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Björk, Jonas; Albin, Maria; Grahn, P; Jacobsson, H; Ardö, Jonas; Wadbro, J; Östergren, Per-Olof

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J Björk, M Albin, P Grahn, H Jacobsson, J Ardö, J Wadbro, P-O Östergren, E Skärbäck

ABSTRACT
Objectives: The aim of this population-based study was to investigate associations between recreational values of the close natural environment and neighbourhood satisfaction, physical activity, obesity and wellbeing.

Methods: Data from a large public health survey distributed as a mailed questionnaire in suburban and rural areas of southern Sweden were used (N = 24 819; 59% participation rate). Geocoded residential addresses and the geographical information system technique were used to assess objectively five recreational values of the close natural environment: serene, wild, lush, spacious and culture.

Results: On average, a citizen of the Scania region, inner city areas excluded, only had access to 0.67 recreational values within 300 metres distance from their residence. The number of recreational values near the residence was strongly associated with neighbourhood satisfaction and physical activity. The effect on satisfaction was especially marked among tenants and the presence of recreational values was associated with low or normal body mass index in this group. A less marked positive association with vitality among women was observed. No evident effect on self-rated health was detectable.

Conclusions: Immediate access to natural environments with high recreational values was rare in the study population and was distributed in an inequitable manner. Moreover, such access was associated with a positive assessment of neighbourhood satisfaction and time spent on physical activity, which can be expected to reduce obesity and increase vitality by having a buffering effect on stress.

There is a growing interest among landscape planners and public health officials in the effects of urbanisation on physical activity, obesity and wellbeing. Most research has focussed on the effects of the built (man-made) environment, including economic influences (cost and access), neighbourhood safety and transportation opportunities. Negative aspects of built environments have been linked to physical inactivity and obesity. Less emphasis has been put on the role of close access to natural environments and few large population-based studies have been based on objective assessments.

Individuals interact with natural environments through active participation (eg, gardening or conservation), personal leisure-time activities (eg, walking, cycling or picnicking) or by simply viewing nature. Active participation and activities in natural environments imply physical activity, which can be expected to have positive effects on obesity. Access to nearby natural environments is also likely to be beneficial for vitality and perceived general health. Neighbourhood satisfaction, as part of the construct social coherence, has been linked to psychological wellbeing. The sounds of nature may reduce stress and improve wellbeing. Drops in blood pressure have been observed after walking in a natural environment. Stronger effects of nearby natural surroundings on perceived general health have been observed in subgroups, eg, the elderly and ill, that spend more time at home.

Since the 1960s, research concerning people’s preferences for natural environments has resulted in evolutionary based hypotheses, claiming that people need natural environments with certain characteristics, eg, wildness, species richness and spaciousness, to enjoy and get on in their neighbourhood. Interview studies conducted in 1995–2005 in landscape architecture/environmental psychology have revealed eight characteristics, recreational values, of urban open spaces (serene, wild, lush, spacious, culture, the common, the pleasure garden and festive/centre) that humans appreciate, but no previous study has investigated the health effects related to such recreational values in large population settings.

In the present study, based on the geographical information system (GIS) and public health survey data from suburban and rural areas in southern Sweden, we aimed at investigating the role of the natural neighbourhood environment in promoting human health. Previous research has shown that the use of green areas already decreases markedly if they are 100–300 metres away from the residence. We therefore hypothesised that the natural neighbourhood environment should be within easy walking distance from the residence in order to yield positive effects. We also hypothesised that not only the distance to but also the recreational values of the natural environment are important. We expected nearby natural surroundings to be more important for tenants, most often modified by gender and age.

MATERIALS AND METHODS
Public health survey
The study, which was conducted in accordance with the Swedish law of ethics, was based on data...
from an extensive public health survey distributed as a mailed questionnaire in the Scania region in southern Sweden. All individuals 18–80 years old, living in this region on 30 June 2004, constituted the study population (N = 855 599). The population was stratified by gender and geographical area, resulting in 2 x 62 = 124 different strata. Samples were randomly selected from the population registry such that an approximately equal number of individuals were contacted in each stratum. Answers were obtained during September 2004 to January 2005 from 27 963 individuals, a 59% participation rate. The participation

Table 1 Self-reported characteristics of 24 819 participants of the public health survey in suburban and rural areas of the Scania region in southern Sweden 2004 in relation to the number of recreational values of the natural environment present within 300 metres distance from their residence.

<table>
<thead>
<tr>
<th>Variable</th>
<th>All N = 24 819</th>
<th>No of recreational values within 300 metres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Age (years)†</td>
<td>24 819</td>
<td>50 (19–76)</td>
</tr>
<tr>
<td>Females</td>
<td>24 819</td>
<td>54.3</td>
</tr>
<tr>
<td>Born abroad</td>
<td>23 740</td>
<td>11.7</td>
</tr>
<tr>
<td>Educational level</td>
<td>23 283</td>
<td>29.2</td>
</tr>
<tr>
<td>Employment status</td>
<td>24 319</td>
<td>58.7</td>
</tr>
<tr>
<td>Type of residence</td>
<td>24 021</td>
<td>60.4</td>
</tr>
<tr>
<td>Problems with paying bills</td>
<td>24 264</td>
<td>74.5</td>
</tr>
<tr>
<td>Smoking status</td>
<td>24 655</td>
<td>55.1</td>
</tr>
</tbody>
</table>

*N Number of answers.
†Median (2.5th–95th percentiles).
All characteristics are given in percentages if not otherwise stated.

Figure 1 Mean number of recreational values of the natural environment within 300 metres distance from the residence in each of the 33 municipalities in the Scania region (range 0.08 for Staffanstorp municipality in the southwest to 1.68 recreational values on average for Höör municipality in the middle of Scania).
rate was higher among women, the elderly, individuals born in Sweden and among individuals with high education and income. Residential geocodes were obtained for 27 879 participants. Only survey participants of rural and suburban areas were included in the present study (N = 24 819; table 1). An assessment of the recreational values of the natural environments in inner city areas, mostly urban parks, was outside the scope of the present study and we therefore excluded survey participants from the inner city areas of Malmö, Lund, Helsingborg and Kristianstad (N = 3060).

We used a survey question regarding neighbourhood satisfaction as a first test of the importance of attractive natural surroundings very close (100–300 metres) to the residence and compared the effect among tenants and house-owners. We then investigated associations between nearby natural surroundings and survey questions regarding: (1) time spent on moderate physical activity per week; (2) body mass index (BMI); (3) self-rated physical and psychological health at present; (4) the 56-item short-form (SF-36) health survey item “vitality”.

The phrasings of the two questions regarding neighbourhood satisfaction and physical activity were specific for the present and similar national and regional surveys (see Appendix 1). BMI was calculated as self-reported weight/length², rounded to the nearest integer and grouped as normal (<25 kg/m²), overweight (25–29 kg/m²) or obese (≥30 kg/m²). The seven-graded scale for self-rated health had specified response options only at the ends of the scale (1, very poor (could not feel better), 7, very good (could not feel worse)), for SF-36 vitality, we used the median rating (1–6) of the four questions (full of life, a lot of energy, (not) worn out and (not) tired).34–36

Assessment of the natural neighbourhood environment

Interview studies conducted in 1995–2005 in landscape architecture/environmental psychology on preferences and habits regarding urban parks have revealed eight characteristics, recreational values, of natural surroundings that humans appreciate and that may have positive health effects.27–28 With available data, we were able to establish objective definitions (see Appendix 2) that were possible to implement using the GIS technique for five of these recreational values, which were originally described as shown in the box.27

We assessed the presence/absence of each of the five recreational values within 100–300 metres from the centre of the property at each geocoded residential address. Data for this automatic assessment were obtained from Lantmäteriet (the National Land Survey of Sweden), which within the European Union program CORINE (Coordination of Information on the Environment)34 mapped the land and vegetation cover of Sweden into approximately 58 classes, using 25 × 25 metre grids. Regional GIS databases from the County Administrative Board of Scania were also used. With the available data, we could not assess objectively the recreational values of urban parks in inner city areas (located in Malmö, Lund, Helsingborg and Kristianstad) and the assessments were therefore restricted to suburban and rural areas.

Statistical analysis

All analyses were conducted using SPSS 14.0 for Windows (SPSS Inc, Chicago, Illinois, USA). We considered p values below 0.05 and 95% confidence intervals (CI) for odds ratios (OR) that excluded unity as statistically significant. As a result of the stratified sampling scheme, weighted statistical analyses were used when population means and prevalences were estimated. We used Spearman’s rank correlation coefficient to test associations between the number of recreational values (0–5) present near the residence and ordered response categories of the survey questions. Suggested associations were investigated further using ordinal regression under the cumulative odds model with location parameters only.35–36 This model estimates the average OR of all possible dichotomisations of the ordinal response variable. All ordinal response variables were coded such that an OR greater than one implied a beneficial health effect. In the regression analyses, individuals with four and five recreational values near the residence were collapsed into one category because of too small numbers. Confounding adjustments were made for the broad list of individual determinants of health in table 1, using the categorisation presented. Four age categories were used: 15–29, 30–44, 45–64 and 65–80 years. For identified associations, we investigated effect modification by gender, age and type of residence (rented flat or room versus own house), respectively, using the likelihood ratio test for the cross-product term.39 In a separate set of analyses, we also evaluated effects of the five individual recreational values by using two binary variables for each characteristic, indicating presence/absence within 100 and 300 metres, respectively. All recreational values with p ≤ 0.30 in univariate analyses were included in a combined regression model, from which we excluded insignificant indicator variables one by one, starting with the variable with the highest p value. For each insignificant recreational value, the variable for 100 metres was always omitted before the 300 metres variable.

RESULTS

Recreational values of the natural neighbourhood environment in the survey sample

On average, a citizen of the Scania region, inner city areas excluded, had access to only 0.67 recreational values within a 300 metres distance from their residence (fig 1). We estimated that more than 70% of the study population had a natural neighbourhood environment either without any of the recreational values (58%) or with only the culture characteristic present (14%) within 300 metres distance. The most prevalent of the five recreational values within 300 metres distance from the residences were culture and lush (both estimated to be present near 24% of all residences in the study population), followed by spacious (10%), serene (6%) and wild (5%). Restricting the distance to 100 metres lowered the prevalences markedly (culture 15%, lush 7%, spacious 5%, serene 4% and wild 1%). The proportions of individuals born in Sweden and living in their own houses were noticeably higher in residential areas where more than one of the five recreational values were present (table 1).

3. Lush—a place rich in species. A place offering a variety of wild species of animals and plants.
4. Spacious—a place offering a restful feeling of “entering another world”, a coherent whole, like a beech forest.
5. Culture—the essence of human culture. A historical place offering fascination with the course of time.
Associations with neighbourhood satisfaction

The number of recreational values near the residence was positively correlated with neighbourhood satisfaction ($p < 0.001$ both for 100 and 300 metres). The overall neighbourhood satisfaction was highest among house-owners but the association with the number of recreational values was much more marked for tenants (fig 2). The effect on neighbourhood satisfaction was also evident among individuals living in their own flats (not in figures). For house-owners, serene (OR 1.4, 95% CI 1.1 to 1.6) and wild (OR 1.4; 95% CI 1.1 to 1.8) within 300 metres had the strongest impact on neighbourhood satisfaction in the multivariable regression analyses, whereas serene (OR 1.7; 95% CI 1.3 to 2.3) within 300 metres, lush within 300 metres (OR 1.4; 95% CI 1.2 to 1.7) and lush within 100 metres (OR 1.4; 95% CI 1.0 to 1.9) were the most important recreational values for tenants.

Associations with physical activity and BMI

There was a clear positive correlation between the number of recreational values present within 300 metres distance from the residence and time spent on moderate physical activities ($p < 0.001$; fig 3). This association remained evident when adjusting for possible individual-level confounders in the multivariable analysis (table 2) and when the analysis was restricted to recreational values present within 100 metres (not in tables). No firm signs of effect modification by gender, age, or

| Table 2 | Ordinal regression analyses for the association between the number of recreational values of the natural environment within 300 metres from the residence and time spent on moderate physical activities and normal body mass index |
|-----------------|-----------------|-----------------|-----------------|
|                | All (N = 24 819) | House-owners (N = 14 520) | Tenants (N = 6390) |
| Time spent on moderate physical activities*† | Normal BMI‡§ | Normal BMI‡§ | Normal BMI‡§ |
| OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| No of recreational values within 300 metres | 4–5 | 1.44 (1.24–1.66) | 0.96 (0.81–1.14) | 1.33 (0.94–1.89) |
| | 3 | 1.41 (1.26–1.57) | 1.07 (0.93–1.22) | 1.26 (0.96–1.67) |
| | 2 | 1.13 (1.04–1.24) | 0.96 (0.86–1.08) | 1.09 (0.87–1.36) |
| | 1 | 1.08 (1.02–1.15) | 1.00 (0.92–1.08) | 1.24 (1.10–1.40) |
| | 0 | 1.00 (Ref) | 1.00 (Ref) | 1.00 (Ref) |

BMI, Body mass index.
*Ordinal scale with five categories: never (reference category), <1 h per week, 1–3 h per week, 3–5 h per week and >=5 h per week (see Appendix 1 available online only).
†Ordinal scale with three categories: obese (>=30 kg/m²; reference category), overweight (25–29 kg/m²) and normal (<25 kg/m²).
‡Adjusted for gender, age, born abroad, educational level, employment status, problems with paying bills, smoking status and type of residence.
§Adjusted for all individual factors in footnote †, except type of residence.
Negative aspects of built (man-made) environments have been linked to physical inactivity and obesity.

**DISCUSSION**

**Principal finding**

Recreational values of the nearby natural environment were positively associated with neighbourhood satisfaction, physical activity and, for tenants, with normal or low BMI. We also observed a positive association with vitality among women but less marked. No evident effect on self-rated health was detectable.

**Strengths and weaknesses of the study**

The major strengths of this study were the large number of participants and the extensiveness of the questionnaire, which made detailed confounding control possible. We used objective measures of the recreational values, which facilitated neighbourhood assessment for each residence using the GIS technique. Such assessment of natural surroundings should also be possible to conduct for other regions and countries if land types are included in the definitions of the recreational values.

A major limitation was that, on the basis of the available data, we could not assess the recreational values of the natural surroundings in inner city areas and the generalisability of the results to such areas is therefore uncertain. We did not adjust the results for urbanity because we aimed at estimating total (direct plus indirect) effects associated with nearby natural surroundings. The absence of recreational values in nearby natural surroundings correlated strongly with urbanity and the health effects of built and natural environments are therefore hard to separate. Another limitation was the cross-sectional

**Table 3** Ordinal regression analyses for the association between the number of recreational values of the natural environment within 300 metres from the residence and self-rated physical and psychological health and vitality

<table>
<thead>
<tr>
<th>No of recreational values within 300 metres</th>
<th>All (N = 24 819)</th>
<th>Men (N = 11 332)</th>
<th>Women (N = 13 487)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted for all individual factors in footnote †, except gender.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adjusted for gender, age, born abroad, educational level, employment status, problems with paying bills, smoking status and type of residence.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>†Adjusted for all individual factors in footnote †, except gender.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Ordinal scale with seven categories ranging from “Very poor (could not feel worse)” to “Very good (could not feel better”).
†Adjusted for gender, age, born abroad, educational level, employment status, problems with paying bills, smoking status and type of residence.
‡Adjusted for all individual factors in footnote †, except gender.

What this paper adds

Positive natural neighbourhood environments, assessed with objective measures, were rare and distributed in a socially inequitable manner in suburban and rural areas of southern Sweden. Furthermore, they were associated with neighbourhood satisfaction and high physical activity and to some extent with high vitality and with normal/low BMI.
Evidence-based policy and practice

Policy implications

Planning for and restoration of natural environments near residential areas should be seriously considered as an additional supportive tool to achieve sustainable and equitable health setup that limits definite conclusions regarding cause-effects. The participation rate was low (59%), although not lower than in similar studies. Participation was positively associated with determinants of socioeconomic status, which implies that some association between the outdoor environment and participation was probably present. This may have yielded a tendency to overestimate the strength of the associations, provided that participation was also positively associated with wellbeing.

The validity of the questionnaire should also be considered. The questions about vitality were taken from a well-established instrument, the SF-36 health survey. Reasonable overall validity of self-reported BMI was observed in a recent Swedish study but the fraction of obesity was markedly underestimated compared with actual measurements. Such underestimations of BMI, would, if non-differential with respect to the neighbourhood environment, produce bias towards the null. The question about self-rated health has shown high concordance with similar single-question measures. The questions about neighbourhood satisfaction and time spent on moderate physical activity were specific for the present and similar national and regional surveys.

The results in relation to previous studies

The effects of the recreational values of the natural environment on physical activity and on BMI among tenants were remarkably strong in relation to the individual determinants that we controlled for. The effects of objective measures of the quality of urban green space on physical activity were not evident in a study from the United Kingdom, whereas a large American study noted an average effect on body weight due to urban sprawl that was small but comparable in size with the effects of gender and smoking. In a study from Greenwich, London, dissatisfaction with green spaces close to the residence was positively associated with being in the lowest quartile for mental health, but was not associated with vitality, as measured by SF-36 subscales. Effects on mental health were not evaluated in the present study, whereas an association with vitality restricted to women was observed, using objective rather than perceived measures of the surroundings.

Contrary to most previous studies, our focus was on the effects of the natural neighbourhood environment and on areas characterised as suburban or rural. The effects of aesthetic qualities of the natural environment have been less clearly elucidated. Two Dutch studies reported associations between the percentage of green space (agricultural and natural) within 1–3 kilometres distance from the residence and self-rated health. Housewives, the elderly and individuals with lower education seemed to benefit more from access to green areas. No evident associations with self-rated health were found in the present study, which used measures of the surroundings much closer to the residence.

Possible mechanisms and implications

The current study highlights the importance of natural surroundings for neighbourhood satisfaction and for obesity avoidance among tenants in particular. Neighbour satisfaction is likely to increase general psychological wellbeing. Access to recreational values of the natural environment was rare and was distributed in a socially inequitable manner. It is likely that the access to a private garden makes the house-owner less dependent on the common natural environment for well-being.

Recent research from the United Kingdom has suggested that sociopolitical, physical and economic features of the neighbourhood environment could be more beneficial for women’s than for men’s health. In our study, the natural neighbourhood environment had a beneficial effect on vitality among women only. As women on average had a lower self-rated vitality than men, it can be argued that women may both have more need for and more benefit from restorative surroundings. It is also possible that women’s everyday lives are still more dependent on their close surroundings than men’s. It may be argued, however, that this would also have applied to the elderly, which we did not find.

A crucial task of public health at present is to support individuals in making healthy choices. Our findings imply that the natural environment is important for public health. Planning for and the restoration of natural environments near residential areas should thus be seriously considered as an additional supportive tool to achieve sustainable and equitable health. In this endeavour, the agendas for public health and natural environment indeed converge. Most natural surroundings close to residential areas do not, however, qualify for natural prescription programmes but should nevertheless be regarded as key areas for human health promotion.

Issues for future research

The research strategy of linking geographically determined exposures to individual information on health status and health-related lifestyles, obtained from public health surveys, represents a fairly novel and very promising pathway. The strategy has the potential for supporting the idea that investments in one sector (the natural environment) could very well yield considerable gains in another sector (public health). It also clearly opens up for further development by means of methods developed in health economics (eg, computing disability-adjusted life years) for estimating the monetary value of health gains of the kind described. This would most certainly be helpful in guiding political priorities, especially if applied in the context of a sustainable development framework.

Competing interests: None declared.

REFERENCES

Appendix 1 Survey questions about neighbourhood satisfaction and time spent on moderate physical activities per week

1. What is it like living in your neighbourhood?
   - Very good
   - Rather good
   - Rather bad
   - Very bad
   - Do not know/not relevant

2. On an ordinary week, how much time do you spend on moderately demanding physical activity?
   - At most 1 hour per week
   - At most 3 hours per week
   - Between 1 and 3 hours per week
   - More than 3 hours, but less than 5 hours per week
   - More than 5 hours per week
   - It may vary during the year but try to give an average estimate. Choose only one alternative!

Appendix 2 Criteria for the assessment of the five recreational values of the natural environment

<table>
<thead>
<tr>
<th>Serene</th>
<th>Wild*</th>
<th>Lush</th>
<th>Space</th>
<th>Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Included areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad-leaved forest</td>
<td>Mixed forest</td>
<td>Mixed forest</td>
<td>Mixed forest</td>
<td>Beaches, dunes, sand plains</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>Pastures</td>
<td>Marshes and mires</td>
<td>Beaches, dunes, sand plains</td>
<td>Bare rock</td>
</tr>
<tr>
<td>Inland marshes</td>
<td>Wet mires</td>
<td>All registered &quot;key biotopes&quot;</td>
<td>Bare rock</td>
<td>Sparserly vegetated areas</td>
</tr>
<tr>
<td>Other mires</td>
<td>Water courses</td>
<td>Pasture land of regional interest</td>
<td>Bird biotopes ref.</td>
<td>Burst areas</td>
</tr>
<tr>
<td>Lakes and ponds</td>
<td></td>
<td>Biodiversity areas</td>
<td></td>
<td>Natural grassland</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Moors and heathland</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Forest &gt; 25 ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Slopes &gt; 10 degrees</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Farmland pointed out in an national plan</td>
</tr>
</tbody>
</table>

| Excluded areas | | | | |
| Noise >30 dB(A) | Noise >40 dB(A) | <800 m distance to | Noise >40 dB(A) |
| No artillery range | | | | |

*All included areas for the Wild characteristics must either be located less than 1 km from a village or have a size above 15 ha.