, *mental balance* includes emotional balance, balanced interpersonal relations, a balance between private and professional life, and being true to oneself, and it is one of several indicators of well-being. However, in our survey, we chose to ask to what extent participants felt well-balanced, a concept that includes physical aspects of well-being. According to Kenney (2000), 'inner balance' is determined by the interrelationships among stressors, personality mediating traits, and symptoms of health problems. We expected that participants would have a commonsense understanding of the term *well-balanced* and presumed that the commonsense meanings of 'stress' or 'inner balance' would be considerably congruent with the corresponding scientific meanings (e.g., Selye, 1976; Kenney, 2000; Kopp and Réthelyi, 2004).

This study's time frame, however, imposes severe limitations in assessing restorative outcomes, since only short-term effects are analysed. Long-term effects of regular physical activity, such as weight loss or lower blood pressure, were not measured. The temporal factors of stress processes are an important aspect of existing stress theories, and there are large differences between the characteristics and effects of chronic stress and acute stress (Avison and Turner, 1988; Krantz and McCeney, 2002). Chronic stress is known to be a risk factor for coronary disease and other potentially fatal conditions, whereas single instances of acute stress are generally a normal coping process. It is also known that many clinical cardiac events do not occur spontaneously but are triggered in susceptible patients by acute physical or mental stress. Monitoring the immediate, mid-term, and long-term changes of subjective and physiological measures in a longitudinal study would

provide clinically important data on the effects of green space visits on chronic stress. Since the present study assesses only short-term changes in subjective well-being and perceived stress levels in connection with single green space experiences, the analysis is limited to the effects of such experiences on acute stress levels. Furthermore, people's subjective restoration experience was assessed without reference to physiological data. Our focus was on the restoration that people subjectively experience.

The survey took place in April 2005 in Zurichberg Forest and Irchelpark. Zurichberg Forest, the city's largest urban forest, is close to the city centre. Irchelpark, a city park, is approximately 600 m from the forest; it is a naturalistic, spacious park of 32 ha with a pond at its centre. To ensure that all respondents had already been in the green space for some time, participants were recruited in the centre of the park, near the pond. For the same reason, people who were just entering the forest were not interviewed. The specific forest and park areas selected for the interviews are highly frequented, and each represents a clear example of its type. Moreover, their proximity facilitated rotation of the interviewers among the locations. Whenever forests and parks are located close to each other it enhances the possibilities of citizens to choose which place to visit, the forest or the park, according to their preference. Nevertheless, it is possible that many participants of our study chose to perform their activities at the location nearest to where they lived or worked.

A total of 164 persons, 71 males and 93 females, participated: 81 interviews were conducted inside Zurichberg Forest, 43 at the forest edge, and 40 in Irchelpark (Fig. 1). Of the participants, 44.5% were employed, 21.3% were students (secondary school, university, or vocational school), 21.9% were retired people receiving pensions, 7.7% did unpaid labour (e.g., housewives or housemen), and 3.3% were unemployed. Respondents were approached regardless of age and sex, but children below the age of 15 were not included in the survey. The age distribution was 5.5% between 15 and 20 years, 25.9% between 21 and 35 years, 19.2% between 36 and 50 years, and 49.4% over 50 years old. A χ^2-test comparing the sample's age distribution with the age distribution of the Swiss population, again excluding children (i.e., 3.9% between 15 and 20 years, 27.6% between 21 and 35 years, 21.8% between 36 and 50 years, and 46.7% over 50 years old), showed no significant differences in age distributions ($df = 3$, $N = 164$, $p = 0.58$). Despite these similarities in the percentage distributions, our sample is not representative of the population of Switzerland, since only forest and park visitors were interviewed. The sample is also not representative of the visitors of Zurichberg Forest and Irchelpark because of the narrow time period during which these interviews conducted. However, the ad hoc sampling took into account authentic visitors of the forest and park settings in which the investigation was conducted.

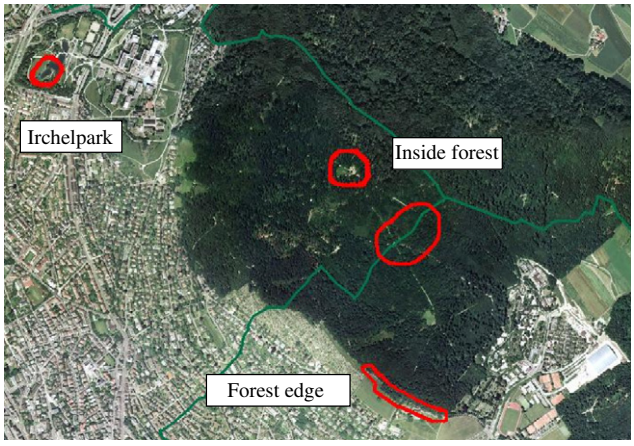

Fig. 1. Interview locations: in Zürichberg Forest, at forest edge, and in Irchelpark.

The first 126 interviews were conducted on a sunny Friday, and the remaining 38 were conducted on two workdays of the subsequent week, in slightly less pleasant weather conditions. The interviews ran from 9.20 a.m. to 3.30 p.m. at the several locations by and large simultaneously; the eight interviewers rotated among the sites to counterbalance possible interviewer biases. The interviewers introduced themselves as students of the Swiss Federal Institute of Technology Zurich and asked passers-by whether they would like to be interviewed. The response rate was good at all locations; rather few persons declined to participate. In most cases the respondents themselves filled in the questionnaires, with interviewers assisting only if questions arose. A few respondents asked interviewers to read the questions aloud and record their responses. The survey started with questions about the respondents' activities in the location and the duration of their visit up to the time of the interview. Next, respondents were asked whether they had been exposed to stress before coming to the green space, and what advice they would give a friend suffering from stress. They were asked to rate on five-point scales (1) their degree of headache, if any, (2) their level of stress, and (3) how well-balanced they felt when they had arrived at the forest (or park). Then they were asked to rate these three items again, using the same five-point scale, but for the time of the interview, and they were asked whether they believed that visits to the forest (or park) contributed to their health and well-being. Finally, socio-demographic data were recorded. Because some individuals did not complete the whole interview, which required approximately 10 min, or could not answer certain questions, the number of respondents varies slightly between a minimum of 151 and a maximum of 164 over all the questions.

Results

Sources of stress and advice for coping with stress

The questionnaire contained a list with several common sources of stress (noise, school or work, social conflicts or arguments, time pressure, travel), and the participants were asked to mark those that had caused them stress before arriving at the green location. In addition, they were invited to name any other source of stress they had undergone before arriving at the location. Multiple sources of stress could be checked or added to the list. Almost half (43.3%) of the participants marked or added at least one source of stress. Stress related to work or school or university was mentioned most frequently (23.8%). Noise (6.1%), time pressure (4.9%), travelling to the present location (3.7%), and arguments or social conflicts (3.1%) were mentioned less frequently. Other sources of stress mentioned by participants that were not suggested by the questionnaire included health concerns (1.8%), the death of a close relative, moving house, and a hangover (Fig. 2).

Respondents were asked to select from eight activities listed on the questionnaire (listening to music, walking in the forest, visiting a park, doing sports, taking medication, sleeping, reading a book, and watching a film) a maximum of three that they would recommend to a friend suffering from stress. They were also encouraged to think of other remedies not included on the list. The respondents strongly favoured walking in the forest (68.9%), followed by doing sports (48.1%), listening to music (35.4%), visiting a park (22.4%), sleeping (18%), and reading a book (13.7%). Watching a film (3.7%) and taking medication (2.5%) were mentioned less frequently. Fourteen participants (8.5%) offered other advice: talking to a friend, playing with a pet, cooking, getting a massage, playing computer games, meditating, doing breathing exercises, and drinking red wine. In Fig. 3 respondents' recommendations are shown by location (inside the forest, at the forest edge, and in the park). No statistically significant differences were found between inside the forest and at the forest edge. However, the answers obtained at the two forest locations showed significant differences from those obtained in the park: forest visitors selected walking in the forest more frequently than did park visitors ($\chi^2 = 4.8$; df = 1; $p < 0.05$), whereas the latter more frequently mentioned doing sports ($\chi^2 = 5.3$; df = 1; $p < 0.05$), visiting a park ($\chi^2 = 9.5$; df = 1; $p < 0.01$), and listening to music ($\chi^2 = 5.0$; df = 1; $p < 0.05$). Still, even the park visitors recommended walking in forest more frequently than visiting the park as good advice for friends suffering from stress, though the corresponding tendency was not significant (McNemar test, $p = 0.26$). The forest visitors recommended walking in a forest significantly more than the other listed activities (for each of eight McNemar tests, $p < 0.001$). They also significantly preferred doing sports over visiting a park ($p < 0.001$).

Activities of the respondents

Participants were asked to categorize their current activities in the green space as taking a walk, socialising, being outdoors with children, walking a dog, doing sports, observing nature, or relaxing. Because these activities are not mutually exclusive, more than one answer was allowed, and consequently many participants checked off more than one activity. The distribution of responses varied depending on the location: taking a walk was the predominant activity inside the forest (59.3%) and at the forest edge (83.7%), whereas relaxing was the dominant activity in the park (55.0%).

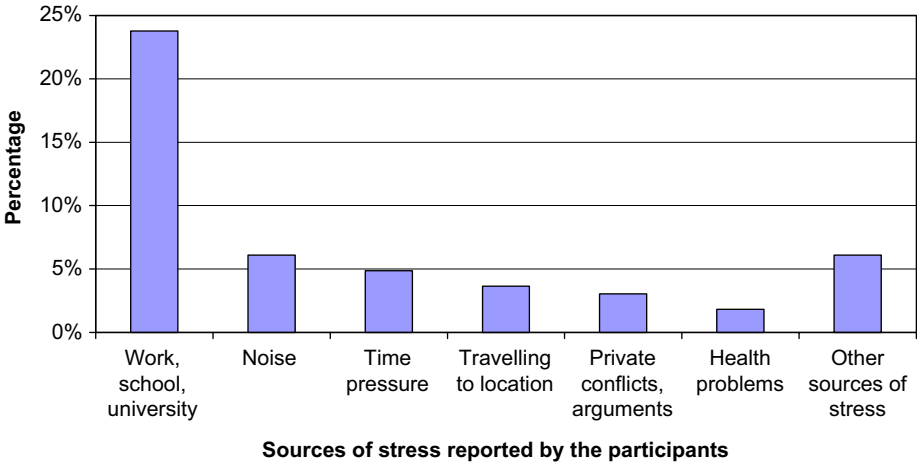

Fig. 2. Percentage of survey respondents exposed to various sources of stress prior to visiting green location ($N = 164$).

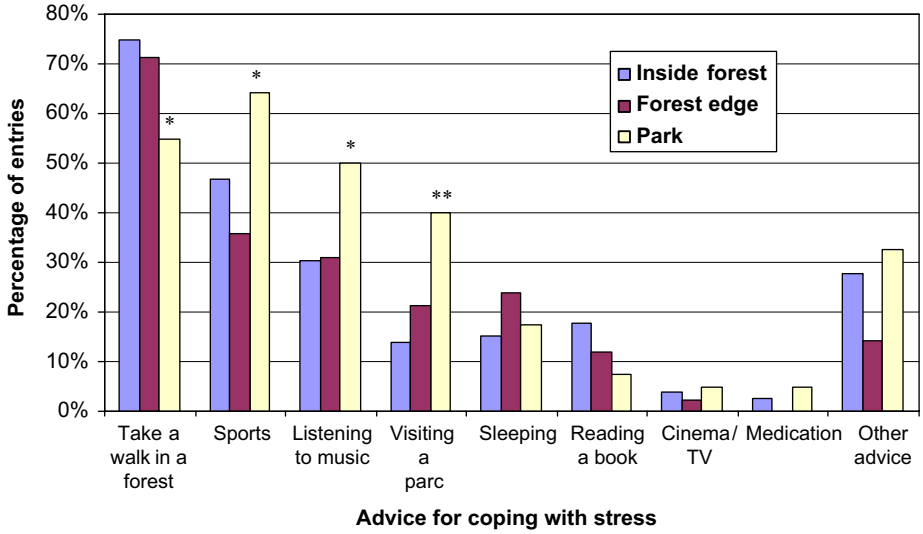

Fig. 3. Respondents' recommendations for ways to reduce stress, by location ($N = 161$, maximum of three recommendations per person). No significant differences were observed between the answers at the forest edge and inside the forest. Significant differences between relative frequencies in the two forest locations on the one hand, and the park environment on the other hand that are statistically significant at the 5% level are marked by * (and those significant at the 1% level by **).

Table 1. Participants' activities and results of χ^2 tests comparing relative frequencies at three locations

Type of activity	Inside the forest		Forest edge		Park		Significance of 2×3-field, χ^2 test	Overall percentage (%)
	%	($N_{entries}$)	%	($N_{entries}$)	%	($N_{entries}$)		
Doing sports	34.6	(28)	20.9	(9)	15.0	(6)	$p<0.05$	0.262
Taking a walk	59.3	(48)	83.7	(36)	30.0	(12)	$p<0.001$	0.585
Relaxing	37.0	(30)	16.3	(7)	55.0	(22)	$p = 0.001$	0.360
Observing nature	42.0	(34)	37.2	(16)	52.5	(21)	$p = 0.35$	0.433
Walking a dog	18.5	(15)	20.9	(9)	7.5	(3)	$p = 0.20$	0.165
Socialising	12.3	(10)	18.6	(8)	12.5	(5)	$p = 0.60$	0.140
Being with children	2.5	(2)	2.3	(1)	7.5	(3)	not tested	0.037
	$N_{location} = 81$		$N_{location} = 43$		$N_{location} = 40$		$N_{total} = 164$	

Note: Because the activities are not mutually exclusive, participants could report more than one. For all six χ^2 tests, df = 3, $N = 164$.

More respondents exercised in the forest (34.6%) than at the forest edge (20.9%) or in the park (15%). Observing nature was very important in all locations (43.3%). The frequencies of the different activities at the three locations are shown in Table 1. For each of the main activities a six-field χ^2-test comparing the frequencies at the three locations was made. As shown in Table 1, the differences between the relative frequencies with which certain types of activities were performed at the three locations were significant in the cases of taking a walk ($\chi^2 = 24.7$; df = 2; $p<0.001$), relaxing ($\chi^2 = 13.6$; df = 2; $p = 0.001$), and practicing sports ($\chi^2 = 6.1$; df = 2; $p<0.05$), but not for observing nature ($\chi^2 = 2.1$; df = 2; $p = 0.35$). Furthermore, averaged over the three locations, 16.5% of participants were walking dogs, and 14.0% mentioned socialising. χ^2-tests revealed no significant differences among the three locations regarding the relative frequency of these activities ($p = 0.20$ for walking a dog; $p = 0.60$ for socializing). Finally, only six respondents (3.7%) were outdoors with children.

Restorative effects of the park and forest visits

Using a five-point scale from zero to four, respondents were asked to rate the severity of their headaches, if any, their level of stress, and how well-balanced they felt immediately before arriving at the location. They were also asked to rate their headaches and stress levels

and how well-balanced they felt at the time they were taking the survey. The five-point scale for headaches ranged from no headache at all (= 0), rather slight headache, moderate headache, and rather strong headache to strong headache (= 4). Most respondents (87.8%) reported no headache upon arriving at the location, 5.1% reported slight headaches, 1.3% moderate headaches, 3.8% rather strong headaches, and 1.9% strong headaches. The arithmetic mean on the five-point scale was 0.27 (SD = 0.83), which reflects the low prevalence of headaches among the participants. For the time of the interview, 94.0% reported no headaches, 2.0% slight headaches, 1.3% (i.e., two persons) reported moderate headaches, 1.3% rather strong headaches, and another 1.3% reported strong headaches. The corresponding arithmetic mean on the five-point scale was 0.14 (SD = 0.62), which corresponds to almost no headaches at all (Fig. 4). A comparison of those two ratings indicates 14 cases of reduced headache and a single case of increased headache. Considering only the 15 people whose level of headache changed, an average reduction of $M_{\Delta\text{headaches}} = 1.4$ scale points was achieved. Wilcoxon-signed rank test showed that this represented a significant reduction in headache (14 decreases, mean rank of difference = 8.2; one increase, rank of the difference = 5.5; $p \leqslant 0.001$). Locations were not compared here because of the low number of observed changes.

Feeling well-balanced was rated by the respondents on a scale ranging from not at all balanced (= 0), rather not well-balanced, moderately well-balanced, and well-balanced to very well-balanced (= 4). The average rating of feeling well-balanced before the visit to the green space was $M = 2.7$ (SD = 1.1). A one-way

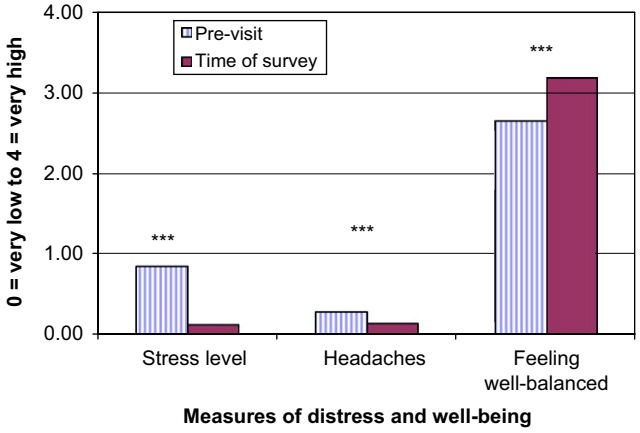

Fig. 4. Respondents' mean ratings of stress levels, headaches, and feeling well-balanced before visiting green space and at time of survey (five-point rating scales: 0 = absent/very low to 4 = very high; $N = 158$). Differences between pre-visit ratings and ratings for the time of the interview that are statistically significant (according to paired sample *t*-tests) at the 1‰ level are indicated by ***.

ANOVA with the independent variable location (three levels: 1 = inside forest, 2 = forest edge, 3 = park) and the well-balanced rating for the time before the green space visit (five-point rating scale) as dependent variable was conducted. It revealed no significant differences among the three locations with regard to the *pre-visit levels of feeling well-balanced* ($M_{\text{inside forest}} = 2.7$; $M_{\text{forest edge}} = 2.7$; $M_{\text{park}} = 2.5$; one-way ANOVA, $F_{(2,153)} = 0.61$; $p = 0.55$). The average rating for feeling well-balanced at the time of the survey was $M = 3.2$ (SD = 1.1), which is significantly higher and indicates a substantial increase in feeling well-balanced (paired sample *t*-test, $t = -6.2$; $p < 0.001$; see Fig. 4). There were no significant differences among the three locations with regard to the ratings of feeling well-balanced at the time of the survey ($M_{\text{inside forest}} = 3.3$; $M_{\text{forest edge}} = 3.3$; $M_{\text{park}} = 2.9$; one-way ANOVA, $F_{(2,153)} = 1.85$; $p = 0.16$).

The five-point rating scale for stress level ranged from not stressed at all (= 0), slightly stressed, moderately stressed, and rather strongly stressed to strongly stressed (= 4). The pre-visit stress levels in the three survey locations were not significantly different from one another ($M_{\text{inside forest}} = 0.7$; $M_{\text{forest edge}} = 1.1$; $M_{\text{park}} = 0.8$; one-way ANOVA, $F_{(2,155)} = 0.88$; $p = 0.42$). Averaged over all participants, the mean rating of the pre-visit stress level was $M = 0.8$ (SD = 1.2), reflecting a rather low stress level in our sample (Fig. 4). Nevertheless, 2.5% of the participants were strongly, 11.4% rather strongly, and 12.7% moderately stressed on arrival. The arithmetic mean of the ratings for the time of the survey was $M = 0.1$ (SD = 0.5), significantly lower than pre-visit stress levels (paired sample *t*-test, $t = 8.7$; $p < 0.001$). The average stress level was accordingly reduced to almost nil during the respondents' time in the green space. There were no significant differences among the three locations with regard to the stress ratings for the time of the survey ($M_{\text{inside forest}} = 0.1$; $M_{\text{forest edge}} = 0.3$; $M_{\text{park}} = 0.0$; one-way ANOVA, $F_{(2,148)} = 2.18$; $p = 0.12$).

Possible differences in the restorative effects of the locations were nevertheless investigated through a repeated measurement ANOVA. It controls for the pre-visit ratings of stress and feeling well-balanced, and also takes into account the length of time spent in the green space. First, a stress-difference measure (Δstress = stress rating before the green space visit minus the rating at the time of the interview) and a feeling well-balanced difference measure (Δfeeling well-balanced = well-balanced rating before the green space visit minus the rating at the time of the interview) were calculated for each participant. Both difference measures were subsequently coded such that positive values indicated restoration during the time spent in the green space (i.e., an increase in feeling well-balanced or a reduction in stress level). Averaged over all participants,

the *increase in feeling well-balanced* was $M_{increase\ in\ feeling\ well\text{-}balanced} = 0.5$ (SD = 1.0) and the mean *reduction in stress* was $M_{stress\ reduction} = 0.7$ (SD = 1.1). These two measures served as the only within-subject factor of the repeated measurement ANOVA. We named this within-subject factor *restorative outcome* (two levels: 1 = *increase in feeling well-balanced*, 2 = *reduction in stress*). The repeated measurement ANOVA furthermore included the between-subject factor *location* (three levels: 1 = inside forest, 2 = forest edge, 3 = park), and the covariate variables *duration of stay* up to the time of the survey, *pre-visit rating of feeling well-balanced,* and *pre-visit level of stress.* The two latter covariates were included to control for possible floor or ceiling effects. Such effects can result because someone who is not stressed before the visit (e.g., pre-visit stress level rating = 0) cannot further decrease his or her stress level. In this case, the second measure of the within-subject factor (i.e., *reduction in stress*) can vary only between zero and minus four.

The results of the repeated measurement ANOVA are described in Table 2. The main effect of the within-subject factor *restorative outcome* proved significant ($F_{(1,145)} = 49.6$; $p < 0.001$). Corresponding to the average *increase in feeling well-balanced* and *reduction in stress* as reported above, this means that stress levels were reduced to a significantly greater extent than feelings of being well-balanced were enhanced. The linear effects of the covariates *pre-visit rating of feeling well-balanced* ($F_{(1,145)} = 36.4$; $p < 0.001$) and *pre-visit level of stress* ($F_{(1,145)} = 77.9$; $p < 0.001$) were both highly significant. Furthermore, the two-way interactions between the within-subject factor *restorative outcome* and both the covariate *pre-visit rating of feeling well-balanced* ($F_{(1,145)} = 40.4$; $p < 0.001$) and the covariate *pre-visit level of stress* ($F_{(1,145)} = 121.9$; $p < 0.001$) were also highly significant: the more stressed the respondents were before they visited the green space, the larger the reduction in stress level ($b = 0.80$), and the less well-balanced they felt, the greater the increase in feeling well-balanced ($b = -0.53$). The linear effect of the covariate *duration of stay* was also significant ($F_{(1,145)} = 4.3$; $p < 0.05$), indicating that the restorative outcomes were greater as duration increased. The interaction effect between the within-subject factor *restorative outcome* and *duration of stay* was, however, insignificant (for *increase in feeling well-balanced*, $b = 0.11$; for *reduction in stress,* $b = 0.06$; $p = 0.53$). The main effect of *location* was also insignificant ($p = 0.93$), as was the interaction between *location* and *restorative outcome* ($p = 0.12$). The latter non-significant p-value relates to a tendency for feeling well-balanced to improve slightly more in the forest locations, whereas reduction in stress was greater in parks.

Relationship between activities and restorative effects

The relationship between each of the main activities and the *restorative outcome* was analysed. To this end four additional repeated measurement ANOVAs were conducted. These four ANOVAs included the identical within-subject factor (i.e., *restorative outcome*) and the same between-subject factors (i.e., *location*) and covariate variables (i.e., *duration of stay*, *pre-visit rating of feeling well-balanced*, and *pre-visit level of stress*) as above. However, in each of these four repeated measurement ANOVAs, one of the variables representing the main activities – *taking a walk*, *relaxing*,

Table 2. Results of repeated measurement ANOVA with within-subject-factor restorative outcome (two dependent measures: 1 = increase in feeling well-balanced, 2 = reduction in stress), between-subject variable location (three levels: 1 = inside forest; 2 = forest edge; 3 = park), and covariate variables *duration of stay*, *pre-visit rating of feeling well-balanced*, and *pre-visit level of stress*

Source of variation	Sum of squares	df	Mean square	F	Significance, p
Tests of between-subjects effects					
Intercept	3.90	1	3.90	6.80	0.010
Duration of stay	2.48	1	2.48	4.32	0.039
Pre-visit stress	44.74	1	44.74	77.95	0.000
Pre-visit feeling well-balanced	20.89	1	20.89	36.39	0.000
Location	0.08	2	0.04	0.07	0.932
Error	83.23	145	0.57		
Tests of within-subjects effects					
Restorative outcome	23.47	1	23.47	49.64	0.000
Restorative outcome∗duration of stay	0.19	1	0.19	0.40	0.529
Restorative outcome∗pre-visit stress	57.64	1	57.64	121.91	0.000
Restorative outcome∗pre-visit feeling well-balanced	19.08	1	19.08	40.35	0.000
Restorative outcome∗location	2.04	2	1.02	2.15	0.120
Error (restorative outcome)	68.56	145	0.47		

practicing sports, and *observing nature* – was included as an additional between-subject effect. Each of these additional variables has two levels: 1 = yes, the activity is performed; 2 = no, the activity is not performed.

The variables *taking a walk*, *relaxing*, and *observing nature* showed no significance, but the previously described results of the repeated measurement ANOVA remained stable over each of the variables: that is, none of the significant results changed and no additional significance emerged. This indicates robustness of the above results with respect to changes in the overall model of the repeated measurement ANOVA. The above results also remained stable when *practicing sports* was included in the repeated measurement ANOVA. However, the effect of *practicing sports* proved significant ($F_{(1, 144)} = 7.9$; $p < 0.01$), indicating that participants doing sports achieved higher measures of both restorative outcomes (see Fig. 5). Furthermore, there was a significant interaction between the within-subject factor *restorative outcome* and the grouping variable *practicing sports* ($F_{(1, 144)} = 4.4$; $p < 0.05$): the reduction of stress was 0.4 scale points higher for those who were doing sports ($M_{\text{stress reduction}} = 1.0$) than for those who were pursuing other activities ($M_{\text{stress reduction}} = 0.6$), and the increase in feeling well-balanced was 0.7 scale points higher for those who were doing sports ($M_{\text{increase in feeling balanced}} = 1.0$) than for those who were pursuing other activities ($M_{\text{increase in feeling balanced}} = 0.3$).

Belief in restorative effects of forests and parks

Respondents in the two forest locations were asked whether they thought that visiting forests improved their health and well-being; those in the park were asked the same questions about the effects of park visits. Three answers were possible: yes, undecided, and no. Of forest visitors, 98.4% stated that visiting forests had a positive effect on their well-being. Only one person was undecided, and another person said no. Similarly, 97.4% of park visitors stated that visiting parks had a positive effect on their well-being.

Regarding the health benefits of visiting the forest, 94.4% of forest visitors responded positively, 4.8% were undecided, and one person said no. The judgments regarding the health benefits of visiting parks were somewhat less positive: 84.6% of the park visitors presumed that there were such health benefits, 2.6% were undecided, and 12.8% assumed no health benefits. The answers of forest and park visitors were coded as ordinal scaled variables (three levels: *no effect* = 1, *undecided* = 2, and *yes* = 3). After this recoding, the ranks of the forest and park visitors were calculated and

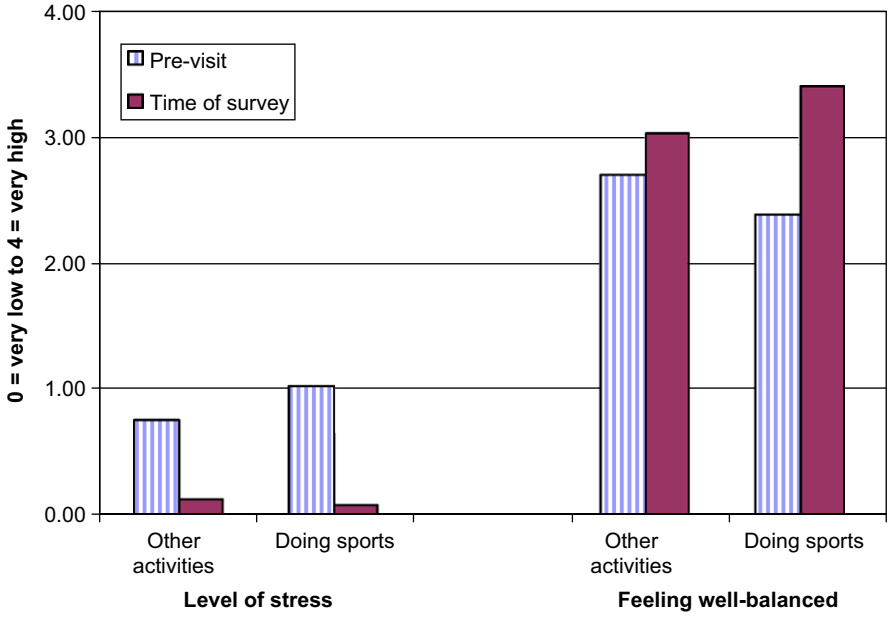

Fig. 5. Mean ratings of respondents 'doing sports' ($N = 43$) versus 'not doing sports' ($N = 116$) for stress level and feeling well-balanced immediately prior to visiting the outdoor location and at the time of the survey (five-point rating scales: 0 = very low to 4 = very high). Decrease of stress and increase in feeling well-balanced was significant ($p < 0.001$; see Fig. 4). A repeated measurement ANOVA (described in text) analysed the restoration-moderating influence of doing sports. A significant main effect of *doing sports* (between-subject factor with 2 levels: yes or no) on the dependent variable *restorative outcome* (within-subject factor with 2 levels: increase in feeling well-balanced, reduction in stress) showed that those who were doing sports experienced greater restorative outcomes ($p < 0.01$). A significant interaction effect between *doing sports* and *restorative outcome* ($p < 0.05$) indicated that the added restorative benefit of exercise was particularly large with respect to increases in feeling well-balanced.

compared using the Mann–Whitney *U*-test. The test showed that the forest visitors were significantly more optimistic about the health benefits of visiting the forest than the park visitors were about the health benefits of park visits (forest visitors: $M = 2.9$, mean rank = 84.0; park visitors: $M = 2.7$, mean rank = 75.6; $p < 0.05$).

Further statistical analyses examined whether those who believed in the health benefits of visiting parks or forests reported greater reduction in stress and larger increases in feeling well-balanced. Both the Spearman rank correlation between judgments of health benefits and reduction in stress ($r = 0.04$; $p = 0.66$) and an increase in feeling well-balanced ($r = 0.10$; $p = 0.22$) were not significant. The rank correlation between both restorative outcomes was, however, significant ($r = 0.33$, $p < 0.001$).

Discussion

The observed reductions in self-reported stress levels and headaches of forest and park visitors are impressive examples of the restorative effects of green space on subjective indicators of well-being. No differences in the restorative effects of the locations were found. In terms of the average improvements over pre-visit levels, the overall recovery rate for stress was 87% and the reduction in headache was 52% of the possible enhancement on a five-point scale. The improvements in the respondents' ratings of feeling well-balanced amounted to 40% of the enhancement permitted by the scale. These percentage values take into account that the restoration experienced by individuals who were not stressed, had no headaches, and felt very well-balanced on arrival could not be captured by a difference between the corresponding ratings on their arrival at the green location and the moment of the interview. Because of the (on average) rather high level of well-being of the participants on arrival, these percentage changes are much clearer than the average difference on the scale as reported above. The increases in well-being were significantly positively related to duration of the green space visit up to the time of the interview. This latter finding supports Kaplan's (1995) theory, in which a considerable time in suitable settings is thought to be necessary for achieving progressive levels of restoration.

Of course, not all types of headaches can be cured simply by visiting a forest or park because the psychological and physiological processes underlying headaches can be very different. Furthermore, since only forest and park visitors were surveyed, the question remains open whether people from a different sample would benefit to the same extent. And since medium- and long-term effects were not assessed, it is not known how long the improvements lasted or to what extent repeated green space visits can mitigate risk factors like hypertension or prevent acute stress from turning into chronic stress. Most of the stress reported by the respondents was related to work and school or university. This is consistent with previous research indicating that modern job and education practices are major sources of stress (e.g., Maslach and Leiter, 1997). Preventive approaches addressing the roots of these problems should focus on improving working conditions and reducing stress in educational settings (Gundlach, 1991). The present investigation demonstrates that visiting green spaces can effectively reduce subjectively experienced acute stress of various intensities. Regarding the restorative effects of respondents' activities, we found that vigorous exercise was associated with greater decreases in stress and increases in feeling balanced, whereas taking a walk, relaxing, or observing nature produced average restorative effects. This finding emphasizes that parks and forests can help people trying to follow the WHO (2006) activity recommendations by offering spaces for physical activity. Even though long-term effects and physiological processes were not assessed in the present study, the finding of an added benefit of doing sports in green spaces compared with the restorative effects of physically less intense activities appears consistent with the WHO assessment that physical activity can improve long-term psychological well-being. People who reported a low level of well-being (feeling stressed and out of balance) before visiting the green spaces experienced large increases in personal well-being during their time in the green area. Even though high stress levels were reported by only few participants, it appears that leisure activities in forests and parks might mitigate even intense levels of psychological stress.

The present study found that more people were doing sports in the forest than at the forest edge or in the park. This difference was not expected beforehand and might well be limited to the specific forest and park areas selected. No significant differences in the restorative effects of park and forest visits were observed. Our results cannot straightforwardly be generalized to other parks and forests: Irchelpark is rather large, has a naturalistic design and a pond in its centre, and affords pleasant views of the nearby forest; car traffic, streets, and city buildings are barely noticeable from the park centre. According to the psycho-evolutionary approach of Ulrich et al. (1991), the presence of water can have particularly powerful restorative effects. The pond might have contributed to the restorative effects observed in park visitors. Notably, the lack of any difference in the restorative effects experienced by the forest and park respondents is to some extent at odds with the higher prevalence of doing sports in the forest, as well as with the answers of the participants in two

questions addressing parks and forests in general. First, respondents more frequently recommended walking in the forest than visiting a park to mitigate stress. Second, the forest visitors believed in the health benefits of visiting forests to a larger extent than the park visitors believed in the health benefits of visiting a park. The restorative effects they experienced, however, were not correlated with their personal belief in the health benefits of visiting the green space in which they were interviewed. This indicates that the outcomes are more than a merely suggestive placebo effect that could be caused by a perception that forests and parks are conducive to human health. Still, this result has to be interpreted with caution: a large majority of participants believed in the health benefits of visiting forests and parks, and therefore the variation of belief in the sample is very low, which in turn limits the statistical power of the corresponding significance testing.

It is important to investigate the specific health roles of various kinds of green spaces (Foster and Hillsdon, 2004) and analyse what factors determine the health services that different sites can provide. Analyses of interrelationships between landscape design and type of green space, activities of visitors, and restorative effects can provide important insights for urban planners who seek to build or modify urban green spaces to be more attractive, maximize well-being, and motivate visitors to become physically active (cf. Kaplan et al., 1998; Frumkin, 2003). The present study needs to be followed by larger studies using more examples of green spaces and controlled experiments that can validate the causal link between outdoor activities in green spaces and their effects on health and well-being. Urban green spaces help promote health in the sense of a "state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO, 1948, p. 100). The balance-enhancing and stress-reducing effects of forest and park visits can be achieved at low cost for a wide range of urban users. Landscape and green space designers have an opportunity to promote health and well-being by creating environments that attract users and encourage them to be physically active. Public urban green spaces have to be appealing to attract those who spend most of their leisure time in sedentary indoor activities like watching television, playing computer games, or surfing the Internet. An attractive design is also important because there appears to be a close link between aesthetics and environmental preference on the one hand, and expected and experienced restoration on the other (Purcell et al., 2001; Herzog et al., 2003; Staats et al., 2003; Van den Berg et al., 2003; Pretty et al., 2005). Public health campaigns (cf. Bailis et al., 2005; Hagberg and Lindholm, 2005) can encourage people to visit green spaces frequently and engage in outdoor exercise, but such outreach could be more effective if the health benefits from specific natural environments and activities were better known.

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