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Green exercise as a workplace intervention to reduce job stress. Results from a pilot study

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Abstract.
BACKGROUND: Stress and mental fatigue are major health threats to employees in office-based occupations. Physical activity is widely used as a stress-management intervention for employees. Moreover, experiences in contact with nature have been shown to provide stress-reduction and restoration from mental fatigue.
OBJECTIVES: In a pilot study designed as a randomized controlled trial we investigated the impact of a *green-exercise* intervention on psychological and physiological indicators of stress in municipality employees.
METHODS: Fourteen employees (7 females and 7 males, 49 ± 8 yrs) volunteered in an exercise-based intervention in workplace either outdoors in a green/nature area or in an indoor exercise-setting. The intervention consisted of an information meeting and two exercise sessions, each including a biking bout and a circuit-strength sequence using elastic rubber bands (45-minutes, at about 55% of HR reserve, overall). Main outcomes were perceived environmental potential for restoration, affective state, blood pressure (BP) and cortisol awakening response (CAR AUC_G and CAR AUC_I) and cortisol levels in serum. Measurements were taken at baseline and in concomitance with the exercise sessions. Furthermore, affective state and self-reported physical activity levels were measured over a 10-weeks follow-up period.
RESULTS: Compared with the indoor group, the nature group reported higher environmental potential for restoration ($p < 0.001$) and Positive Affect ($p < 0.01$), along with improved CAR AUC_I ($p = 0.04$) and, marginally, diastolic BP ($p = 0.05$). The nature group also reported higher ratings of Positive Affect at follow-up ($p = 0.02$). Differences at post-exercise were not found for any of the other components of affective state, systolic BP, CAR AUC_G and cortisol levels measured in serum.
CONCLUSIONS: Green-exercise at the workplace could be a profitable way to manage stress and induce restoration among employees. Further studies on larger samples are needed in order to improve the generalizability of the results.

Keywords: Natural environment, workplace intervention, restorative environment, mental fatigue, job stress

1. Introduction

1.1. Work & stress

Extensive job stress is a threat to employees' health. It has been reported that 40% of North American workers perceive their job as very or extremely stressful and 25% appointed their job to be the main source of stress in their life [1]. Situations perceived as stressful typically imply the mobilization of organic responses in order to re-establish the organism's homeostasis, which in turn leads to depletion of resources that need to be restored [1]. The major mechanisms regulating the physiological stress-response are the hypothalamic-pituitary-adrenal and the sympathetic-adrenal-medullary axes, which

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superintend responses such as increased production of stress hormones (e.g. cortisol) and adaptation of cardiovascular activity (e.g. increased blood pressure) [2]. *Mental fatigue* is both a result and a source of stress that can affect those employed in office-based occupations. Mental fatigue is associated with feelings of "tiredness" and "lack of energy" that leads to impairment of cognitive, as well as physical performance [3]. Therefore, mental fatigue can further exacerbate one's perception of stress because it increases the discrepancy between the environmental demands and the individual's abilities to manage them. Long term over-exposure to stress can have deleterious effects, with increased risk of poor mental health, sleep disorders, cardiovascular diseases, cancer and premature aging [2]. It is, therefore, important to protect employees' from the health threats of stress by implementing workplace interventions that can elicit restoration from stress and mental fatigue.

1.2. Physical activity in workplace as a stress-management strategy

In the last two decades, attention has been directed to promoting health among employees through workplace intervention, and a particular focus given to physical activity (PA) [4]. Besides being associated with reduced risks for several health threats, promoting PA in the workplace have been found to be effective as a stress-management intervention [1]. In several countries, many employers endorse participation in PA during working hours in order to promote good health amongst their employees. In Norway, for instance, it has been estimated that 57% of the employees receive financial support for exercising and 28% of the employees have the opportunity to exercise during regular working hours [5]. Usually such financial support consist of offering access to exercise-facilities (i.e. fitness centers nearby or exercise-facilities within the work place), as only 14% of the employees have access to different types of workplace exercise facilities [5]. Although promoting PA by itself can positively impact the stress load among employees [4], giving more attention to the environment the PA takes place in could enhance the possible benefits of the activity, especially in terms of restoration from stress and mental fatigue. Especially, it has been shown that engaging in PA in natural environments can provide greater benefits in terms of psychological responses and stress reduction as compared to exercising indoors [6, 7].

1.3. Restorative effects of nature and natural environments

According to the *Stress Recovery* Theory developed by Roger Ulrich, viewing aesthetically pleasing environments can reduce physiological activation [8]. The theory further states that we automatically respond with more positive affect to nature compared to built environments and that experiences in nature more easily initiate restoration from stress. Viewing natural environments can also provide greater potential for restoration from mental fatigue [9]. According to Kaplan & Kaplan's *Attention Restoration Theory*, mental fatigue is due to exhaustion of *directed attention* when one has to stay focused on tasks and information that are not spontaneously interesting, such as working with cognitively demanding work tasks [9]. Directed attention is a *limited* cognitive resource, and in order to regenerate it one has to resort to an *unlimited* and *spontaneous* form of attention, which in the Attention Restoration Theory is defined as *fascination*. In this perspective, a *restorative environment* is an environment that requires minimal demands on the capacity to direct attention and at the same time triggers undirected (i.e. spontaneous) attention provided by attractive sceneries. Being outdoors in natural environments can provide such environmental features, along with a sense of being away from everyday hassles and tasks and thereby offer restorative experiences [9, 10].

The stress-relieving benefits of nature have been corroborated by several studies, in which viewing scenes of nature, as compared to scenes of built environment, induced faster recovery from induced stress [8] and improvements of *psycho-physiological* parameters [11]. Exposure to nature has also been shown to elicit restoration from mental fatigue with enhancement of cognitive performance [10].

1.4. Green-exercise: The reciprocal benefits of physical activity and nature eliciting stress-reduction

Green-exercise refers to the "synergistic benefit in adopting physical activities whilst at the same time being directly exposed to nature" [12], with PA referring to any bodily movement produced by skeletal muscles that require energy expenditure above baseline. In a study using mobile electroencephalogram, walking in a quiet natural environment was associated with neurological patterns in line with attention-restoration mechanisms described by Kaplan & Kaplan in the

Attention Restoration Theory [13]. This study corroborates the greater potential for restoration elicited by engaging in PA in natural environments. Experiences of physical activity in natural environments such as walking or running in pleasant green spaces has been associated with higher ratings of perceived potential for restoration and improved cognitive performance, as compared to equivalent activities carried out indoors or in urban settings [10, 14]. In a cross-sectional study on members of fitness centers that offer the opportunity to exercise both indoors and outdoors it was found that the outdoor setting was assigned higher restorative qualities (especially *perceived fascination*) than the indoor setting, suggesting that 'green' exercise-settings might provide greater restorative benefits than 'traditional' exercise-facilities indoors [15]. Positive psychological states along with reduced production of stress hormones (adrenaline, noradrenaline and cortisol) have also been described during walks and trips in forest environments [16, 17]. In addition, positive impact of green-exercise has been shown on blood pressure in field studies comparing walking in a forest vs. urban environment [17], as well as in a controlled laboratory trial with subjects exercising on a treadmill whilst images of nature or urban setting were displayed on a screen [18].

In light of the findings showing greater stress reduction and reduced mental fatigue when one engages in green-exercise as compared with other types of indoor exercise, green-exercise intervention would be particularly appropriate as a stress-management strategy in the workplace. To the authors' best knowledge, studies investigating the impact of green-exercise interventions during work hours are still scarcely available in the literature, although its potential in occupational health has been addressed [19].

1.5. Aim of the study

The aim of the study was to explore possible effects of green-exercise interventions in the workplace on psychological and physiological indicators of stress. This study was meant to be a pilot investigating novel methodologies, with respect to both outcome measures and type of PA intervention. We hypothesized that, compared to 'traditional' indoor exercise, green-exercise interventions would provide greater potential for restoration, leading to more positive psychological and physiological responses such as improved affect/mood, cardiovascular parameters and profile of stress hormones.

2. Methods

2.1. Study design

The study was designed as a between-subjects randomized controlled trial, including preliminary and follow-up measurements (Fig. 1). The randomization was stratified by gender and age, in order to ensure the creation of balanced groups. In an attempt to standardize the experimental conditions as much as possible, all measurements were taken in the same days for both groups, and activities were implemented in regular working days.

2.2. Recruitment and participants

An invitation to participate in the study was sent by e-mail to all, i.e. about 350, employees in two workplaces in a small town in the north of Norway. Within the two weeks preceding the intervention, twenty-three individuals responded and were subsequently contacted by the research coordinator for an assessment of compatibility with the inclusion criteria. Severe pathologies that would interfere with the ability to perform the PA, and being an athlete or ex-athlete were grounds for exclusion. Fourteen healthy employees, sedentary or moderately active, (seven females and seven males; age $= 49 \pm 8$ yrs, BMI $= 25.20 \pm 2.47$) were selected to participate in the intervention (Fig. 2). Their occupation consisted mainly in office-based work. They were informed about the general structure of the experiment and that they would be randomly assigned either to the green-exercise or the indoor group. However, the research question and hypothesis of the study were not disclosed. All participants were informed of the benefits and risks of participating in the research project, and signed an informed consent. The study was approved by the Norwegian Social Science Data Service.

2.3. Intervention

The intervention was organized by the researchers in cooperation with the administration of one of the two workplaces. For the intervention to be a realistic workplace exercise intervention it consisted of an initial information meeting, which was also our *baseline* (day 1). Additionally, the intervention consisted of two exercise sessions on different days (day 2 and 3) over a two-week span. The reasoning for this was to be able to make composite measures and better control for variation related to external factors. The subjects met at

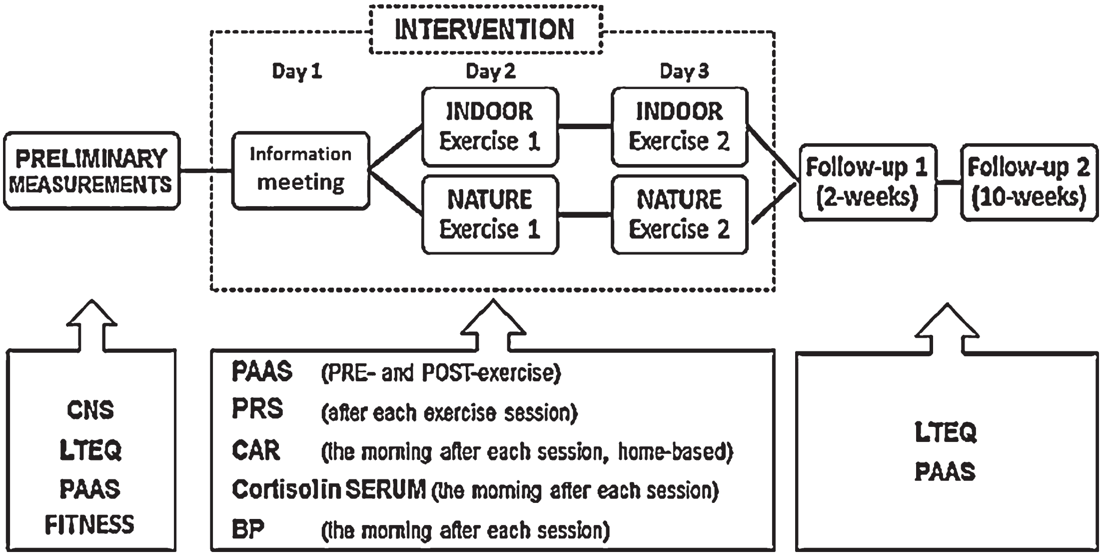

Fig. 1. Study design. *INDOOR/NATURE* = The intervention was designed as a controlled trial with parallel-groups. The subjects performed the same exercise program in two environmental settings: INDOORS (control group) was a 'traditional' exercise environment (gym-hall), while NATURE was a green area nearby the employees' workplace. *CNS* = Connectedness to Nature Scale. *LTEQ* = Adjusted version of the Leisure Time Exercise Questionnaire. *PAAS* = Physical Activity Affective Scale. *PRS* = Perceived Restorativeness Scale (subscales *Fascination* and Being *Away*). $CAR\ AUC_I$ = Cortisol awakening response with respect to increment. $CAR\ AUC_G$ = Cortisol awakening response with respect to ground. *BP* = Blood Pressure.

15:00, after a regular working day, on each of the three days. A light snack (a banana and cereal biscuits) was served before each activity; at completion, they gathered for dinner, and eventually went home (17.30). They were asked to restrict intake of coffee and nicotine, on the days the exercise sessions were performed. Furthermore, they were instructed to avoid PA other than the one planned for the intervention at least 48-hours before the baseline and both exercise sessions.

2.3.1. Exercise program

The exercise program consisted of two parts: a biking session (25-minutes), and strength session using elastic rubber bands with handles (20-minutes). The program aimed to represent an exercise session that could be proposed in real-life interventions in the work-place, with focus on both cardiovascular health as well as muscular strength, as in accordance with international PA recommendations [20]. In order to instruct the subjects on what intensity to keep during the biking bout, a Borg scale [21] was preliminary shown: they were instructed to maintain a self-perceived *moderate* intensity during the warm-up and the cool-down parts and a *moderately high* intensity during the work-out. The subjects in the indoor group used Spinning® Fitness bikes. The subjects in the nature group had the option to use bikes provided for the project, or their own bikes, which all of them chose. The outdoor track was chosen in order to reproduce exercise stimuli as similar as possible indoors, with a fairly even terrain and only one steep up-hill (length ab. 200 m; high difference 25 m), where the subjects were asked to get off the bike and walk. This was reproduced indoors by stepping up-and-down from a bench, which also provided some variation within the indoor biking. The overall length of the biking track was 6082 m. In order to standardize the duration of the biking, the subjects who biked faster were asked to keep biking on the same track until everybody was finished. The strength part included a set of eight exercises covering all the major muscular groups. The exercise bands used for the strength part were of the type with tubular elastic and hard-plastic handles. Females used the medium-resistance, while males used the hard-resistance. Experienced instructors led the activity sessions, and the instructions and communication were standardized during the sessions. Preliminary experimentations with a separate sample were performed in order to verify that the two exercise-settings provided fairly even workload stimuli. To monitor the PA workload during the exercise, heart rate (HR, as percent of the individual HR reserve, i.e. difference between the individual HR_{max} and HR at rest) was continuously measured by a HR-monitor belt (Polar Team2®, Polar Electro, Finland). Furthermore, ratings of perceived exertion were measured across the biking and

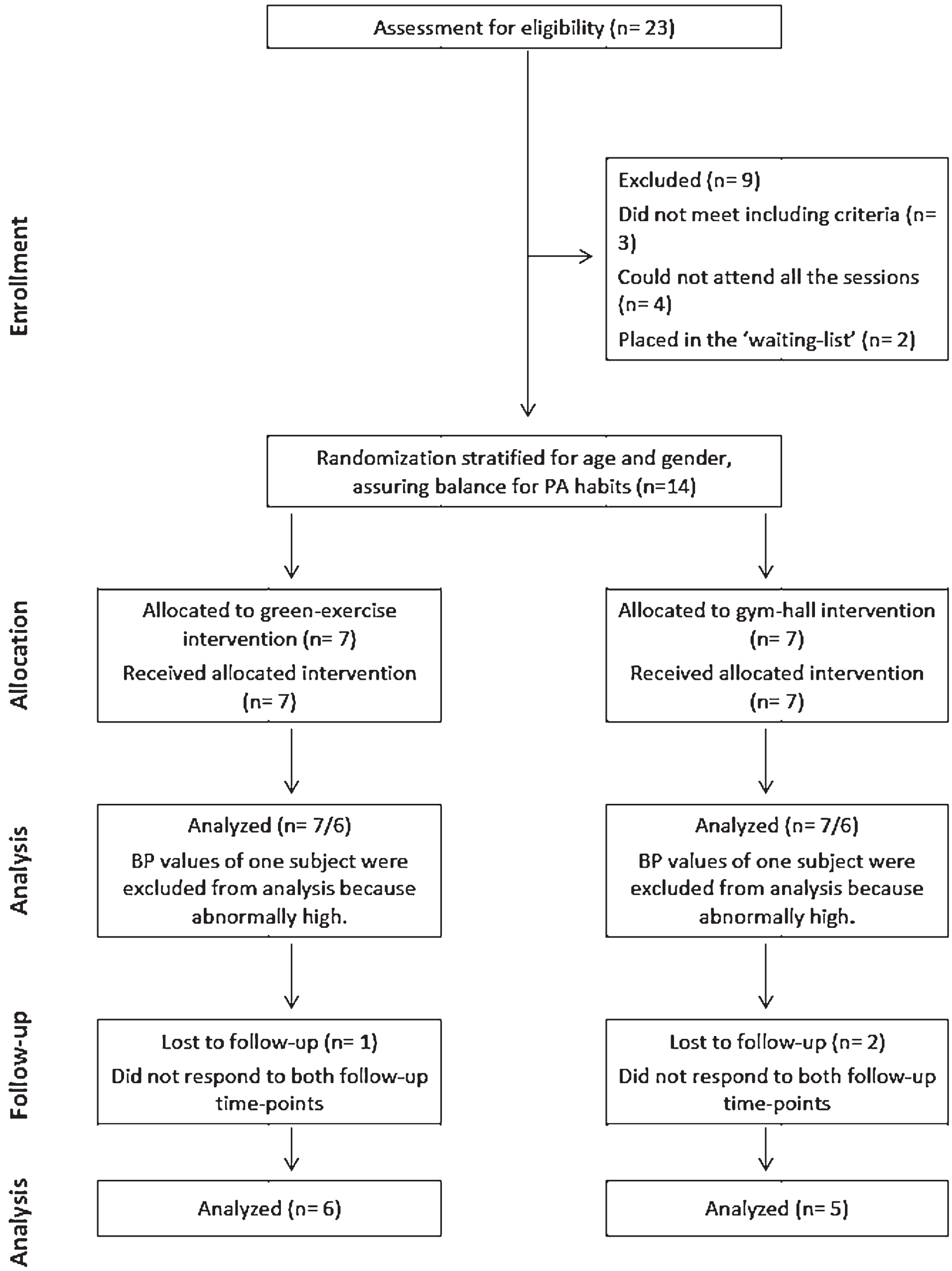

Fig. 2. Diagram showing the flow of participants through each stage of a randomized trial.

the strength bouts using Borg's scale [21]. A detailed description of the exercise program and procedure to standardize the indoor vs. nature exercise is provided elsewhere [22].

2.3.2. Environmental settings

The indoor setting aimed to reproduce a 'typical' exercise setting (gym-hall) (Fig. 3), and, the subjects did not have visual contact with nature. The room was well illuminated with artificial light, and natural light also filtrated through a large line of windows covered by white curtains. A large mirror covering the wall in front of the bike lines amplified both light and space perception of the room. The nature group biked along a track in a forest area nearby both workplaces. The rubber-bands session took place in a grass-yard of one of the

Fig. 3. Exercise settings for a physical-activity-based intervention for employees. The physical-activity-based intervention (seminar) was compounded of one theoretical meeting and two workshops, during which the participants undertook an exercise program in two different environmental settings: a 'traditional' setting (indoor; on the left), and outdoors in a park close to the workplace (nature; on the right).

workplaces just outside the forest area. The intervention took place in September, and the weather conditions were sunny on day 2 and overcast on day 3, with outdoor temperatures around 8–10°C both days, while in the gym-hall temperature and air humidity were 20°C and 60%, respectively.

2.4. Measurements and Instruments

Psychological and physiological indicators of stress were measured in order to ascertain the possible stress-relieving effects of the intervention. These included perceived potential for restoration of the environment, affective states, blood pressure and cortisol levels.

Self-reported affective state was measured by the Physical Activity Affective Scale (PAAS), which place feeling states within four factors corresponding to the quadrants *circumplex model of affect and arousal* [23]: 'Positive Affect', 'Tranquility', 'Negative Affect', and 'Fatigue'. PAAS consists of 12 items measured on a 5-point Likert scale (0 = strongly disagree to 4 = strongly agree). Two versions of the PAAS were used; within the preliminary measurements and in the follow-up a mood version was used (in the caption: "describe how you feel generally these days"), while in concomitance with the exercise an *effective response* was used (in the caption: "describe how you feel generally right now"). Reliability analysis based on baseline data showed that the subscales of Positive and Negative affect and Fatigue had good reliability (Cronbach's alpha = 0.81–0.91), while reliability of the subscale of Tranquility was poor (Cronbach's alpha = 0.51).

The environment's perceived potential for restoration was measured by the two subscales perceived *Fascination* (5 items) and *Being Away* (2 items) derived from the Perceived Restorativeness Scale (PRS) [24]. Reliability analysis showed that perceived fascination and being away had adequate reliability for both session 1 and 2 for the nature group (Cronbach's alpha = 0.68–0.93). For the indoor group reliability for Fascination was adequate for both sessions (Cronbach's alpha = 0.72–0.89), while it was quite poor for Being Away, especially in session 2 (Cronbach's alpha $\leq$0.55).

Blood Pressure (BP) was measured by the researchers the morning *after* each session (day1, day2 and day3) between 8:00 and 9:00 AM by automatic sphygmomanometer (MW701, Rossmax Medical, Berneck, Switzerland), after the subject was sitting quietly on a chair for five-minutes. Two measurements were performed (a third measurement was made only in case there was a difference >10mmHg between the measurements), at one minute apart, and mean was calculated.

Two measures of cortisol as an indicator of stress were used: Cortisol Awakening Response (CAR) and serum concentration. Saliva samples were self-administered by the subjects for the determination of the CAR the morning *after* each session. Saliva samples were collected by chewing a cotton swab (Salivette, Sarstedt, Numbrecht, Germany) over a 1-min period at three time-points after awakening (awakening, +15 minutes, +30 minutes). The *area under the curve with respect to increase* (AUC_I) and *area under the curve with respect to the ground* (AUC_G) were calculated as described elsewhere [25]. Cortisol levels in serum were measured by professional nurses through blood test the morning after each session between 8:00 and 9:00 AM (about 2-hours after awakening). Diurnal cortisol levels were also measured through multiple salivary samples at 15:00, 17:00 and 21:00 in all three experimental days (baseline and both exercise sessions) in order to control for possible anomalies of the hormonal production preceding the morning measurements of acute exercise effects [22]. All samples were stored in a –80°C within 24-hours from collection. All laboratory analyses have been performed at the Hormone Lab (Oslo University Hospital HF, Aker, Norway).

2.4.1. Control variables

Fitness and HR maximum (HR_{max}) were determined through a bike-ramp maximal test on cycle-ergometer (Lode BV, The Netherland) with measurements of respiratory gasses *breath by breath* using metabolic system Oxycon-Pro® (Oxycon Pro, Erich Jaeger, Germany). The individuals' oxygen uptake ($V{\cdot}O_{2max}$) absolute values were categorized for gender and age according to guidelines in use at the Norwegian Institute of Sport Medicine [26], which were preliminary controlled against recent data for Norwegian population [27]. HR_{max} was determined as the highest value +5. HR at rest was measured with the subject laying in semi-supine position for 10-minutes (mean of the values recorded in the last 5-minutes was calculated), in a day the subject did not engage in intensive PA.

The Godin's Leisure Time Exercise Questionnaire (LTEQ) [28] was used to determine individuals' habitual activity behavior. This instrument measured how often a subject engages in PA for at least 30-minutes within a typical week. Total time (in hours/week) was also measured. Our version of the LTEQ was controlled against Actigraphy data in preliminary measurements (Spearman's rho = 0.60) (data not reported).

The Connectedness to Nature Scale (CNS) was used [29] to control for the individuals' feeling of connectedness towards nature. CNS is 14-items scale consisting of statements to which the subject has to indicate degree of agreement on a 5-points Likert scale (1 = strongly disagree to 5 = strongly agree). The reliability of the scale was good (Cronbach's alpha = 0.85).

Socio-demographic information (gender, age, marital status, having small children at home, work percentage and education) were collected to control for possible differences between the two groups (data not reported).

2.5. Procedure

Before the intervention, all subjects filled in a preliminary questionnaire including i) socio-demographic information; ii) the CNS; iii) the PAAS in the mood form; and iv) the LTEQ. Afterwards, they underwent the fitness test. In day1, after the common dinner, before going home, they received a set of salivettes for the CAR measurement. The following day, between 8:00 and 9:00 AM, they met the researchers at agreed locations for delivery of the saliva samples, take the blood test and measurement of BP. On day 2 and 3 PAAS was administered before and after the exercise, while the subscales of PRS were administered at the completion of the exercise. Also these days the subjects received a set of salivettes for the CAR measurement and the same procedure was repeated for collection of these. Two and 10 weeks after the intervention, an e-mail was sent to all the participants asking to complete an on-line questionnaire consisting of PAAS, LTEQ and two items inquiring about the frequency the subjects engaged in the specific activities during the intervention (i.e. biking indoors, biking in natural settings and exercising with rubber bands).

2.6. Statistics

All statistics was performed by IBM SPSS Statistics 20. Preliminary analyses were performed, including exploration of the data for normal distribution and outliers. Outliers were removed only if the values were considered out of norm or associated with possible collection bias. Student's *t*-test on independent samples (two-tailed; after applying Levene's test of equality of variance) was performed to investigate possible differences between the groups before the intervention. Correlation (Pearson's *r*) between the dependent and control variables was also studied, as well as homogeneity of regression slope for possible covariates. Preliminary analysis was run to investigate possible interaction between group and time point (day 2 and 3), which was not shown. Intra-class Correlation Coefficient (ICC) between the different repeated measurements was also calculated to control that the measurements were actually correlated.

For each study variable an estimate of the fixed effect 'group' (indoor vs. nature) was performed using Linear Mixed-Effects Modelling (LMM) [30]. Major advantages of using linear mixed-effects modelling are that it takes into account the between and within individuals variations over time and it handles datasets with missing observations [31]. The measurements' time-points were set as repeated effect. For HR the repeated effect was 'exercise-bout' ('Biking bout/Strength bout'). For all post-exercise dependent variables (PRS subscales, PAAS components, BP and cortisol parameters) the repeated effect was 'Session' (exercise-session 1 and exercise-session 2). For PAAS components measured over the follow-up, the repeated effect was

'Follow-up week' (week-2 and week-10). The repeated measures were not set as a *fixed* effect, therefore the different time-points were collapsed together as an overall post-exercise effect. If assumptions for covariance were met, baseline values were set as covariates and random effects (Scaled identity used as type of covariance). For post-exercise Positive Affect, pre-exercise values were also independently set as random effect. CNS was considered as a covariate for Fascination and Being Away, but assumptions were not met. Data are presented as estimated marginal means and standard errors (EMM ± SE). Significance was set as $p \leq 0.05$.

3. Results

Negative Affect and Fatigue were excluded from the dependent variables because it showed very poor normality at all time-points. No significant differences across subjects were found for what concern the socio-demographic and physical characteristics (BMI, fitness, HR parameters, BP and Cortisol parameters) (Table 1). The subjects were found to be physically active, reporting in average 6.5 hours PA within a typical week (including walking and other forms of active transport), although with large inter-individual variations (see SD = 4.5 hours). CNS values were medium (3.35), with quite little inter-individual variation (SD = 0.55) and no differences between groups. The subjects had mean BP being 123/77 (systolic/diastolic BP), serum cortisol was 433.00 nmol/l, AUC_I was 31.98 and AUC_G was 542.63, although both the CAR measurements showed quite large inter-individual differences (SD = 124.97, 108.42 and 110.15, respectively).

No significant difference across groups were found for HR during the exercise (EMM ± SE: indoor group = 54.26 ± 2.01%; nature group = 55.52 ± 2.09%). Significant differences between groups were found for PRS

Table 1
Preliminary and baseline* measurements

	Mean value ± SD Overall sample (N = 14)	t-test between groups indoor vs. nature
Physical activity (hours/week)	6.46 ± 4.51	n.s.
Fitness	3.64 ± 0.84	n.s.
BMI	25.20 ± 2.47	n.s.
Connectedness to Nature Scale (CNS)	3.35 ± 0.55	n.s.
Heart Rate (HR), bpm		
HR_{max}	177.39 ± 60.87	n.s.
HR Baseline*	60.66 ± 4.66	n.s.
Physical Activity Affective Scale (PAAS)		
Pos. affect	2.88 ± 0.71	n.s.
Tranquility**	2.80 ± 0.59	n.s.
Blood Pressure (BP)*		
Systolic	123.06 ± 12.52	n.s.
Diastolic	77.64 ± 9.75	n.s.
Cortisol*		
CAR AUC_I	31.98 ± 108.42	n.s.
CAR AUC_G	542.63 ± 110.15	n.s.
Serum concentration (nmol/l)	433.00 ± 124.97	n.s.

**Baaseline measurements were performed in standardized conditions and time of day, with the subject abstaining from exercise or other intensive physical activity for at least 48-hours.* ***Tranquility was used for analysis and reported, although Cronbach's alpha showed low internal consistency. Fitness* = individuals' VO_{2max} absolute values, measured during incremental maximal test, were adjusted for and categorized for gender and age (see methods): 1 = 'very low'; 2 = 'low'; 3 = 'middle/average'; 4 = 'high'; 5 = 'very high'; 6 = 'top level'. *CNS* = Score ranging between one (very low feeling of connectedness to nature) and five (very high feeling of connectedness to nature). *PAAS* = PAAS consists of 12 items, four for each component, consisting of affective states such as "exhausted", "relaxed", "optimistic", and "enthusiastic" measured on a 5-point Likert scale (0 = strongly disagree; 4 = strongly agree). HR_{max} = Derived from HRpeak measured during incremental maximal fitness test (HRpeak +5). *HR Baseline* = Measured between 15:00 and 16:00, within a 5-minutes span after 5-minutes of stabilization, with subjects in semi-supine posture. *Blood Pressure (BP)* was measured between 8:00 and 9:00 AM (about two hours after awakening). *CAR* = Cortisol awakening response; it was measured with three saliva points within 30 minutes after awakening. AUC_I = Area under the curve with respect to the increment. AUC_G = Area under the curve with respect to the ground. AUC_I and AUC_G were calculated from three repeated cortisol measurements using the formulas presented by Pruessner et al. (2002) [25]. *Cortisol serum concentration* = Measured by blood test taken between 8:00 and 9:00 AM (about two hours after awakening).

components in both exercise sessions (Table 2), with the nature groups scoring higher ratings for both, Fascination ($p < 0.01$ in both exercise-sessions) and Being Away ($p = 0.01$ and $p < 0.01$ in the first and second exercise-session, respectively). Concerning the PAAS components, a significant effect of group was found for Positive Affect when corrected for baseline values, with higher ratings reported by the nature group (Table 2). However, the effect was only marginally significant ($p = 0.06$) when the POST-exercise values were corrected for PRE-exercise values. No effect of group was found for Tranquility. As compared to the indoor group, the nature group had reduced BP values after the exercise sessions, although significance, although marginal ($p = 0.05$), was achieved only for diastolic BP (Table 2). The nature group had also improvements in CAR AUC_I ($p = 0.04$), showing smaller increments than the indoor group (Table 2). No significant differences between groups were found for CAR AUC_G and cortisol concentration in serum (Table 2).

Overall, eleven subjects responded to the follow-up, with eight subjects responding to both the time-points and three subjects responding only to either the first or the second. The subjects who participated in the nature intervention reported that they tended to engage more often in the activities they were taught during the intervention, such as biking in natural settings, as compared to those who participated in the indoor intervention (data reported elsewhere [32]). At the same time, the nature group was found to score higher ratings of Positive Affect ($p = 0.02$) than the indoor group, while significant differences were not found for Tranquility (Table 3).

4. Discussions

The aim of this study was to investigate the effects of green-exercise on self-reported affective states and physiological indicators of stress among employees.

Table 2
Outcomes of an estimates of fixed effect using linear mixed-effects modelling on psychological and physiological indicators of stress measured during an exercise intervention in workplace, with exercise sessions indoors or outdoors in natural environment ($N = 14$)

Variable	EMM±SE		p	F	B	95% C.I.	
	Indoor group	Nature group				Lower bound	Upper bound
PRS							
Fascination	1.90 ± 0.42	6.54 ± 0.42	<0.001	58.16	–4.64	–5.89	–3.39
Being Away*	4.82 ± 0.40	7.75 ± 0.40	<0.001	27.06	–2.93	–4.90	–1.77
PAAS (post-exercise)							
Pos. Affect[a]	2.79 ± 0.10	3.50 ± 0.11	0.001	20.46	–0.66	–0.99	–0.33
Pos. Affect[b]	2.91 ± 0.13	3.31 ± 0.14	*0.06*	4.28	*–0.40*	*–0.82*	*0.018*
Tranquility	3.41 ± 0.13	3.42 ± 0.13	n.s.				
Blood Pressure							
Systolic[a]	122.28 ± 2.83	119.99 ± 2.85	n.s.				
Diastolic[a]	78.28 ± 1.70	72.96 ± 1.71	0.05	4.91	5.32	–0.12	10.75
Cortisol							
CAR AUC_I[a]	67,23 ± 23.79	10.56 ± 27.93	0.04	4.56	77.78	2.34	153.23
CAR AUC_G[a]	583.10 ± 52,0.81	551.01 ± 53.78	*n.s.*				
Serum[a]	343.78 ± 20.20	362.92 ± 21.87	n.s.				

**Being Away was used for statistics and values are reported, although internal consistency for the indoor group was insufficient (Cronbach's alpha ≤0.55).* [a]The dependent variables were corrected for individual scores measured at preliminary the intervention, which was set as a random effect. [b]The dependent variables were corrected for individual scores measured pre-exercise, which was set as a random effect.

Table 3
Outcomes of an estimates of fixed effect using linear mixed-effects modelling on self-reported mood and physical activity over a 10-week follow-up period after participating in an exercise intervention in workplace, with exercise sessions indoors or outdoors in natural environment ($N = 11$)

Variable	EMM±SE		p	F	B	95% C.I.	
	Indoor group	Nature group				Lower bound	Upper bound
Pos. Affect[a]	2.82 ± 0.11	3.21 ± 0.10	0.02	7.43	–0.40	–0.71	–0.09
Tranquility[a]	3.00 ± 0.17	3.15 ± 0.15	n.s.	0.39			

[a]The dependent variable was corrected for individual scores measured at preliminary the intervention (baseline), which was set as a random effect.

We found that the exercise in the two environments was overall fairly equivalent in terms of total workload. The participants assigned greater potential for restoration to the nature exercise-environment than the indoor exercise-environment, which was associated with greater psychological benefits at post-exercise for the nature group, with higher ratings of Positive Affect as compared to the indoor group. Furthermore, some improvements of BP and CAR profiles were observed, although they were somewhat weak. These findings provide novel insights concerning methods to study the health effects of green-exercise. Furthermore, they indicate that green-exercise interventions in the workplace can have the potential to impact employees' health, reducing the psychological and physiological burdens of experience of stress and mental fatigue. Especially, reduced CAR and morning BP measured 16-hours after the exercise indicates medium/long-term effects of the organic stress response potentially able to chronically impact the employees' stress and health status. Not least, the pleasant feelings that one can experience while engaging in green-exercise might motivate the employees to keep choosing exercise-environments with greater restorative potential on a regular basis, perpetuating the stress-relieving benefits in the long term. In fact it has been previously observed that exercise environment can impact one's affective responses to exercise as well as one's intention to engage in exercise in future [33].

The type of PA intervention used in this study was a novelty. In most of the previous studies the PA mainly consisted of simpler activities, such as walking or running at a comfortable pace, which allows the participants to have a main focus of attention on the external environment. It is therefore not yet clear if engaging in physical activities that require a major attention on the motor control could somehow interfere with attention-restoration mechanisms. In this study, the PA consisted of a complex program including activities that require a major focus of attention on performing the task, as compared to simpler activities such as walking. General guidelines for physical activities highlight the importance of including strength conditioning for all major muscular groups within an exercise program [20], and this is especially important for office based employees who are often subjected to back/neck pain [34].

Although the results of this study cannot be generalized due to the small sample size, the study shows encouraging findings regarding novel methodologies and unexplored mechanisms underlying the health effects of green-exercise, especially concerning CAR as a physiological indicator of stress. The range of increment of cortisol levels after awakening is believed to be the most reliable indicator of the activation of the hypothalamic-pituitary-adrenal axis [35], with smaller increments and faster decrements indicating lower stress burden. In our study, the serum cortisol levels measured at 8:00–9:00 (about 2-hours after awakening) showed no differences across groups. However, the participants in the nature group had higher levels of salivary cortisol upon awakening (first sample) than those in the indoor group, followed by a rapid reduction within the first 30-minutes after awakening. Contrary to this, the overall slope of increment for the indoor group appeared to be un-altered as compared to baseline (Fig. 4). Altogether, this finding corroborated that the nature group tended to have a more rapid drop of the cortisol levels overall, indicating a lower stress burden. Although positive effects of green-exercise interventions on cortisol [17, 36] and blood pressure [17, 18] have been previously described, up to date these findings remain somehow inconclusive [6]. In these studies cortisol and BP have been mainly measured shortly after exercise, often not taking into account the circadian fluctuation of both cortisol production and BP values, nor acute responses to exercise. Such methodological approach might lead to bias. Also, it does not conclusively define to what extent green-exercise can impact an individual's allostatic load in medium-long term and health risk connected to chronic exposure to stress. In the Authors' best knowledge, this is the first study using CAR to assess the impact of green-exercise on individuals' allostatic load. Furthermore, our design also highlights potential mechanisms that may underlie health effects in the long-term, and not only in the immediate post-exercise.

4.1. Strengths and limitations

The main aim of this study was to explore the method and possible effects to be applied on larger studies and longer interventions. Especially, the advantage of a small-N and short intervention study consisted in having a better control over possible confounding variables, and explored more closely physiological responses to the intervention. Although this was not purely a laboratory-based study, we were able to create quite controlled conditions, for example limiting exercise behaviors, and to a certain extent, controlling the food intake in concomitance with the measurements.

The major limitation of this study is that due to a small-sample size, the generalizability of the results is

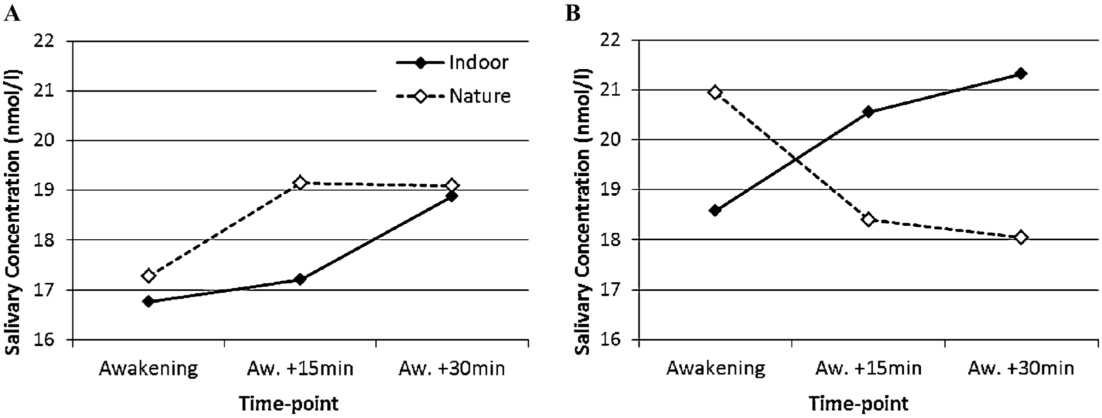

Fig. 4. Salivary cortisol measured within 30-minutes from awakening in 14 employees at baseline (A) and after participating in exercise program indoors or in nature setting (B). A. Values are reported as EMM. Samples were collected during a working-day (Friday), with the subjects abstaining from physical exercise for at least 48-hours. B. Values are reported as EMM, corrected for individuals' values at baseline. Samples were collected the mornings after two exercise sessions (Wednesday and Friday). ICC between the two exercise sessions was 0.68.

quite limited. Using a between-subjects design represented a further limitation. However, a within-subjects design was preferred as in previous studies it was shown that nature-based interventions can have long lasting effects on physiological parameters [16], possibly leading to misleading results if a cross-over design is applied. Furthermore, we were interested in carrying out follow-up measurements to investigate possible difference between the participants in the two different interventions.

Other limitations need to be addressed. One is the challenging task to compare PA in such different exercise-environments. While exercising with elastic rubber bands is easily reproducible in indoor and outdoor settings, biking outdoors on track has intrinsic differences as compared to indoor biking. Especially, outdoor biking involves a major recruitment of muscles from the upper-body due to need of maintain balance and ride the bike. Furthermore, variation of scenery and optical perceptions, are issues that differentiate greatly during indoors or outdoors biking. Although we carried out a number of preliminary experimentations to test the feasibility of making the indoor and the outdoor biking as similar as possible in terms of workload, we used only HR monitoring and perceived exertion as a controller of workload. Including other measurements such as recording the pedaling cadence and use of power-meter can allow for a better evaluation of the workload. The greater psychological and physiological effects that we have observed in the nature group could therefore also be associated with other factors than just the exposure to nature.

For practical reasons, we had to explain the general structure of the experimentation to the employees who volunteered in our intervention, although the underlying research question and hypothesis were not disclosed. This may have led to a self-selection phenomenon, i.e. only individuals interested in participating in an indoor or outdoor exercise agreed to participate. Furthermore, the subjects in the nature group were allowed to use their own bikes. This may have triggered an anticipated effect on the psychological responses. In fact the between-groups difference in Positive Affect was smaller when correcting for pre-exercise values than baseline values. Although often, when studying workplace interventions, subject blinding is not possible, this limitation have to be taken into account when interpreting the results.

Another limitation of the study is that mental fatigue was not directly measured, while only the environmental potential for restoration was assessed. Furthermore, we found the scale for Being Away had quite a low reliability when administered indoors. In future studies, all these limitations concerning the protocol and the instruments need to be addressed.

4.2. Practical implication

Overall, we received positive feedback from the participants, and we did not experience any drop-out during the exercise program, although drop-outs occurred during the follow-up period. Green-exercise interventions may not be easy to implement in all workplaces. Weather conditions and perceived safety are important constraints on employees' participation in green-exercise interventions [37], and many may prefer to exercise indoors as they perceive it more comfortable and safe. It is therefore important when implementing green-exercise interventions in workplaces to consider these challenges and plan a reasonable organization that includes information about the added benefits of exercising in natural environments. Different types of green-exercise intervention could be organized, ranging from 'walking-groups' to more complex exercise programs. Especially, circuit-strength training like the one used for this study presents several advantages, such as providing complete exercise conditioning and not requiring expensive equipment or large locations. Another challenge in implementing green-exercise interventions for employees is the availability of quality natural environments nearby the workplace. Green-exercise interventions could be organized as occasional happenings (e.g. a 'kick-off' happening), with the goal of educating the employees in self-managing their own exercise in natural environments.

4.3. Conclusions

This pilot study provides insights of methods and practice for future studies on health-impact of green-exercise interventions in the workplace. Furthermore, it also provides some evidence that green-exercise interventions in the workplace can be a more valuable resource than 'traditional' indoor exercise in promoting health among employees, especially reducing psychological as well as physiological stress. We recommend that further studies make use of psychophysiological indicators of stress such as CAR. Measurements of mental fatigue and/or cognitive performance could also be used to better define long term effects on work productivity and health.

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