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Natural outdoor environments and mental health: Stress as a possible mechanism

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ABSTRACT

Introduction: Better mental health has been associated with exposure to natural outdoor environments (NOE). However, comprehensive studies including several indicators of exposure and outcomes, potential effect modifiers and mediators are scarce.

Objectives: We used novel, objective measures to explore the relationships between exposure to NOE (i.e. residential availability and contact) and different indicators of mental health, and possible modifiers and mediators.

Methods: A nested cross-sectional study was conducted in: Barcelona, Spain; Stoke-on-Trent, United Kingdom; Doetinchem, Netherlands; Kaunas, Lithuania. Participants' exposure to NOE (including both surrounding greenness and green and/or blue spaces) was measured in terms of (a) amount in their residential environment (using Geographical Information Systems) and (b) their contact with NOE (using smartphone data collected over seven days). Self-reported information was collected for mental health (psychological wellbeing, sleep quality, vitality, and somatisation), and potential effect modifiers (gender, age, education level, and city) and mediators (perceived stress and social contacts), with additional objective NOE physical activity (potential mediator)

Abbreviations: NOE, natural outdoor environments; NDVI, Normalized Difference Vegetation Index; IQR, interquartile range; SF-36, 36-item Short Form Health Survey Questionnaire; 4DSQ, four-dimensional symptom questionnaire

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derived from smartphone accelerometers.
Results: Analysis of data from 406 participants showed no statistically significant associations linking mental health and residential NOE exposure. However, NOE contact, especially surrounding greenness, was statistically significantly tied to better mental health. There were indications that these relationships were stronger for males, younger people, low-medium educated, and Doetinchem residents. Perceived stress was a mediator of most associations, and physical activity and social contacts were not.
Conclusions: Our findings indicate that contact with NOE benefits mental health. Our results also suggest that having contact with NOE that can facilitate stress reduction could be particularly beneficial.

1. Introduction

Existing evidence shows that exposure to natural outdoor environments (NOE) is beneficial for human health, including mental health (Carter and Horwitz, 2014; Richardson et al., 2013; Sturm and Cohen, 2014; Triguero-Mas et al., 2015; de Vries et al., 2013). Few studies in this area have focused on more than one aspect of mental health (van den Berg et al., 2016; Triguero-Mas et al., 2015). There has also been a common focus on mental health benefits of green space or blue space (i.e. sea, lakes, rivers, etc.). Researchers have rarely considered the potentially beneficial role of all NOE (an exception is Richardson et al., 2013). Moreover, the choice of NOE exposure indicators (e.g. surrounding greenness availability around residence, contact with green and/or blue spaces, etc.) and related implications for the NOE-mental health association remain unclear. This could have implications when investigating the links, underlying mechanisms and potential differences by social group (for an overview and a framework see Hartig et al., 2014).

In terms of the social patterning of NOE-health relationships, some findings suggest that people of low socioeconomic status (SES) may benefit more from NOE exposure (van den Berg et al., 2016; Dadvand et al., 2012a, 2012b; McEachan et al., 2015; de Vries et al., 2003). Other studies suggest that the health benefits of NOE vary by gender, age and cultural background (Astell-Burt et al., 2014; Dadvand et al., 2014). Yet, these differences are not well-established for mental health outcomes given the small number of studies exploring them (van den Berg et al., 2016; McEachan et al., 2015; Triguero-Mas et al., 2015; de Vries et al., 2003).

In terms of the mechanisms thought to explain the NOE-health relationship, reduction of stress, increased social interactions and increased physical activity have all been suggested as possible mechanisms underlying physical and mental health benefits of NOE (Hartig et al., 2014; Markevych et al., 2017). To date, the evidence on whether physical activity lies on the mechanistic path is mixed, while the evidence for stress and social interactions is reduced but consistent (Markevych et al., 2017).

This study aimed to explore: (i) the associations between NOE exposure (including both residential availability and contact with NOE) and mental health; (ii) whether these relationships were modified by gender, age, education, and city; and (iii) whether stress, social contacts or physical activity mediated these associations.

2. Methods

2.1. Study population

The Positive Health Effects on the Natural Outdoor environment in TYPical populations of different regions in Europe (PHENOTYPE) project aimed to investigate some of the mechanisms underpinning the commonly observed NOE-health relationships (Nieuwenhuijsen et al., 2014). PHENOTYPE collected data from four European cities: Barcelona (Spain), Stoke-on-Trent (United Kingdom), Doetinchem (The Netherlands) and Kaunas (Lithuania). Cities were selected to represent different European regions. The high-intermediate population density of these cities exemplified the type of area where most of Europeans live. Moreover, these cities provided diversity in typology, size and amount of NOE (Nieuwenhuijsen et al., 2014; Smith et al., 2017).

Data reported here were collected from a subsample of participants from a larger study (Nieuwenhuijsen et al., 2014). In the larger study, study neighbourhoods were selected in each city, sampled to maximise variability in residential availability of NOE and neighbourhood socioeconomic status (described in detail elsewhere (Smith et al., 2017)). Within each neighbourhood, adults (18–75 years) were randomly recruited to participate in a face-to-face survey (n = 3946). All the 3946 participants were invited to take part in another part of the study. Those interested were included in the present study if they were able to walk 300 m on ground level. The only exception to this sampling approach was in Stoke-on-Trent, where further mail shots to randomly selected households in the study neighbourhoods and opportunistic sampling within the area were required to boost the sample (see Supplemental material - Table S1). As a result, approximately half of Stoke-on-Trent participants were from the original random sample. The final study sample was 406: Barcelona (n = 107), Stoke-on-Trent (n = 90), Doetinchem (n = 105), and Kaunas (n = 104) inhabitants.

The study was conducted in accordance with Declaration of Helsinki principles. Ethical approvals were obtained from each of the relevant bodies: Clinical Research Ethics Committee of the Municipal Health Care (CEIC PS-MAR), Barcelona, Spain (2012/4978/I); Staffordshire University Faculty of Health Science ethics committee, United Kingdom; Medical Ethical Committee of the University Medical Centre Utrecht, Netherlands; Lithuanian Bioethics Committee, Lithuania (2012-04-30 Nr. 6B-12–147). Moreover, all participants provided written informed consent before taking part. Each participant received financial compensation on completion of the study (retail voucher or money depending on the country).

2.2. Design

Participants were asked to complete a daily diary and wear a smartphone with the CalFit application installed for seven consecutive days. The start (and finish) day of the study was always a weekday.

In the daily diary participants were asked to record the time periods when they had not worn the smartphone and the activities they undertook during those periods. They were also asked to complete a series of questions in the morning when they started to wear the smartphone (questions on psychological wellbeing, somatisation, vitality, and sleep quality) and in the evening when removing the smartphone (psychological wellbeing, somatisation, vitality).

Each participant carried the smartphone on a belt attached to the waist. Instructions were given to each participant to remove the belt only when performing activities that could damage the smartphone (e.g., aquatic activities), when sleeping, and when charging the smartphone battery. The open-source CalFit software runs on Android operating system smartphones. CalFit uses the Global Positioning System (GPS) receivers in smartphones to collect information on location. This information was treated to determine the contact with NOE (Supplemental material - page 5). CalFit uses the accelerometer motion sensor to collect valid information on physical activity (Donaire-Gonzalez et al., 2013; de Nazelle et al., 2013; Triguero-Mas et al., 2017) and to determine non-wear time. Wear-time of at least 10 h per day was