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Access to Green Space in Disadvantaged Urban Communities: Evidence of salutogenic effects based on biomarker and self-report measures of wellbeing

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Abstract

This paper describes two case studies from Scotland, UK, exploring links between access to green space, perceptions of and activities in green space, and health and quality of life. One study involved a natural experiment to study the effects of improvements to woodlands near a disadvantaged urban community, compared with a similar community without such interventions. The second study, a recent, innovative study for the Scottish Government, demonstrated use of a biomarker as a method for measuring the salutogenic effects of environmental settings such as green space, offering evidence of environment-body interactions within a real-world context of people's everyday lives.

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Keywords:

1. Introduction

Green and open space is part of the wider landscape in which people live and work. The European Landscape Convention (Council of Europe, 2000) emphasises the importance of people's everyday

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landscapes – not just those designated as having special qualities. The appeal of the natural environment has long been recognized in aesthetic and wildlife terms (Ward Thompson and Travlou, 2009) but there has been a recent resurgence of interest in nearby access to green and natural environments because of their potential role in people's health and wellbeing (Marmot, 2010; Ward Thompson, 2011). The developed and developing world is facing a health crisis of alarming proportions as physical inactivity, obesity and mental illness increase. Awareness that the environment might play a role in enhancing health, and perhaps prevent illness at a fraction of the cost of post hoc medical intervention, has attracted attention from policy makers (Morris et al, 2006).

There is a growing body of research that has explored the relationship between green space and health, from national level epidemiological studies (e.g. Mitchell &Popham, 2007, 2008; Maas et al., 2008) to very localised case studies (Grahn et al, 2010) and experimental studies (Hartig et al., 2003). While there is some evidence of a relationship between green or natural environments and people's perceived overall general health (Bowler et al., 2010; de Vries et al, 2003; Maas et al 2006), mental health (Hartig et al 2003; Ottosson&Grahn, 2005; Grahn and Stigsdotter 2003), longevity (Takano et al, 2002), physical health (Humpel et at al 2002) and social health (de Vries, 2010; Maas et al 2009; Sullivan et al 2004), the relationships amongquality, quantity and use of green spaceand different health outcomes are still poorly understood.Nonetheless, a common theme across these studies is that green and natural environments might be salutogenic, i.e. health-enhancing, and contribute significantly to quality of life (Ward Thompson, 2011).

A study in the UK (Campbell et al., 2007) identified personal factors (such as health, income coping, and relationships with family and friends) as most important to quality of life but the quality of the neighbourhood was also identified as a key factor, including the availability of parks and green spaces, along with neighbourhood appearance and feeling safe, a sense of belonging and community spirit. In a separate study, a review of data across England (CABE, 2010) showed a strong link between people's satisfaction with their local parks and open spaces and their satisfaction with their neighbourhood.Concerns have been raised about inequalities in access to green and natural open space that appear to be associated with deprivation in urban populations (Macintyre et al, 2008; Mitchell &Popham, 2008), and which may contribute in turn to poorer health and quality of life. Conversely, there is a need for evidence to demonstrate whether green space planning, design and management can enhance health and wellbeing and contribute to a reduction health inequalities between different socio-economic segments of the population.

The studies described in this paper are attempts to address this evidence gap, firstly by investigating the effects of an intervention to improve local green space – in this case woodlands - for community use, and secondly, by investigating the associations between different amounts of green space in the local neighbourhood environment and residents' wellbeing and stress levels. In both studies, the participants were from communities with high levels of socio-economic deprivation, as it is among these populations that there is strongest epidemiological evidence for the links between green space and health (Mitchell &Popham, 2008).

2. Study 1

2.1. Study aims

The first study focused on urban forestry and was supported by the Forestry Commission Scotland (FCS). It took advantage of planned improvements to community woodlands under the FCS's Woods in and around Towns (WIAT) scheme to treat the intervention as a natural experiment, comparing two

communities in the same city, one where WIAT improvements were undertaken and one where no such improvements were undertaken. Further details of the study are reported in Ward Thompson et al (2013).

WIAT works with very deprived communities to regenerate local woods and promote them as safe and accessible places for enjoying the outdoors, with the ultimate aim of improving health and quality of life in towns and cities. The study compared attitudes to the neighbourhood environment and local woodlands, and use of the woodlands, before and after the intervention. The primary outcomes of interest were whether such an intervention impacts on behaviour patterns in relation to woodland use and physical activity levels, and/or influencesoverall perceptions of quality of the neighbourhood environment, over time.

2.2. Methodology

The research compared two communities in Glasgow, one (Drumchapel) where WIAT interventions took place and one (Milton) without such interventions, the latter acting as a comparator. These communities satisfied criteria for potential inclusion in the WIAT programme, both being communities of high socio-economic deprivation (within the top 15% of the Scottish Index for Multiple Deprivation (Scottish Executive Statistics, 2006)) and, in the case of the intervention site, being within 500m of woodlands earmarked for WIAT activity.

The first stage of the woodland intervention under WIAT included clearing of rubbish and signs of vandalism and the construction of improved footpaths, signage and entrance gateways. It also involved silvicultural work to improve the appearance and safety of trees and vegetation, including clearing sightlines along pathways to extend visibility and views. The second stage included both publicity and group-based activities to encourage knowledge of the woodlands ways to enjoy them. The intervention started with changes to the physical woodland environment in the winter of 2006/7 and was completed with community engagement activities in 2007.

A repeat cross-sectional survey of the community resident within 500 m of the local woodlands/green space was used to examine perceptions of neighbourhood quality of life, neighbourhood environment, and local woodland qualities, frequency of woodland visits and levels of outdoor physical activity. A random quota sampling approach to the household survey was used to match the sample (n=110 in the intervention site; n=106 in the comparison site) to the national census profile for age, gender, ethnicity and socio-economic group for each of the areas sampled.Although the baseline data showed a difference in age profile between the demographics of the two communities (the intervention community had more people aged 16-34 and the comparison community had more aged 65 or older), they were comparable in terms of overall deprivation. The focus of analysis was in change over time between 2006 and 2009 differed across the two study sites (Ward Thompson et al, 2013).

An interview-based questionnaire was developed to compare community perceptions and behaviour patterns between 2006 and 2009.It drew on previous community surveys used to elicit woodland perceptions and use in similar urban contexts in Scotland and on analysis of the factors most relevant to the research questions (Ward Thompson et al, 2005).The first section of the questionnaire covered satisfaction with quality of life and quality of physical environment (including local woodlands) in the neighbourhood. The second section covered physical activity, asking how much time per week, on average, respondents spent taking physical exercise outdoors, including walking. The third section asked for responses on attitudes, perceptions and values associated with local woodlands, covering issues such as ease of access, safety, quality of paths, and value as a place to be active or for a social visit. A final section covered frequency of visits to local woodlands and associated social activities. In addition, a range of individual demographic questions covered age, gender, occupation and other personal characteristics.

The focus of analysis was a comparison of the change over time (2006 to 2009) between the two sites,intervention and comparison. As the data was not normally distributed, nonparametric means tests (Mann-Whitney) were used. A principal component analysis with varimax rotation was run on the perception and attitudinal data to explore the pattern of associations between variables.

2.3. Results

Table 1 summarises the results of interest for this paper, indicating where significant change was found over time and the direction of change. Satisfaction with quality of physical environment in the neighbourhood increased three-fold over time in the intervention site, a highly significant change ($p < 0.001$)as compared to the comparison, where perceptions of the quality of the woodlands significantly declined over time ($p=0.005$). The importance of the quality of the local woodlands for quality of life of participants changed significantly in the intervention site only ($p=0.002$) and reflects fewer neutral respondents, with both positive and negative responses increasing by 20% of the sample.

There was a highly significant, five-fold increase in visits to the local woodlands in the intervention community ($p<0.001$), but none in the comparison. This was accompanied by a significant increase in summer visits in particular ($p=0.021$). When we looked for evidence that this was associated with an increase in physical activity, we found significant differences over time in self-reported physical activity across both communities. However, this was an increase in activity levels for the intervention community and a decrease for the comparison. For those in the intervention site who had visited their local woodlands in the last 12 months (a minority of the sample), there was a more significant increase in physical activity ($p<0.001$), than for those who hadn't visited the woodlands ($p=0.001$) but the positive change across this community suggests that the woodlands improvements alone are not responsible for this increase, although they may have contributed to it.

Perceptions of the woodlands' qualities reveal interesting patterns in helping to understand the above findings. In all cases where there was significant change over time in the intervention site, this was associated with a reduction in those 'neutral' about the issue and an increase both in positive and in negative responses. There was a significant different over time for the intervention site only in attitudes to the woodlands as places where one can pursue healthy activities ($p=0.001$), and as places where one feels safe ($p=0.039$), in both cases the positive attitude increased to a greater extent than the negative. However, the attitudes to litter in the woodlands, again only significantly different over time in the intervention site ($p=0.039$), increased more negatively than positively.

There were significant differences over time across both communities in attitudes to how difficult it was to get into the woodlands, and on the woodlands as a social place to visit with family and friends. However, this was reflected in a much larger positive than negative change in the intervention community (30% less of the sample finding it difficult to get into the woodlands, $p<0.001$, and 30% more of the sample seeing the woodlands as a place to visit socially, $p=0.003$), whereas the comparison community showed smaller changes, with 19% less of the sample seeing the woodlands as a place to visit socially ($p=0.001$).

The two aspects where there was significant change in the comparison site only were responses to: liking the natural appearance of the woodlands, where there was a 39% increase in the sample disagreeing with this statement ($p=0.016$); and to perceptions that poorly maintained paths make it difficult to visit, where there was a 16% increase in the sample who agreed with this and a 14% decline in those disagreeing ($p<0.001$).

Table 1. Study 1, Outcome measures and variables of interest showing significant change between 2006 and 2009 (Mann Whitney U test)

Variable	Intervention site difference between 2006 and 2009	Comparison site difference between 2006 and 2009
Satisfaction with quality of physical environment in neighbourhood	+ ***	ns
Quality of local woodlands	ns	-**
Importance of quality of local woodlands to quality of life	±**	ns
Visited woods in last 12 months	+***	ns
Frequency of woods visits summer	+*	ns
[at least once/week vs less often] [n=22 2006; n=50 2009]		
Time in outdoor physical activity for those who visited woodlands in last 12 months [n=22 2006; n=50 2009]	+***	-**
Time in outdoor physical activity for *those who did not visit woodlands* in last 12 months [n=192 2006; n=166 2009]	+**	-**
I can pursue healthy activities in the woodlands	±**	ns
It is difficult to get *into* the woodlands	±***	-**
The woodlands are free from litter	±*	ns
Poorly maintained paths make it difficult to visit woodlands	ns	+***
I like the natural appearance of the woodlands	ns	-*
I feel safe in the woodlands	±*	ns
The woodlands provide a place to visit with family and friends	±**	-**

Notes:

Unless otherwise indicated, Intervention n=110; Comparison n=105 (2006), n=106 (2009)

+ refers to % increase in those responding positively on the Likert Scale (strongly agree or agree)

- refers to % increase in those responding negatively on the Likert Scale (strongly disagree or disagree)

± refers to % increase both in those responding positively (strongly agree or agree) and in those responding negatively (strongly disagree or disagree) on the Likert Scale. The neutral intermediate category and ‘don’t knows’ are unreported.

*** $p<0.001$

** $p<0.01$

$p<0.05$

2.4. Discussion of Study 1

A key finding of the study is the highly significant difference in levels of woodland visits over time in the intervention site, versus static levels in the comparison site, although total woodland visits remained comparatively low across both sites in 2009. This, and the significant difference over time in frequency of summer visits for the intervention community, suggest the intervention has influenced the level of woodland visits. Results show significant differences over time at the intervention site in perceptions of the quality of the physical neighbourhood environment, an indicator of quality of life.

The study also found significant differences in attitudes to woodlands as places for physical activity and in perceptions of safety in the intervention site over time, compared with no significant change in the comparison site. The more highly significant difference in outdoor physical activity over time associated with those who do visit woodlands in the intervention site, suggests there may be some contributory effect from the intervention.

The intervention was associated with significantly different perceptions over time that local woodlands were not difficult to get into. Differences over time in perceptions of woodlands as safe and as a place to visit with family and friends suggest that the intervention has had a positive influence for some but a negative influence for others. Such complex differences in perceptions over time may reflect a greater general awareness of the local woods among the community in Drumchapel after the intervention, where people have a better sense of what the woodland experience is like. In support of this interpretation, a number of measures showed a sharp decline over time in the proportion of respondents who were neutralabout an aspect of the woodland environment in the intervention site – much more marked than in the comparison - with greater numbers both positive and negative but generally with a greater increase in those positive.

This studypoints to the potential contribution of quality of neighbourhood environment to quality of life (Campbell, et al., 2007), including the role of natural environments such as woodlands. The findings show that environmental interventions to improve green and natural space in deprived urban locations can have a positive impact on levels of use of the green space use and on perceptions of the environment. These changing perceptions and use may, in turn, be reflected in greater activity levels and quality of life.

The findings confirm the value of using a ‘natural experiment’ approach when assessing the impact of environmental interventions and highlight the need for further experimental work, with larger samples and better matching of comparison sites on environmental conditions. This study has acted as a pilot for a further study currently under way to address these issues, exploring the impact of woodland improvement interventions on community-level, self-report stress, wellbeing, physical activity and quality of life (Silveirinha de Oliveira et al, 2013).

3. Study 2

3.1. Study aims

The second study was undertaken by OPENspace researchers as part of the GreenHealth project, supported by the Scottish Government and part of a wider collaboration with the James Hutton Institute and the Universities of Heriot-Watt, Glasgow and Westminster. Its aim was to explore relationships between the amount of green space in the residential environment and different measures of health and wellbeing. Drawing on Study 1, described above, and other work by our collaborators suggesting that the beneficial relationship between health and green space access was stronger among deprived populations (e.g. Mitchell &Popham, 2008), Study2 focused on residents of deprived urban communities in Scotland.

The study built on recent research suggesting that contact with natural environments is associated with reductions in stress (Hartig et al., 2003; Ulrich et al., 1991), a possible explanation for the relationship between green space and health. It also drew on evidence that stress reduction associated with time spent in green or natural environments was measurable via patterns in participants' cortisol levels (Park et al, 2007; Lee et al. 2011; van den Berg and Custer, 2011).

The study sought to understand whether, among residents of deprived urban areas, the presence of different amounts of green space in the environment around people's homes was associated with varying levels of stress, mental wellbeing, physical activity and other measures or indicators of health. A number of different approaches were used to address this aim, the principal two being a household questionnaire survey and tests of salivary cortisol as a biomarker of stress, both analysedin relation to GIS-derived measures of levels of green space in the local environment.

3.2. Household survey

3.2.1. Methodology

The research used participants sampled from case study areas located in the cities of Edinburgh and Dundee, Scotland, likely to be areas experiencing high levels of deprivation, as measured using the Carstairs Index (Carstairs& Morris, 1991). These areas varied in the amount of green space nearby, from 22% to over 70% of the total area. Measures of green space quantity around each participant's home included parks, woodlands, scrub and other publicly accessible natural environments. For the household survey, such data were gathered at a detailed level and included private gardens.

The case study areas were surveyed using a random sample of participants (n=305)in a single, cross-sectional survey carried out in June 2010. The primary outcomes of interest were stress and mental wellbeing levels. A questionnaire was developed to explore these and other self-report wellbeing measures, perceptions of local green space, and patterns of green space use.

Stress levels were measuredusing the Perceived Stress Scale (PSS) (Cohen et al, 1983). Mental wellbeing was measured using the shortened version of the Warwick-Edinburgh Mental Wellbeing Scale (Stewart-Brown et al., 2009)**.** (SWEMWBS). In addition, physical activity was measured using one item asking for the number of days on which physical activity (of sufficient exertion to raise breathing rate) reached or exceeded 30 minutes, recalled over the past 4 weeks (Milton et al., 2011). We also included an overall measure of self-perceived general health, recorded using a simple, five-point ordinal scale.

The analysis took into account factors other than green space that might influence stress and mental wellbeing, such as age, income, and level of deprivation. In the findings described below, these potential confounders have been controlled for in the analysis.Analysis is ongoing for these data, so the results reported below only give an overview of some of the key findings, also reported inJames Hutton Institute et al (2013).More details of the findings will be presented in future publications.

3.2.2. Results

Firstly, GIS-based levels of green space were related toself-reported stress or mental wellbeing. Stress levels were inversely associated with green space quantity for both men and women, i.e. higher levels of green space were associated with lower levels of perceived stress. However, after controlling for confounding variables, green space was only a significant factor for men. There was no association between green space quantity and mental wellbeing for the total sample, although for women there was some suggestion of a reverse association, i.e. for some of the sample at least, high green space was associated with low mental wellbeing.

Secondly, people's perceptions of their local green space quantity and quality were considered. Interestingly, in contrast to the findings for GIS-based measures of green space quantity, people's

perception that there is 'sufficient local green space' was significantly associated with mental wellbeing for the total sample, but not significant for any other health or wellbeing variable. Satisfaction with the *quality* of the local green space, as opposed to quantity, was significantly associated both with lower stress and with higher mental wellbeing in the total sample, but not associated with physical activity levels or overall health.

Thirdly, people's reports of how often they visited it in a typical summer or winter month, were considered.80% of participants used their local green space at least once a year and 25% used their local green space daily. There was no significant difference in overall usage between men and women and in general usage was lower in winter than in summer.Frequency of use of local green spaces was positively associated with GIS-based measures of quantity of green space, and this relationship was stronger for summer than for winter levels of use. People's perception that there is 'sufficient local green space'was also significantly associated with higher frequency of visits, both in summer and in winter.

Frequency of use was associated with *higher* stress levels in women – a pattern, initially hard to explain, that appears to reflect a group of women in our sample with major recent life events and poor life conditions affecting their wellbeing. Frequency of use was associated with greater overall physical activity levels in women in summer and in winter, but for men only in summer.

Finally, people's reports of the activities they might do in green space and the social company (if any) they might choose for visiting it were considered. Figure 1 indicates people's reasons for visiting and indicates that many were seeking restorative qualities; relaxing, seeking peace and quiet and fresh air are important for a majority of the sample. About one third of participants usually visited their local green space with other people (35%), whilst 28% regularly visited alone, and 37% visited either alone or with at least one other person. Significantly more men visited alone compared to women.Social contact when visiting green space was associated with lower levels of stress for men and for women.Social contact was also associated with higher levels of mental wellbeing and general health for men, but not for women.

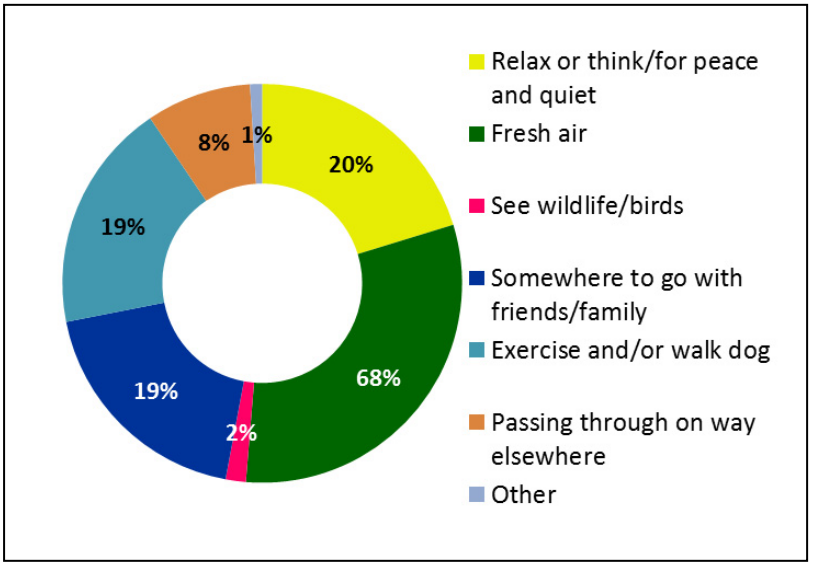

Fig. 1. Household Survey: reasons for visiting the local green space. Statistics are based on two reasons for visiting (participants n = 153).

3.3. Survey using cortisol measures

The survey using cortisol measuressought to understand better the mechanism behind any associations between levels of stress, mental wellbeing and green space quantity, and to elucidate any differences between men and women in this. In particular, it examined stress as measured by levels and/or patterns of cortisol secretion over the day, alongside self-report measures of stress and mental wellbeing, in relation to levels of green space in the local area. We sought participants from a narrower age range than the household survey, to minimise difficulties in interpretation of results because patterns of cortisol secretion vary by age. We also sought participants not in work for any reason because we were interested in any apparent influence of green space around the home on their stress levels; we surmised that those not in work would be likely to spend much of their day around the home compared with those in employment. Further details of this study are reported in Ward Thompson et al (2012) and Roe et al (2013).

3.3.1. Methodology

For the survey using salivary cortisol measures, a broader measure of green space was used than for the household survey, excluding private gardens (although participants indicated whether they had access to a garden). Green space measures were based on the Census Area Statistics (CAS) Ward of the participant's residence (see www.cresh.org.uk for details). The CAS Ward is a geographical unit used in the administration of the UK's decennial census.

The study was cross-sectional in design. The sample (n=106) was taken from men and women aged 33-55 years who were not in work for any reason (e.g. job-seeking unemployed, on invalidity benefit, carers) living in socio-economically deprived areas of Dundee as measured by the Carstairs indices of deprivation (Carstairs and Morris 1991), obtained via each participant's postcode.

Recruitment was carried out in two ways:via unemployment centres in Dundee and by door-to-door requests with follow-up appointments carried out by the research team. Participants were briefed on the protocol for cortisol sampling and completed a short questionnaire on individual characteristics, including how well the household was coping on current income, stress (PSS), wellbeing (SWEMWBS) and a single item measure of levels of physical activity, all as described above for the household survey. Repeated salivary cortisol sampling took place over two consecutive weekdays (4 times per day) with text prompts sent to participants as reminders. The data were gathered between January and June 2010.

In statistical analyses, we explored green space quantity as a continuous (percentage) variable and as a binary variable split at an optimal level (derived statistically) of plus or minus 43%. The term 'low green space' subsequently referred to here relates to areas with less than or equal to 43% green space, 'high green space' to areas with over 43% green space. We also considered gender, age and deprivation level as potential confounders; these are taken into account in the analyses described below.

3.3.2. Results

A greater diurnal cortisol decline was significantly associated (Pearson correlation, $p<0.01$) with the binary variable of high green space, compared to low green space. Thispattern is illustrated in Fig 2, showing that participants living in areas of higher green space had a steeper (healthier) cortisol diurnal decline (the green line) while participants living with lower neighbourhood green space had a flatter (less healthy) slope profile (the black line). Linear regression analyses also showed that the level of green space (measured as a continuous variable) was a significant predictor of perceived stress ($p<0.05$).Perceived stress was lower in high green space areas.

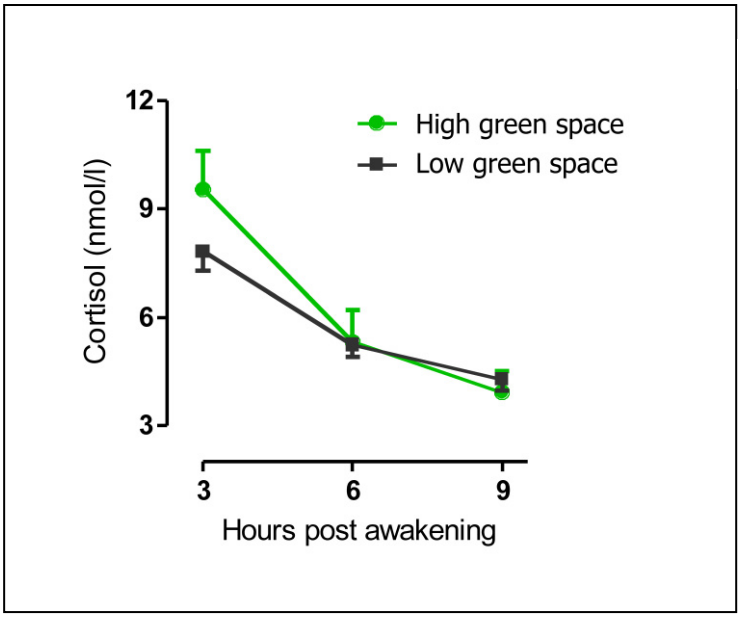

Fig 2. Difference in cortisol slope between participants living in high versus low greenspace areas (First published in Roe et al., 2013).

We found higher stress levels more frequently in women than in men (Mann-Whitney U Test, $p<0.05$) and, for men only, higher stress levels were associated with not having a garden. In linear regressions, gender was a statistically significant predictor of mean cortisol concentrations, with lower concentrations of mean cortisol found in women ($p<0.01$). As a steep cortisol slope is considered an indicator of better health, and higher mean cortisol levels were associated with steeper cortisol slopes; this supports the interpretation that women in our sample were suffering higher stress levels than the men.

We also found a significant linear regression interaction effect between percentage green space and gender ($p<0.05$): more neighbourhood green space was associated with higher – and healthier – diurnal cortisol levels among women.In low green space, women showed a 'low and flat' slope, indicative of prolonged and more chronic levels of stress. For men, lower green space was associated with a 'high flat' cortisol slope, considered a more typical stress response.In all three models, age was a significant predictor of stress: with increasing age, perceived stress decreased and mean cortisol concentrations were higher with a healthier—and steeper—diurnal slope

3.4. Discussion of Study 2

Our study 2 has shown that, for deprived urban populations in Scotland,perceived stress and mental wellbeing were both linked with green space quantity. The strength and direction of relationships varied by gender and likely amount of time spent at home.

For such populations, we showed that *quantity* of green space in the neighbourhood environment appeared to influence use and was associated with salivary cortisol as an independent measure – a biomarker – of stress. However, it was perceived *quality* of green space that was associated with lower self-reported stress and better mental wellbeing. Social engagement while using green space was also associated with lower levels of self-reported stress.

In almost all of the findings reported in this study, we found a different response in women than in men. This was associated with generally higher levels of stress found in the female sample compared with the male, and was further elucidated by the results from use of cortisol as a biomarker. We found a

significant association between higher levels of green space and lower levels of physiological stress, as indicated by diurnal salivary cortisol patterns in a sample of unemployed men and women, and showed that this differed by gender. Further, this was innovative in demonstrating an objective method for measuring the salutogenic effects of environmental settings such as green space within the context of people's everyday lives.

Unlike Study 1, Study 2 was cross-sectional in design and therefore cannot demonstrate causality.It is evident that more research is needed to understand better how perceptions and use of nearby green space may affect the pattern of stress associated with higher neighbourhood green space. Nonetheless, our study represents a valuable step in establishing a biological pathway linking green space with stress levels in deprived urban environments.

4. Conclusion

The findings of these two studies add to our understanding of the relationship between green space and health and suggest valuable ways forward for future research.

Firstly, they point to the importance of green and natural environments near to where people live, as potential contributors to relief from stress, mental wellbeing and quality of life.

Secondly, they suggest that some (but by no means all) of these health and wellbeing benefits may derive from the opportunity that green space affords for physical activity.

Thirdly, they point to innovative approaches to research on links between green space and health, such as the use of diurnal patterns of biomarkers to measure stress within everyday lives and environments. They also underline the value of natural experiments, where before-and-after studies of environmental interventions in green space can illuminate the effects of such interventions over time, especially if compared with a site where there is no intervention, to strengthen the evidence for any causal pathways that may exist between environment and health.

Finally, it is clear that deprived communities are sensitive to differences in, and changes to, their local green space, but that women respond to their environment in different ways to men, certainly in the Scottish context and possibly reflecting wider cultural contexts. We need to recognize the importance of the environment (and access to it) both for men and for women, but also be open to the possibility that it may turn out to be more important for women than for men to have free and easy access to green and natural space.

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