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Research Paper

Restorative benefits of everyday green exercise: A spatial approach

Anna Kajosaari[a,*], Tytti P. Pasanen[b,c]

[a] Department of Built Environment, Aalto University, Espoo, PO Box 14100, 00076 Aalto, Finland
[b] Finnish Institute for Health and Welfare, Helsinki, Finland
[c] Faculty of Social Sciences, Psychology, Tampere University, Tampere, Finland

HIGHLIGHTS

- We employ PPGIS methods to study restorative experiences in real life physical activity environments.
- Spatial approaches help to translate evidence of the health benefits of green exercise to urban planning.
- Exercising in natural environments and in blue spaces is strongly associated with restorative benefits.

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ABSTRACT

Contact with green space has been associated with diverse beneficial impacts on human health. Studies focusing on green exercise suggest that physical activity undertaken in green environments provides more mental health benefits than physical activity in indoor or other outdoor settings. However, this evidence is largely based on experimental field studies that control the participants' contact with green space, while there is a lack of evidence that the real-life settings for green exercise promote mental health. This study applies a spatial approach using public participation GIS (PPGIS) methods to explore the perceived restorative outcomes of diverse outdoor physical activity environments. The data were collected in the Helsinki Metropolitan Area, Finland, with a map-based online survey directed to adults aged 18–65 years ($n = 760$). Perceived restoration was measured with three variables; stress reduction, relaxation, and nature enjoyment. Logistic regression analyses revealed significant differences in the perceived restoration outcomes between diverse outdoor physical activity environments. Stress reduction and relaxation during physical activity were most likely to be experienced near blue spaces and in large (>30 ha) urban and recreational forests, while nature enjoyment was associated with natural environments of all sizes. The results of this study suggest that exercising in blue spaces and in large natural areas provides additional restorative benefits compared to exercise undertaken in built outdoor environments. These results support a synergistic conception of urban health that acknowledges the diversity of health benefits provided by public open spaces, in particular blue and natural green settings.

1. Introduction

Contact with green space, such as urban parks and forests, has been linked to several beneficial impacts on human health. These include restorative benefits related to attention restoration and stress recovery (Hunter, Gillespie, & Chen, 2019; Bowler et al., 2010), lower levels of air and noise pollution, increased physical activity, and positive impacts on social cohesion (Hartig et al., 2014; Hartig, Evans, Jamner, Davis, & Arling, 2003; Markevych et al., 2017; Sugiyama, Carver, Koohsari, & Veitch, 2018). Additionally, the possible synergies between the different health benefits have received increasing interdisciplinary research interest. Evidence from studies focusing on green exercise, i.e., physical activity undertaken in green and natural settings, suggests that green exercise may be more positively associated with mood enhancement and emotional well-being than physical activity indoors (Hug et al., 2009; Thompson Coon, Boddy, Stein, Whear, Barton, & Depledge, 2011) or in other outdoor settings (Barton & Pretty, 2010; Mitchell, 2013; Pasanen, Tyrväinen, & Korpela, 2014). These positive effects have been reported particularly in association with exercising in natural environments (Mitchell, 2013; Pasanen et al., 2014) and near blue spaces, such as lakes and coastal areas (Barton & Pretty, 2010; White, Pahl, Ashbullby, Herbert, & Depledge, 2013), and with varying types of positive feedback on

* Corresponding author.
E-mail addresses: anna.kajosaari@aalto.fi (A. Kajosaari), tytti.pasanen@thl.fi (T.P. Pasanen).

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mental health. Green spaces and other natural settings are, accordingly, visited due to lower levels of environmental and social stressors such as noise, traffic, and other people (Pasanen, Neuvonen, & Korpela, 2018). These type of motives have been characterized as 'push' motives for visiting natural settings (Knopf, 1987). However, absence of stressors does not fully explain the restorative benefits associated with green and natural settings, but their restorative qualities have also been attributed to 'pull' factors, that is, positive, engaging aspects of nature such as pleasant aesthetic experiences (Hartig et al., 2014). In practice, these 'push' and 'pull' motives are, however, likely to intertwine (Hartig et al., 2014; Knopf, 1987).

Accounting for synergies between physical activity, green and natural environments, and mental health poses both challenges and opportunities for spatial planners aiming to promote population health through urban planning and built environment interventions. However, most of the evidence on the beneficial impact of green exercise on mental health is based on experimental field studies with relatively small sample sizes that control the participants' contact with green space (Barton & Pretty, 2010; Bodin & Hartig, 2003; Pretty et al., 2007; Thompson Coon et al., 2011) while research on the mental health benefits of green exercise in the everyday life of urban residents remains limited. The few studies focusing on the mental health benefits of green exercise in everyday life generally support observations from experimental studies, highlighting the restorative benefits of exercising in natural outdoor environments. A study by Mitchell (2013) took a population-level look into green exercise, and observed that physical activity in natural settings was associated with a greater reduction in the risk of poor mental health than physical activity in indoor or other outdoor settings. Pasanen, Ojala, Tyrväinen, and Korpela (2018) likewise studied the restorative effects of physical activity in diverse environments, reporting that physical activity in natural outdoor settings was experienced to be more restorative than physical activity in indoor or built outdoor settings. However, instead of spatially locating the physical activity environments, both studies relied on the respondents' own evaluations on the type of physical activity settings. These environmental evaluations, such as the types of outdoor settings that are considered 'natural' or 'built', are often subjectively and culturally biased, which complicates the translation and application of these kind of results into urban planning (Hartig et al., 2014).

Despite the growing empirical evidence on the health benefits of green exercise, few studies to date have studied the mental health benefits of green exercise with spatially explicit methods or technologies. While the existing evidence on the health benefits associated with green and natural environments can support strategic aims of urban planning, it only weakly supports the knowledge requirements of urban and land-use planning practice and the development of recreational environments. In this respect, Markevych et al. (2017) emphasize the need for research focusing on green spaces and health in order to provide knowledge on the accessibility, quality, size, and usage patterns which can then be applied in planning scenarios aiming to identify and maximize the health benefits gained by built environment interventions. Concerning research on the health benefits of green exercise, this means more detailed knowledge about the environmental settings that provide synergies between physical activity and aspects of mental health. Thus, following recommendations of Markevych et al. (2017), we identify two key methodological aims for research on green exercise in order to better facilitate translating evidence on the restorative benefits of green exercise into urban planning practice, namely 1) identifying environmental settings for physical activity that are perceived as particularly restorative by different users, and 2) identifying objective environmental measures and thresholds that promote both physical activity and mental health, and which are transferrable to planning practice, such as land-use type, area, accessibility, and related spatial measures.

This study addresses the gaps identified in the green exercise literature by introducing a spatial framework for the analysis of perceived restoration of outdoor physical activity environments. While the use of GPS and related geospatial methods help with locating physical activity settings, research focused on the mental health benefits of green exercise is faced with the methodological challenge of combining this spatial data with knowledge on perceived environmental quality. In this study, we employ public participation GIS (PPGIS) methods in order to bridge this gap between environmental perceptions and spatially located behavioral data. Focusing on the leisure-time physical activity (LTPA) behavior of adults living in the Helsinki Metropolitan Area, Finland, we identify and typologize real-life settings for outdoor LTPA employing GIS methods, and study associations between these objectively measured built environmental characteristics and perceptions of the restorative benefits gained in these settings. Lastly, we discuss the practice and policy implications of the results focusing on planning for health-supportive urban environments.

2. Methods

2.1. Mapping perceived restoration with PPGIS

PPGIS refers to a growing field of participatory planning and research methods used to study of person-environment interactions (Brown & Kyttä, 2014). Common to these methods is the aim to capture spatial knowledge produced by non-expert participants based on their own experience and expertise of their lived environment. In contrast to conventional participatory mapping methods, contemporary applications of PPGIS use digital tools for data collection (Brown & Kyttä, 2014). This enables large-scale data collection, as well as the joint analysis of primary spatial data produced by respondents together with secondary sources of geographic data, such as land-use, georeferenced census data, or planning documents. PPGIS methods are applied in various fields for locating and communicating place-based experiential knowledge from respondents and residents. Applications focusing on green and natural environments include, for example, studies mapping the perceived health benefits of urban parks (Brown, Rhodes, & Dade, 2018; Brown, Schebella, & Weber, 2014), values attached to urban green spaces (Ives et al., 2017; Pietrzyk-Kaszyńska, Czepkiewicz, & Kronenberg, 2017; Tyrväinen, Mäkinen, & Schipperijn, 2007), positive and negative urban experiences (Laatikainen, Broberg, & Kyttä, 2016; Samuelsson et al., 2018), and urban ecosystem services (Brown & Fagerholm, 2015).

2.2. Study procedure and survey structure

The data were collected between August and September 2018 in the Helsinki Metropolitan Area, Finland, which consists of the municipalities of Helsinki, Espoo, Vantaa, and Kauniainen. With 1.2 million inhabitants, the Helsinki Metropolitan Area is the largest urban area in Finland (Official Statistics of Finland OSF, 2019a). A random sample of 10,000 inhabitants living permanently in this area and aged 18 to 65 years was obtained from the Finnish Population Register Centre. The sample members received a letter of invitation to participate in the online survey, followed by a reminder post card.

The online survey included sections on personal characteristics, self-rated health, and physical activity behavior. Some items were not relevant to this study and are thereby not reported here. The main mapping activity in the survey requested the respondents to identify locations they frequently visit for LTPA. Respondents were instructed to think of all the places that they frequently visit for LTPA in the time of the year of the data collection and to locate them in the survey's mapping view. For each mapped location, the respondents indicated the approximate *visiting frequency* (converted into times visited per month during data analysis), *level of PA* (moderate or vigorous), typical *travel mode* to the location (active transport, public transportation or car), and whether the activity took place in an indoor or outdoor setting. Additionally, the respondents were asked to evaluate the LTPA location and to assess whether the environment had restorative qualities (described in detail in section 2.3.1.).

2.3. Measures

2.3.1. Outcome variables

Three variables were used to measure the perceived restorative outcomes of the LTPA environments. Following Hartig et al. (2014), we identified restorative benefits both in relation to decreased amount of stressors (stress reduction) and the positive effect that contact with nature and green spaces may have in restoring adaptive resources (relaxation, nature enjoyment). These restorative effects were operationalized for mapping following Brown et al. (2018) as the following variables:

- *Relaxation* – “Environments that help me to relax”
- *Stress reduction* – “Environments that help me to escape stress”
- *Nature enjoyment* – “Environments where I enjoy nature and the outdoors”

For each mapped location, respondents expressed their agreement with the above restorative statements on a binary scale (“yes/ no”), resulting in three binary outcome variables describing whether or not the respondent associated restorative health benefits with the mapped LTPA location.

2.3.2. Built environment characteristics of outdoor LTPA settings

GIS overlay analyses (ArcMap 10.6, Esri Inc., 2018) were used to identify the predominant land-use around each LTPA location, resulting in a typology of outdoor LTPA environments in the study area (Table 1). Each mapped location was assigned to only one environment type to facilitate comparison with previous studies and translation of the results into planning practice. With the mental health benefits associated especially with blue spaces (Barton & Pretty, 2010; de Bell, Graham, Jarvis, & White, 2017; de Vries et al., 2016; White et al., 2013), all LTPA locations located in the immediate vicinity (<50 m) of water bodies were categorized as blue spaces. LTPA locations situated in outdoor sports facilities, such as sport fields and tracks, were categorized in their own category, because these areas facilitate a specific range of activities (Brown, Schebella, & Weber, 2014; Mitchell, 2013). LTPA locations situated in public green space were divided into two main categories (McMahan & Estes, 2015): LTPA in maintained public green space, such as parks and public gardens, and LTPA in natural environments, such as forest, wetlands, and similar habitats. These natural environments were divided into three subcategories based on the size of the natural green space and the LTPA locations’ remoteness from residential development, which may affect their accessibility and suitability for PA (Giles-Corti et al., 2005; Jansen, Ettema, Kamphuis, Pierik, & Dijst, 2017): small (≤30 ha) urban forests, large (30–150 ha) urban forests, and large (>150 ha) recreational forest areas (including, for example, Nuuksio and Sipoonkorpi National Parks) (Table 1). Last, the remaining LTPA locations situated predominantly on walkways and in residential areas with no direct contact to green land-use or blue spaces were categorized as “other built outdoor environments”.

2.3.3. Covariates

To take account of variation in the respondents’ physical activity levels and in its effect on perceived restorative benefits, the analyses controlled for the total number of outdoor physical activity locations mapped by each respondent and the combined amount of self-reported moderate-to-vigorous LTPA and transport-related PA (based on the long form of the International Physical Activity Questionnaire (Craig et al., 2003). Weekly MET-minutes (metabolic equivalent of task) were calculated according to the IPAQ scoring protocol (IPAQ Research Committee, 2005). For example, a minute of walking was estimated to equate to 3.3 MET-minutes and a minute of vigorous-intensity PA (e.g., jogging, swimming) to 8.0 MET-minutes. Due to large variance, MET-minutes were transformed into weekly MET-hours for the logistic regression analysis. The accessibility of the LTPA locations was measured as street-network distance from the residential location. The usual travel mode to LTPA location (motorized / active) was likewise controlled for.

On the individual level, the analyses controlled for gender and age (measured in years). Socio-economic indicators, namely household income, occupation (employed, student, unemployed, or other) and education, were excluded as they had a large number of missing values (see Table 2). However, an additional analysis was conducted to ensure that their exclusion did not change the main results (results provided in Appendix A).

2.4. Data analysis

Prior to fitting a more comprehensive model, bivariate relationships between the LTPA environments, covariates and outcomes were assessed with the chi-square test for categorical variables and Kruskal-Wallis test for continuous variables. Logistic regression models were fitted to the three restorative outcomes (relaxation, stress reduction, and nature enjoyment) with the LTPA environment type as the explanatory variable, controlling for the covariates in Section 2.3.

The mapped locations were the unit of analysis used in the dataset. As a single respondent could have mapped several locations and the same locations could have been mapped by several respondents, the data contained two potential sources of non-nested clustering. We ran initial models only taking into account clustering on the respondent level, and inspected the model residuals for the presence of spatial autocorrelation using the global Moran’s I statistic with inverse Euclidean distance and a

Table 1
Typology of LTPA environments.

Outdoor LTPA environment	Description
Blue spaces	All LTPA locations situated within 50 m of sea, river, or lakeside
Outdoor sports facilities	LTPA locations in or within a 50 m buffer distance from sport and recreational land-use (Topographic database 2018, National Land Survey of Finland)
Maintained urban green space	LTPA locations on park and garden land-use (Topographic database 2018, National Land Survey of Finland)
Small urban forests	LTPA locations within forest and semi natural areas with an area of ≤ 30 ha (CORINE Land Cover 2018, class 3), and located within 500 m of residential land-use (CORINE Land Cover 2018, class 11)
Large urban forests	LTPA locations in forest and semi natural areas with an area of > 30 ha and ≤ 150 ha (CORINE Land Cover 2018, class 3), and located within 500 m of residential land-use (CORINE Land Cover 2018, class 11)
Large recreational forests	LTPA locations in forest and semi natural areas with an area of > 150 ha (CORINE Land Cover 2018, class 3), and LTPA locations in forest and semi natural areas located further than 500 m from residential land-use (CORINE Land Cover 2018, class 11)
Built outdoor environments	All remaining LTPA locations, situated on walkways and in residential areas with no direct contact to green or blue spaces

Table 2
Socio-economic and demographic characteristics of the survey respondents.

	n	Mean (SD) or %
Gender		
Female	412	52.4
Male	334	43.9
Missing	14	3.7
Age, in years		
18–29	168	22.1
30–39	154	20.3
40–49	133	17.5
50–59	183	24.1
60–65	113	14.9
Missing	9	1.2
Educational level		
University degree[a]	390	51.3
Lower	263	34.7
Missing	107	14.1
Employment status		
Employed	447	58.8
Retired	48	6.3
Student	102	13.4
Unemployed	34	4.5
Other	27	3.6
Missing	102	13.4
Household monthly gross income		
< 1,500 euros	97	12.8
1,500–3,000 euros	215	28.3
3,001–4,500 euros	169	22.2
4,501–6,000 euros	109	14.3
> 6,000 euros	104	13.7
Missing	66	8.7
Self-reported PA, MET-minutes / week[b]	712	2,801 (2,039)

[a] Including undergraduate, graduate and postgraduate degrees.
[b] Including moderate-to-vigorous LTPA and transport-related PA.

threshold value of 1 km (ArcMap 10.6, Esri Inc., 2018). Spatial clustering was observed for residuals of the models for stress reduction (Moran's I = 0.0439) and nature enjoyment (Moran's I = 0.0869). In order to account for the spatial autocorrelation, clusters of point data were identified and included as a clustering variable in the logistic regression models. Clusters were formed using density-based clustering with a minimum of two point features per cluster. This method was chosen as it is well-suited for detecting linear clusters following coastlines and green corridors (Laatikainen, Piiroinen, Lehtinen, & Kyttä, 2017). The average distance between each mapped point feature and its nearest neighbor was 286 m, which was identified as a suitable distance band value (i.e., the maximum distance between points within a cluster). Altogether 176 clusters were identified. Points with no cluster membership ($n = 373$) were treated in the analysis as individual clusters.

As a result, the standard errors of the logistic regression models needed an adjustment for clustering on both the respondent and the spatial level (McNeish, Stapleton, & Silverman, 2017). Accordingly, the models were fitted using the 'logitor' function in package 'mfx' (Fernihough, 2019) in R version 3.6.0 (R Core Team, 2018) which provides cluster-robust standard errors for two non-nested clustering variables, while the estimates remain the same as in 'regular' logistic regression analysis with independent observations (Fernihough, 2019; McNeish et al., 2017).

In the analysis, the reference category for the LTPA environments was 'built outdoor environments', and differences in the estimates between all other environmental categories were tested by changing the reference category. According to established conventions, statistical significance was determined with the criterion of $p < .05$ and results close to this (criticized) threshold were interpreted with more caution (Wasserstein & Lazar, 2016). The effect sizes of the adjusted odds ratios (OR) were evaluated according to the guidelines for social sciences by Ferguson (2009), which suggest 2.0 as the criteria for recommended minimum for practical significance, > 3.0 for a moderate and > 4.0 for a strong effect.

Lastly, we applied Getis-Ord Gi* hot spot analysis (O'Sullivan & Unwin, 2010) with a distance band of 1 km to detect statistically significant clusters of LTPA locations that either were or were not associated with restorative benefits (i.e. hot spots and cold spots, respectively). In this analysis, a Getis-Ord Gi* statistic is calculated for each feature within the context of its neighboring features. The resulting statistic and its significance are used to identify features that are surrounded by more features with similarly high or low values than what one would expect to find by random chance.

3. Results

3.1. Participant characteristics

A total of 1,531 respondents participated in the survey, resulting in a response rate of 15%. Across all mapping activities in the survey, individual respondents mapped on average 8.7 geographical features. As the main unit of analysis was mapped locations, the sample of this study was narrowed to the 760 respondents who had mapped at least one frequently visited outdoor LTPA location and their residential location (Table 2). On average, the respondents mapped 1.6 outdoor places for LTPA, with the number of places mapped by an individual respondent ranging from 1 to 12.

The demographic and socio-economic characteristics of the survey respondents were compared to corresponding data from the study area (Official Statistics of Finland OSF, 2019a; Official Statistics of Finland OSF, 2019b). Respondents with higher levels of formal education were over-represented, comprising 51% of the sample compared to 37% in the study area. In addition, age groups from 50 to 65 years were slightly over-represented in the sample.

3.2. Descriptives of LTPA environments

The respondents mapped a total of 1,232 point features indicating places for outdoor LTPA. Points outside of the Greater Helsinki Region were removed from the analysis, which excluded points further than approximately 40 km from the respondents' home, and resulted in a sample of 1,210 places for LTPA (Fig. 1). Urban natural environments, including small and large urban forests, were the most visited settings for outdoor LTPA comprising more than a quarter (25.8%) of all of the LTPA visits (Table 3). 9.4% of the visits were located in larger (>150 ha) forest areas outside of the urban structure, and 14.2% in environments categorized as blue spaces, most of which (72.7%) being by the seaside. Visits to outdoor sports facilities formed 16.2% and visits to maintained urban green space 13.7% of all LTPA visits. A fifth (20.7%) of the visits were located outside of green and recreational land-use, and were categorized as LTPA in other built outdoor environments.

The identified LTPA settings differed significantly in respect of attributes related to their use. Average street-network distances from home to the LTPA locations varied significantly between the different environment types ($H(6) = 109.00$, $p < .001$). On average, LTPA locations in small urban forests were situated the closest to, and locations in large recreational forests the furthest from home (2.4 km and 10.9 km, respectively). However, the majority of LTPA was undertaken relatively close to home, as 23% of the mapped locations were situated within a network distance of 1 km, and 52% within 2 km of the residential location. A negative correlation was observed between the network distance from home to the LTPA location and the visiting frequency ($r = -0.246$, $p < .001$), indicating that near-by locations were visited more often. The majority of the locations were reported to be places where physical activities were performed at a moderate level (73.4%). On average, the highest activity levels were reported in places for LTPA located in outdoor sports facilities (40.4% vigorous PA) and in large recreational forests (43.5% vigorous PA; Table 3). Activity levels were the lowest near blue spaces (17.1% vigorous PA) and in other built

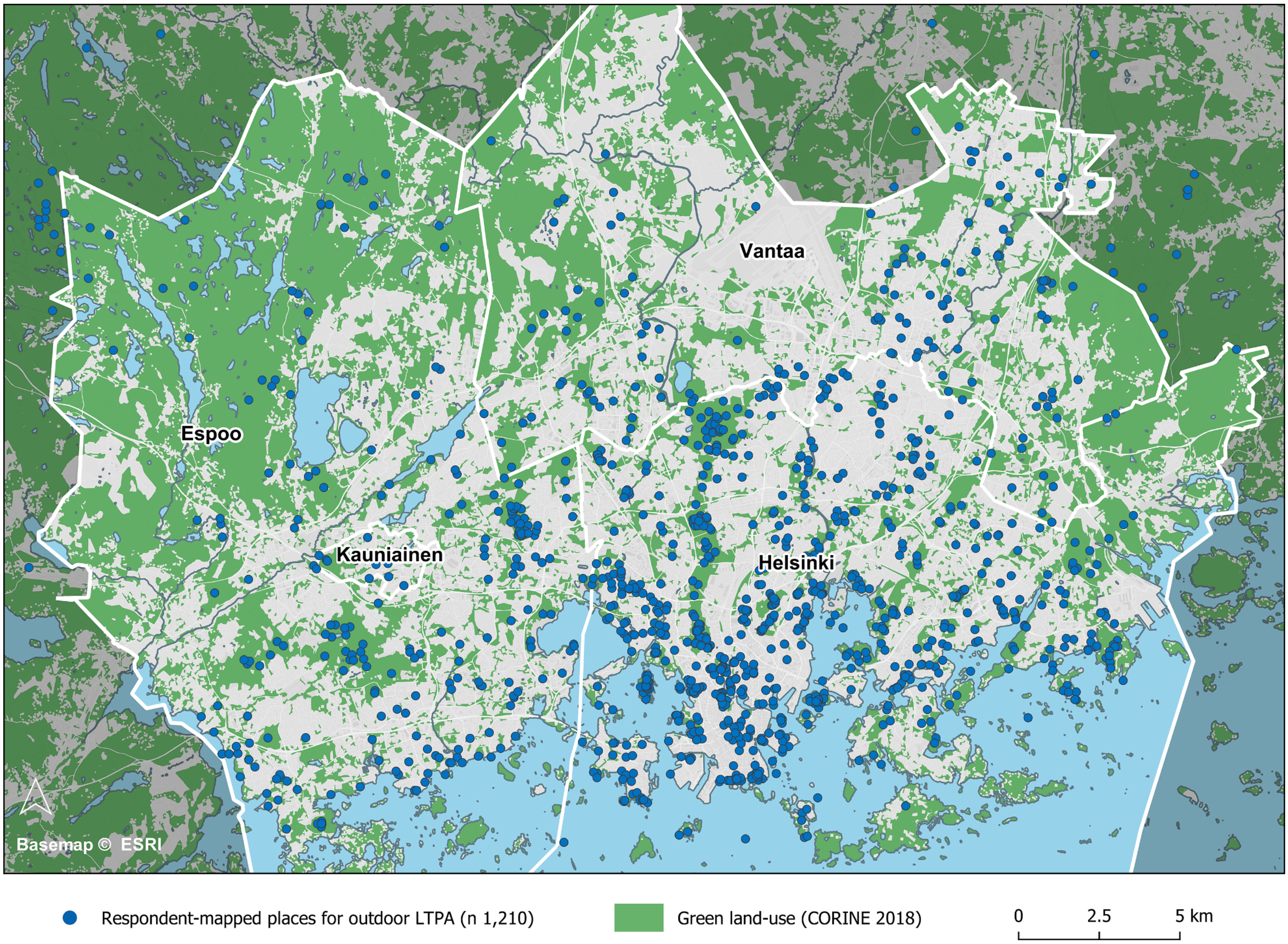

Fig. 1. Study area (the Helsinki Metropolitan Area) and the distribution of respondent-mapped outdoor LTPA locations.

outdoor environments (17.6% vigorous PA). These results are in line with previous studies on how diverse types of recreational outdoor environments support varying physical activity intensities (Elliott et al., 2015; Giles-Corti et al., 2005; Jansen et al., 2017).

The proportion of restorative benefits associated with diverse LTPA settings varied significantly (Table 3). Of all the environmental settings considered here, large recreational forests and blue spaces were most often linked to perceived relaxing effects (74.8% and 71.5% of mapped locations, respectively), while LTPA in built outdoor environments was identified with such effects less often (50.0%). Likewise, stress reduction was most often identified with places for LTPA situated in large recreational forests (69.9%) and blue spaces (65.0%), and least often with built environments (42.0%). Nature enjoyment was most often experienced in large recreational forests (91.1%) and in small (88.6%) and large (91.5%) urban forests, and least often connected to LTPA in outdoor sports facilities (63.1%).

3.3. *Hot spot analysis*

Hot spot analyses were conducted for each of the three restorative outcome variables. The results of the hot spot analysis of the outdoor LTPA environments associated with perceived stress reduction are presented in Fig. 2 (consult Appendices B and C for Getis-Ord Gi* hot spot analyses for outcome variables "nature enjoyment" and "relaxation"). Clusters of statistically significant cold spots, i.e., exercise locations not associated with stress reduction, were located in central urban areas and around outdoor sports facilities. Clusters of hot spots, i.e., locations with perceived stress reduction were found primarily in natural conservation areas and in urban park and forest areas.

3.4. *Predictors of restorative qualities*

LTPA in blue spaces, large urban forests and large recreational forests was more likely to be associated with all restorative outcomes, compared with built outdoor settings, with small-to-medium effect sizes (Table 4). While their estimates regarding relaxation (ORs 2.11 and 3.12 in large urban and recreational forests, and 2.51 in blue spaces) and stress reduction (ORs 2.12, 3.28, and 2.78, respectively) did not significantly differ from each other, LTPA in large urban or recreational forests was more likely to be associated with nature enjoyment (ORs 6.16 and 6.71, implying a strong effect) than LTPA in blue spaces (OR 1.92; p = .056; Table 4). LTPA in maintained green spaces (parks and gardens) and in small urban forests mostly did not differ from LTPA in built outdoor settings in terms of the perceived restorative benefits (Table 4). The main difference concerned the odds of nature enjoyment, which was more likely experienced in small urban forests (a moderate effect size with OR = 3.91, $p < .01$) than in maintained green space (OR = 1.52, p = .12). LTPA in sports facilities was associated with higher odds of stress reduction than LTPA in built urban settings (a small effect; OR = 1.84, p = .03) but lower odds of nature enjoyment (OR = 1.07, p = .82) than small and large urban forests and large recreational forests.

Regarding the covariates, each additional mapped outdoor LTPA location was associated with increased odds of experiencing each of the assessed restorative benefits (ORs 1.13–1.18). Age, measured in years,

Table 3
Characteristics of the LTPA locations.

	Total n 1,210	Blue spaces n 200	Outdoor sports facilities n 236	Maintained urban green space n 161	Small urban forests n 114	Large urban forests n 200	Large recreational forests n 123	Built outdoor environments n 176	Test statistic[a]	*p*-value
Share of LTPA locations	100.0	16.5	19.5	13.3	9.4	16.5	10.2	14.5		
Share of visits to LTPA locations[b]	100.0	14.2	16.2	13.7	10.3	15.5	9.4	20.7		
Distance from home (km)	4.0	3.8	4.0	3.1	2.4	2.9	10.9	2.8	109.00	< 0.001
Travel mode to the destination (%)										
Private vehicle	15.3	9.5	23.1	6.8	7.1	10.2	43.0	11.0	125.58	< 0.001
Public transport	7.9	7.0	10.7	10.6	4.4	4.6	3.3	12.1		
Active transport (walking and biking)	76.8	83.5	66.2	82.6	88.5	85.3	53.7	76.9		
Monthly visiting frequency[b]	8.5	7.5	7.0	8.7	9.3	7.9	7.9	12.3	41.77	< 0.001
PA intensity (%)										
Moderate	73.4	82.9	59.6	76.4	80.0	76.4	56.5	82.4	58.59	< 0.001
Vigorous	26.6	17.1	40.4	23.6	20.0	23.6	43.5	17.6		
Restorative benefits (%)										
Relaxation	62.0	71.5	57.6	58.4	55.3	67.0	74.8	50.0	34.09	< 0.001
Stress reduction	56.0	65.0	55.9	48.4	49.1	61.0	69.9	42.0	38.11	< 0.001
Nature enjoyment	78.7	81.5	63.1	77.0	88.6	91.5	91.1	68.2	84.28	< 0.001

[a] Chi–square test were used for categorical variables and Kruskal–Wallis H tests for continuous variables.
[b] The following estimates were used in calculating visiting frequency: "every day" = 30, "nearly every day" = 20, "a couple of times a week" = 8, "once a week" = 4, "a couple of times a month" = 2, "once a month" = 1.

was weakly associated with reduced odds of experiencing stress reduction (OR = 0.99, $p = .03$) and increased odds of nature enjoyment (OR = 1.02, $p < .01$) but not with relaxation (OR = 1.00, $p = .68$). In the initial models, each additional kilometer of distance to the LTPA location increased the odds of experiencing relaxation, but in the final model, this result was more uncertain (OR = 1.04, $p = .06$). Similarly, males tentatively rated less relaxation (OR = 0.71, $p = .057$) and nature enjoyment (OR = 0.71, $p = .069$) than females. PA intensity, visiting frequency, mode of transport or the total amount of leisure-time and transport-related PA were not associated with any of the outcomes (Table 4).

4. Discussion

This cross-sectional study examined associations between the built environment characteristics of outdoor settings for leisure-time physical activity and self-reported restorative mental health benefits. This study adds to the literature on the perceived restorativeness of everyday green exercise by introducing a spatial framework for the analysis of physical activity environments and their perceived mental health benefits. The use of PPGIS methods enabled the joint analysis of the objectively measured environmental characteristics of the physical activity locations and the respondents' perceptions about the typical mental health benefits in these locations.

4.1. Environment type and perceived restorative benefits

Our finding that physical activity in natural environments was perceived as more restorative than physical activity in built or maintained green outdoor settings is in line with earlier results from controlled experiments and survey studies that apply self-reported environmental measures (Barton & Pretty, 2010; Mitchell, 2013; Pasanen, Neuvonen, & Korpela, 2018). More specifically, using GIS analyses, we were able to infer that physical activity in large (>30 ha) natural areas (urban forests and recreational forests) and near blue spaces - but not in smaller urban forests (≤30 ha) – was perceived to be the most restorative. Thus, regarding natural environments, it appears that the size of the area (green spaces) and content (blue spaces) are relevant in terms of the obtained restorative benefits of PA. We recognize two main connections between the size and the restorative benefits. First, the size of a green environment is likely to correlate with the length of exposure to natural environments, as larger areas offer opportunities for longer and more extensive trail and path networks. Second, larger natural areas have the potential to support higher biodiversity and ecological connectivity, which have been shown to predict restorative experiences in natural environments (Giusti & Samuelsson, 2020).

The results of this study also support observations from previous research (Mitchell, 2013; Pasanen, Neuvonen, & Korpela, 2018) suggesting that exercising in different environments positively contributes to different aspects of mental well-being and psychological restoration. Relaxation and stress reduction were more likely to be experienced during exercise in larger natural areas and near blue spaces, while experiencing nature enjoyment was more likely when exercising in natural environments of all sizes (in comparison to built outdoor environments). The fact that physical activity in sports facilities was more likely to be associated with stress reduction but not with relaxation or nature enjoyment is in line with the notion that these more built-up environments can foster a sense of escape from everyday stressors, but that they provide fewer opportunities for engaging aspects of human-environment interaction, which are more typically found in natural settings (Hartig et al., 2014). Furthermore, these potentially engaging human-environment interactions do not seem to be related to PA intensity, which was similar in sports facilities and in large recreational forests. The difference in experienced stress reduction between built outdoor areas and sports facilities could be related to variation in other aspects of the activity, such as social interaction or the type of activity or

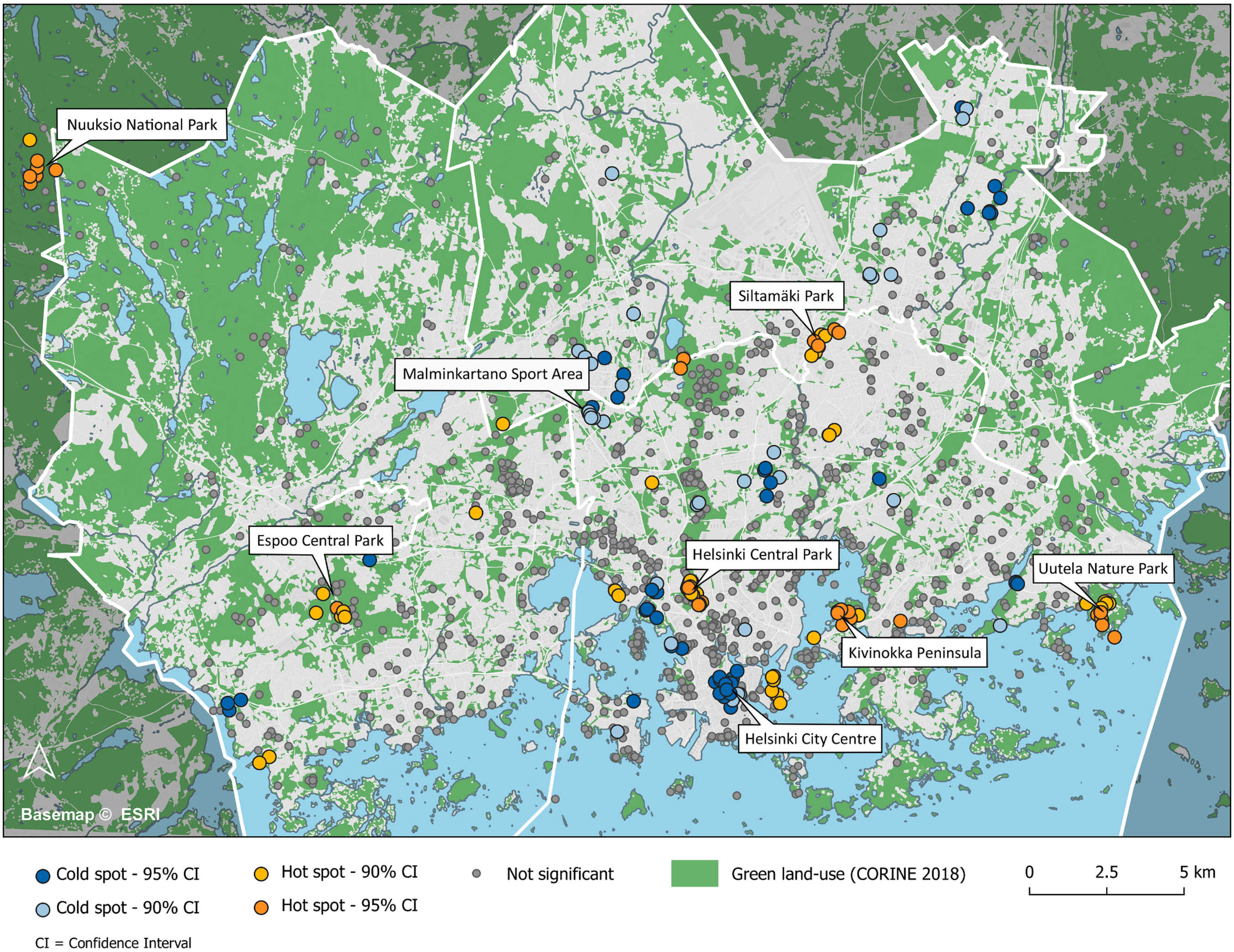

Fig. 2. Results on hot spot analysis (Getis-Ord Gi*, distance band 1 km) of perceived stress reduction. Clusters of statistically significant "hot" and "cold" spots are identified on the map.

sport (Hug et al., 2009; Husu, Paronen, Suni, & Vasankari, 2011; Johansson, Hartig, & Staats, 2011).

Likewise, this study concurs with previous observations highlighting the particular role of blue spaces for restoration, found in experimental field studies of physical activity settings (Barton & Pretty, 2010) and regarding everyday nature visits (White et al., 2013). In our study, blue physical activity environments were more likely to be associated with all measured aspects of perceived restoration than built outdoor environments. Moreover, activities in blue spaces were most often lower in intensity, compared with the other areas. This result is concurrent with previous studies (Elliott et al., 2015; Jansen et al., 2017) and it may be explained by the suitability of these spaces for walking for leisure, which is the most common activity for outdoor recreation in Finland (Husu et al., 2011), as well as the most popular activity when visiting coastal areas in other countries (Elliott et al., 2015). These results highlight the importance of providing access to blue spaces and facilities that enable moderate-level physical activity near them.

The finding that maintained urban green space was equally restorative as built urban spaces, and less restorative than unmaintained natural settings, contrasts with the general findings in experimental research (McMahan & Estes, 2015). Our finding might be attributed to the use of a land-use-based typology of physical activity environments, which is unable to detect some of the micro-scale built environment features that inevitably contribute to the functionality and perceived quality of urban environments. Empirical evidence suggests that, for instance, the presence of streetscape greenery (De Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013), quality and design of urban parks (Nordh, Hartig, Hagerhall, & Fry, 2009), or the distinction between physical activity undertaken in public or private green space, such as gardens (Mavoa, Davern, Breed, & Hahs, 2019) may affect the restorative experience. Future studies might benefit from including measures focusing on micro-scale design features, such as information on the type and amount of streetscape greenery derived from expert audits or remote sensing data. Moreover, this study focused solely on physical activity which usually requires larger areas than more passive visits (Brown, Schebella, & Weber, 2014). Although we detected no added benefits of conducting physical activity in parks and gardens, and only a few additional benefits of exercising in small urban green settings, compared to built-up environments, previous work has indicated that small green spaces might provide important restoration opportunities during more passive visits (Peschardt, Schipperijn, & Stigsdotter, 2012).

4.2. *Visitation patterns and perceived restorative benefits*

While more than half of the respondent-mapped places for outdoor LTPA were located within a 2-km distance from home, some places for outdoor physical activities were also accessed beyond considerable travel distances. Network distance from home was tentatively and

Table 4
Factors predicting the likelihood of perceiving an outdoor LTPA environment as restorative ($n = 995$). In environmental categories 1–6, the reference category is "built outdoor environments".

	Relaxation ($R^2 = .088$[b])					Stress reduction ($R^2 = .112$[b])					Nature enjoyment ($R^2 = .166$[b])				
	OR	s.e.	z	p (>|z|)	Diff.[a]	OR	s.e.	z	p (>|z|)	Diff.[a]	OR	s.e.	z	p (>|z|)	Diff.[a]
LTPA environment category															
Blue spaces (1)	**2.51**	0.70	3.32	0.001	> 3, 4	**2.78**	0.77	3.71	<0.001	> 3, 4	1.92	0.66	1.91	0.056	< 5, 6
Outdoor sports facilities (2)	1.57	0.41	1.74	0.082	< 6	**1.84**	0.52	2.15	0.031	> 3	1.07	0.33	0.22	0.825	< 4, 5, 6
Maintained urban green space (3)	1.42	0.36	1.41	0.160	< 1, 6	1.06	0.28	0.24	0.814	< 1, 2, 5, 6	1.52	0.41	1.55	0.121	< 4, 5, 6
Small urban forests (4)	1.23	0.37	0.70	0.483	< 1, 5, 6	1.20	0.34	0.63	0.527	< 1, 5, 6	**3.91**	1.69	3.14	0.002	> 2, 3
Large urban forests (5)	**2.11**	0.55	2.87	0.004	> 4	**2.12**	0.57	2.79	0.005	> 3, 4	**6.16**	2.11	5.29	<0.001	> 1, 2, 3
Large recreational forests (6)	**3.12**	1.05	3.38	0.001	> 2, 3, 4	**3.28**	1.17	3.33	0.001	> 3, 4	**6.71**	3.60	3.55	<0.001	> 1, 2, 3
Covariates															
Gender	0.71	0.13	−1.91	0.057		0.78	0.14	−1.36	0.172		0.71	0.13	−1.82	0.069	
Age	1.00	0.01	−0.29	0.771		**0.99**	0.01	−2.22	0.027		**1.02**	0.01	2.80	0.005	
Self-reported PA (MET hours / week)	1.00	<0.01	−0.22	0.825		1.00	<0.01	−0.45	0.654		1.00	<0.01	−0.12	0.901	
PA intensity (vigorous vs moderate)	0.83	0.15	−1.03	0.302		1.12	0.21	0.59	0.558		0.74	0.14	−1.62	0.105	
Distance from home (km)	1.04	0.02	1.87	0.062		1.03	0.02	1.40	0.160		0.99	0.02	−0.53	0.595	
Monthly visiting frequency	0.99	0.01	−0.54	0.591		1.01	0.01	0.49	0.625		1.00	0.01	0.27	0.790	
Active transportation mode (vs motorized)	1.42	0.34	1.45	0.146		1.43	0.34	1.50	0.134		1.28	0.35	0.89	0.372	
Number of mapped LTPA locations	**1.13**	0.06	2.20	0.028		**1.18**	0.06	3.23	0.001		**1.15**	0.07	2.40	0.016	

Bolded values are significant ($p < .05$).
[a] Significant ($p < .05$) differences and their directions in the estimates between LTPA environments 1–6.
[b] Nagelkerke's Pseudo R^2.

weakly positively associated with perceived relaxation, which could suggest that urban residents are willing to increase travel distance to reach recreational environments that promote perceived relaxation. However, travel distances from the residential location correlated negatively with the visiting frequency, thus likely reducing the overall health benefit gained by exercising in these environments. Visiting natural settings that are far from home might promote perceived relaxation via the sense of being away from everyday life, as suggested by the attention restoration theory (Kaplan & Kaplan, 1989). Thus, nature destinations that are further from home and less frequently accessed may contribute to restorative experiences by offering not only a sense of but also an actual distance to everyday issues and activities.

Considering their accessibility, use, and perceived restorative benefits, large urban forests and blue spaces were the most accessible environments for restorative green exercise. This observation supports the results of a recent Finnish study reporting that living in the vicinity of at least a middle-sized (25–150 ha) green area significantly increased participation in green exercise (Pyky et al., 2019). While large recreational forest areas had the strongest associations with all restorative outcomes in our study, visitation of these environments relied for the most part on private vehicle use. Improved accessibility to large natural environments has the potential to increase their cumulative mental health benefits at the population level. On the other hand, urban forests, i.e. forest and semi-natural areas up to 150 ha located in the immediate vicinity of residential areas, were identified with greater restorative benefits in comparison to built outdoor settings, while being at same time already relatively accessible. These environment types were on average accessed close to participants' homes and were primarily reached using active transportation modes.

Lastly, while built-up outdoor physical activity settings were the least often related to restorative experiences, they were, nevertheless, identified as an important setting for leisure-time physical activity, comprising of 21% of all visits. These settings were visited frequently and they were often situated close to the residential location. Built environment interventions directed at public space in residential areas could thus potentially increase the restorative value of already much used physical activity environments. This can potentially be achieved by developing greener and more engaging walking environments and public open spaces in residential areas, or within a good access to them.

4.3. Implications for policy and practice

The increasing evidence for the positive health impacts of green and other natural environments (Sandifer, Sutton-Grier, & Ward, 2015) challenges urban planners and researchers to think further about how to effectively translate this evidence into urban planning practice. As the share of the world's urban population is estimated to reach 68% by 2050 (United Nations (UN), Department of Economic and Social Affairs, Population Division, 2019), many urban areas undertake densification policies due to population growth and in order to mitigate problems related to urban sprawl and overreliance on private vehicle use. Knowledge of the perceived quality of green spaces is increasingly important in order to manage urban densification without losing quality green space (Francis, Wood, Knuiman, & Giles-Corti, 2012; Lindholst et al., 2015; Taylor & Hochuli, 2017; Haaland & van den Bosch, 2015).

Participatory mapping approaches, such as the PPGIS method applied in this study, produce both quantitative and qualitative spatial knowledge applicable in planning processes. As a part of a participatory planning process, participatory mapping methods can likewise help to identify suitable areas for urban densification and to mitigate tensions in the planning process (Kyttä, Broberg, Tzoulas, & Snabb, 2013). More specifically, georeferenced data on environmental perceptions can be integrated into planning support systems or related spatial data driven tools, thus providing an additional source of knowledge supporting evidence-based planning. For example, a joint analysis of respondent-produced information on green space use, its perceived quality, and ecological values, such as biodiversity indicators or forest quality, can be used to identify spatial overlaps between the social and ecological values attributed to diverse green and natural environments (Korpilo, Jalkanen, Virtanen, & Lehvävirta, 2018). Spatio-statistical analyses such as hot spot, cluster, or density analyses can be further applied to identify areas with high perceived restorative benefit, and to visually communicate the results in urban planning and policy formation. For example, the hot spot analysis used in this study shows specific settings where the residents in the Helsinki Metropolitan Area not only conduct physical activity, but also experience restorative benefits from exercising in these environments (see Fig. 2). These kinds of analyses support spatial decision-making by identifying potentially sensitive areas that are at the same time particularly meaningful for the residents and have a high number of visitors.

Finally, we would like to note that this study has examined outdoor recreational environments strictly from the perspective of physical activity and perceived restoration outcomes. However, the potential pathways linking greenspace to human health and well-being reach beyond health benefits gained by moderate-to-vigorous physical activity and restorative experiences, and include, for instance, health benefits related to harm mitigation (e.g. pollution, noise, heat stress (Lee, Mayer, & Chen, 2016; van den Bosch & Sang, 2017)) and to community and social health (Lee & Maheswaran, 2011; Markevych et al., 2017). In addition to the various benefits for human health, green, blue, and other natural environments provide a wide range of other ecosystem services and landscape values with high social, cultural, and ecological value (Andersson, Tengö, McPhearson, & Kremer, 2015; Bolund & Hunhammar, 1999; Tyrväinen et al., 2007). Consequently, promoting physical activity in green and natural environments requires management strategies that ensure their sustainable use, and which consider human health benefits in conjunction with other ecosystem and community level benefits.

4.4. Limitations

The current study has certain limitations. Due to the cross-sectional nature of the study design, the results cannot be used to infer causality or to predict behavior change. The assessment of the restorative effects relies on the respondents self-stated measures and may be affected by recall bias (Cooper, 1998). The survey used in data collection did not include a measure for time spent in mapped location or the duration of that time allocated to physical activity. It is possible that the high perceived restorativeness associated in this study with large natural green areas is affected by their lower accessibility, consequently resulting in those making a visit to these areas spending there more time and increasing their exposure to the environment. However, Hunter et al. (2019) reported that natural environment exposures between 20 and 30 min resulted in significant stress relief, suggesting that already shorter visits to natural environments can produce positive effects on mental health. This study applied a typology of outdoor physical activity environments based on the self-reported behavior of urban residents in the Helsinki Metropolitan Area. The resulting categorization of outdoor leisure-time physical activity environments might exclude physical activity settings relevant for other urban contexts, and should not be applied without context-specific modifications. For example, as large (>30 ha) green spaces were relatively abundant and accessible in the study area, we did not assess very small urban green spaces ('pocket parks') as a separate category, which might indeed be relevant in more urbanized and densely built areas (Nordh et al., 2009; Peschardt et al., 2012). Finally, the discrete categorization of the environment types applied in this study could in some cases be over-simplified. For example, blue spaces can be situated within green areas and taking into account the presence of both the 'green' and 'blue' could have yielded more fine-grained results.

5. Conclusions

According to the results of this cross-sectional study, exercising in natural green environments and in blue spaces is associated with more perceived restorative benefits than exercising in built outdoor environments. From a public health perspective, small (≤30 ha) to large (30–150 ha) urban forests provide important access to green exercise close to the residential location, while improving the accessibility of larger recreational natural environment and forest areas has the potential to increase the benefits of green exercise on a population level. These mental health benefits should be considered in urban planning practice and in green space management, taking into account the availability, type, and accessibility of green and blue spaces suitable for moderate-to-vigorous physical activity. Geospatial research methods applying participatory mapping have the potential to link spatial data with environmental perceptions to inform health-supportive land-use planning and policy.

CRediT authorship contribution statement

Anna Kajosaari: Conceptualization, Methodology, Formal analysis (spatial analyses), Investigation, Writing - original draft, Writing - review & editing, Visualization. **Tytti P. Pasanen:** Methodology, Formal analysis (statistical analysis), Writing - review & editing.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2020.103978.

References

Andersson, E., Tengö, M., McPhearson, T., & Kremer, P. (2015). Cultural ecosystem services as a gateway for improving urban sustainability. *Ecosystem Services, 12*, 165–168. https://doi.org/10.1016/j.ecoser.2014.08.002.

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health- A multi-study analysis. *Environmental Science & Technology, 44*, 3947–3955. https://doi.org/10.1021/es903183r.

Bodin, M., & Hartig, T. (2003). Does the outdoor environment matter for psychological restoration gained through running? *Psychology of Sport and Exercise, 4*, 141–153. https://doi.org/10.1016/S1469-0292(01)00038-3.

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics, 29*, 293–301. https://doi.org/10.1016/S0921-8009(99)00013-0.

Bowler, D., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health, 10*.

Brown, G., & Fagerholm, N. (2015). Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. *Ecosystem Services, 13*, 119–133. https://doi.org/10.1016/j.ecoser.2014.10.007.

Brown, G., Kyttä, M., 2014. Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. Applied Geography. Doi: 10.1016/j.apgeog.2013.11.004.

Brown, G., Rhodes, J., & Dade, M. (2018). An evaluation of participatory mapping methods to assess urban park benefits. *Landscape and Urban Planning, 178*(2018), 18–31. https://doi.org/10.1016/j.landurbplan.2018.05.018.

Brown, G., Schebella, M. F., & Weber, D. (2014). Using participatory GIS to measure physical activity and urban park benefits. *Landsc. Urban Plan., 121*, 34–44. https://doi.org/10.1016/j.landurbplan.2013.09.006.

Cooper, C. (1998). *Individual differences*. London, England: Arnold.

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International physical activity questionnaire: 12-Country reliability and validity. *Medicine and Science in*

Sports and Exercise, 35, 1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB.

de Bell, S., Graham, H., Jarvis, S., & White, P. (2017). The importance of nature in mediating social and psychological benefits associated with visits to freshwater blue space. *Landscape and Urban Planning, 167*, 118–127. https://doi.org/10.1016/j.landurbplan.2017.06.003.

de Vries, S., ten Have, M., van Dorsselaer, S., van Wezep, M., Hermans, T., & de Graaf, R. (2016). Local availability of green and blue space and prevalence of common mental disorders in the Netherlands. *BJPsych Open, 2*, 366–372. https://doi.org/10.1192/bjpo.bp.115.002469.

De Vries, S., van Dillen, S. M. E., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science and Medicine, 94*, 26–33. https://doi.org/10.1016/j.socscimed.2013.06.030.

Elliott, L. R., White, M. P., Taylor, A. H., & Herbert, S. (2015). Energy expenditure on recreational visits to different natural environments. *Social Science and Medicine, 139*, 53–60. https://doi.org/10.1016/j.socscimed.2015.06.038.

Esri Inc. (2018). ArcMap (Version 10.6). Esri Inc. https://desktop.arcgis.com/en/arcmap/.

Ferguson, C. J. (2009). An Effect Size Primer: A Guide for Clinicians and Researchers. *Prof. Psychol. Res. Pract., 40*, 532–538. https://doi.org/10.1037/a0015808.

Fernihough, A., 2019. 'mfx': Marginal Effects, Odds Ratios and Incidence Rate Ratios for GLMs. R package version 1.2-2. https://cran.stat.unipd.it/web/packages/mfx/mfx.pdf.

Francis, J., Wood, L. J., Knuiman, M., & Giles-Corti, B. (2012). Quality or quantity? Exploring the relationship between Public Open Space attributes and mental health in Perth, Western Australia. *Social Science and Medicine, 74*, 1570–1577. https://doi.org/10.1016/j.socscimed.2012.01.032.

Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A., & Donovan, R. J. (2005). Increasing Walking How Important Is Distance To, Attractiveness, and Size of Public Open Space? *American Journal of Preventive Medicine.*, 169–176. https://doi.org/10.1016/j.amepre.2004.10.018.

Giusti, M., & Samuelsson, K. (2020). The regenerative compatibility: A synergy between healthy ecosystems, environmental attitudes, and restorative experiences. *PLoS ONE, 15*, 1–20. https://doi.org/10.1371/journal.pone.0227311.

Haaland, C., van den Bosch, C.K., 2015. Challenges and strategies for urban green-space planning in cities undergoing densification: A review. Urban For. Urban Green. Doi: 10.1016/j.ufug.2015.07.009.

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Arling, T. G. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology, 23*, 109–123. https://doi.org/10.1016/S0272-4944(02)00109-3.

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and Health. *Annual Review of Public Health, 35*. https://doi.org/10.1146/annurev-publhealth-032013-182443.

Hug, S. M., Hartig, T., Hansmann, R., Seeland, K., & Hornung, R. (2009). Restorative qualities of indoor and outdoor exercise settings as predictors of exercise frequency. *Health and Place, 15*, 971–980. https://doi.org/10.1016/j.healthplace.2009.03.002.

Hunter, M. C. R., Gillespie, B. W., & Chen, S. Y. P. (2019). Urban nature experiences reduce stress in the context of daily life based on salivary biomarkers. *Frontiers in Psychology, 10*, 1–16. https://doi.org/10.3389/fpsyg.2019.00722.

Husu, P., Paronen, O., Suni, J., Vasankari, T., 2011. Physical activity and fitness of Finns in 2010. Current status and changes in health-enhancing physical activity (in Finnish). Publications of the Ministry of Education and Culture, Finland 2011:15.

Ives, C. D., Oke, C., Hehir, A., Gordon, A., Wang, Y., & Bekessy, S. A. (2017). Capturing residents' values for urban green space: Mapping, analysis and guidance for practice. *Landscape and Urban Planning, 161*, 32–43. https://doi.org/10.1016/j.landurbplan.2016.12.010.

Jansen, F. M., Ettema, D. F., Kamphuis, C. B. M., Pierik, F. H., & Dijst, M. J. (2017). How do type and size of natural environments relate to physical activity behavior? *Health and Place, 46*, 73–81. https://doi.org/10.1016/j.healthplace.2017.05.005.

Johansson, M., Hartig, T., & Staats, H. (2011). Psychological benefits of walking: Moderation by company and outdoor environment. *Applied Psychology: Health and Well-Being, 3*, 261–280. https://doi.org/10.1111/j.1758-0854.2011.01051.x.

Kaplan, R., & Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective.* Cambridge University Press.

IPAQ Research Committee, 2005. Guidelines for data processing and analysis of the international physical activity questionnaire (IPAQ) – short and long forms (referred 28.7.2020). Access method: https://sites.google.com/site/theipaq/home.

Knopf, R.C., 1987. Human behavior, cognition, and affect in the natural environment, in: Stokols, D., Altman, I. (Eds.), Handbook of Environmental Psychology. Wiley, New York, p. Vol. 1., pp. 783–825.

Korpilo, S., Jalkanen, J., Virtanen, T., & Lehvävirta, S. (2018). Where are the hotspots and coldspots of landscape values, visitor use and biodiversity in an urban forest? *PLoS ONE, 13*. https://doi.org/10.1371/journal.pone.0203611.

Kyttä, M., Broberg, A., Tzoulas, T., & Snabb, K. (2013). Towards contextually sensitive urban densification: Location-based softGIS knowledge revealing perceived residential environmental quality. *Landscape and Urban Planning, 113*, 30–46. https://doi.org/10.1016/j.landurbplan.2013.01.008.

Laatikainen, T. E., Broberg, A., & Kyttä, M. (2016). The physical environment of positive places: Exploring differences between age groups. *Preventive Medicine, 95*, S85–S91. https://doi.org/10.1016/j.ypmed.2016.11.015.

Laatikainen, T. E., Piiroinen, R., Lehtinen, E., & Kyttä, M. (2017). PPGIS approach for defining multimodal travel thresholds: Accessibility of popular recreation environments by the water. *Applied Geography, 79*, 93–102. https://doi.org/10.1016/j.apgeog.2016.12.006.

Lee, A. C. K., & Maheswaran, R. (2011). The health benefits of urban green spaces: A review of the evidence. *Journal of Public Health*. https://doi.org/10.1093/pubmed/fdq068.

Lee, H., Mayer, H., & Chen, L. (2016). Contribution of trees and grasslands to the mitigation of human heat stress in a residential district of Freiburg, Southwest Germany. *Landscape and Urban Planning, 148*, 37–50. https://doi.org/10.1016/j.landurbplan.2015.12.004.

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., … Fuertes, E. (2017). Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environmental Research, 158*, 301–317. https://doi.org/10.1016/j.envres.2017.06.028.

Lindholst, A. C., Hjorth Caspersen, O., & Konijnendijk Van Den Bosch, C. C. (2015). Methods for mapping recreational and social values in urban green spaces in the nordic countries and their comparative merits for urban planning. *Journal of Outdoor Recreation and Tourism, 12*, 71–81. https://doi.org/10.1016/j.jort.2015.11.007.

Mavoa, S., Davern, M., Breed, M., & Hahs, A. (2019). Higher levels of greenness and biodiversity associate with greater subjective wellbeing in adults living in Melbourne, Australia. *Health and Place, 57*, 321–329. https://doi.org/10.1016/j.healthplace.2019.05.006.

McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: A meta-analysis. *The Journal of Positive Psychology, 10*. https://doi.org/10.1080/17439760.2014.994224.

McNeish, D., Stapleton, L. M., & Silverman, R. D. (2017). On the unnecessary ubiquity of hierarchical linear modeling. *Psychological Methods, 22*, 114–140. https://doi.org/10.1037/met0000078.

Mitchell, R. (2013). Is physical activity in natural environments better for mental health than physical activity in other environments? *Social Science and Medicine, 91*, 130–134. https://doi.org/10.1016/j.socscimed.2012.04.012.

Nordh, H., Hartig, T., Hagerhall, C. M., & Fry, G. (2009). Components of small urban parks that predict the possibility for restoration. *Urban Forestry & Urban Greening, 8*, 225–235. https://doi.org/10.1016/j.ufug.2009.06.003.

Official Statistics of Finland (OSF), 2019a. Population structure. Statistics Finland [referred: 15.1.2020]. Access method: http://www.stat.fi/til/vaerak/index_en.html.

Official Statistics of Finland (OSF), 2019b. Educational structure of population. Statistics Finland [referred: 15.1.2020]. Access method: Available from: http://www.stat.fi/til/vkour/index_en.html.

O'Sullivan, D., & Unwin, D. (2010). *Geographic information analysis* (2nd ed.). Hoboken, New Jersey: Wiley & Sons.

Pasanen, T. P., Neuvonen, M., & Korpela, K. M. (2018). The Psychology of Recent Nature Visits: (How) Are Motives and Attentional Focus Related to Post-Visit Restorative Experiences, Creativity, and Emotional Well-Being? *Environment & Behavior, 50*, 913–944. https://doi.org/10.1177/0013916517720261.

Pasanen, T. P., Ojala, A., Tyrväinen, L., & Korpela, K. M. (2018). Restoration, well-being, and everyday physical activity in indoor, built outdoor and natural outdoor settings. *Journal of Environmental Psychology, 59*, 85–93. https://doi.org/10.1016/j.jenvp.2018.08.014.

Pasanen, T. P., Tyrväinen, L., & Korpela, K. M. (2014). The Relationship between Perceived Health and Physical Activity Indoors, Outdoors in Built Environments, and Outdoors in Nature. *Applied Psychology: Health and Well-Being, 6*, 324–346. https://doi.org/10.1111/aphw.12031.

Peschardt, K. K., Schipperijn, J., & Stigsdotter, U. K. (2012). Use of Small Public Urban Green Spaces (SPUGS). *Urban Forestry and Urban Greening, 11*, 235–244. https://doi.org/10.1016/j.ufug.2012.04.002.

Pietrzyk-Kaszyńska, A., Czepkiewicz, M., & Kronenberg, J. (2017). Eliciting non-monetary values of formal and informal urban green spaces using public participation GIS. *Landscape and Urban Planning, 160*, 85–95. https://doi.org/10.1016/j.landurbplan.2016.12.012.

Pretty, J., Peacock, J., Hine, R., Sellens, M., South, N., & Griffin, M. (2007). Green exercise in the UK countryside: Effects on health and psychological well-being, and implications for policy and planning. *Journal of Environmental Planning and Management, 50*, 211–231. https://doi.org/10.1080/09640560601156466.

Pyky, R., Neuvonen, M., Kangas, K., Ojala, A., Lanki, T., Borodulin, K., & Tyrväinen, L. (2019). Individual and environmental factors associated with green exercise in urban and suburban areas. *Health and Place, 55*, 20–28. https://doi.org/10.1016/j.healthplace.2018.11.001.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Samuelsson, K., Giusti, M., Peterson, G. D., Legeby, A., Brandt, S. A., & Barthel, S. (2018). Impact of environment on people's everyday experiences in Stockholm. *Landscape and Urban Planning, 171*, 7–17. https://doi.org/10.1016/j.landurbplan.2017.11.009.

Sandifer, P. A., Sutton-Grier, A. E., & Ward, B. P. (2015). Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. *Ecosystem Services, 12*, 1–15. https://doi.org/10.1016/j.ecoser.2014.12.007.

Sugiyama, T., Carver, A., Koohsari, M. J., & Veitch, J. (2018). Advantages of public green spaces in enhancing population health. *Landscape and Urban Planning, 178*, 12–17. https://doi.org/10.1016/j.landurbplan.2018.05.019.

Taylor, L., & Hochuli, D. F. (2017). Defining greenspace: Multiple uses across multiple disciplines. *Landscape and Urban Planning, 158*, 25–38. https://doi.org/10.1016/j.landurbplan.2016.09.024.

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science and Technology, 45*, 1761–1772. https://doi.org/10.1021/es102947t.

Tyrväinen, L., Mäkinen, K., & Schipperijn, J. (2007). Tools for mapping social values of urban woodlands and other green areas. *Landscape and Urban Planning, 79*, 5–19. https://doi.org/10.1016/j.landurbplan.2006.03.003.
United Nations (UN), Department of Economic and Social Affairs, Population Division, 2019. World Urbanization Prospects: The 2018 Revision. New York: United Nations.
van den Bosch, M., & Sang, Ode (2017). Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews. *Environmental Research, 158*, 373–384. https://doi.org/10.1016/j.envres.2017.05.040.
Wasserstein, R. L., & Lazar, N. A. (2016). The ASA's Statement on p-Values: Context, Process, and Purpose. *American Statistician, 70*, 129–133. https://doi.org/10.1080/00031305.2016.1154108.
White, M. P., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. H. (2013). Feelings of restoration from recent nature visits. *Journal of Environmental Psychology, 35*, 40–51. https://doi.org/10.1016/j.jenvp.2013.04.002.