

Exploring the role of exposure to green space in preventing anxiety and depression among young people aged 14-24 living in urban settings: a systematic review

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Research Article

Keywords: Young people, green spaces, natural environments, anxiety, depression

Posted Date: March 2nd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-255123/v1>

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Abstract

Background

Despite the growing problem of anxiety and depression amongst young people aged 14-24 years living in urban settings, reviews about the role of exposure to green space or nature in preventing anxiety and depression tend to focus on children, adults or sometimes adolescents. This review aims to explore whether, and if so how, exposure to green space reduces the risk of anxiety and depression among young people aged 14-24 living in urban settings.

Methods

CINAHL plus, Global Health, MEDLINE, ProQuest: Dissertations and Theses, PsycINFO, Scopus and OpenGrey were searched for research published in English between January 2000 and June 2020, including all study designs.

Results

9,208 sources were identified and 48 were included. Experimental studies provided evidence that walking or being in a green space improves mood and state anxiety immediately following the intervention. Observational studies suggest that social interaction, physical activity, and mindfulness mediate the relationship between exposure to green space and mental health. We propose that the absence of noise and traffic and the presence of nature promotes mindfulness and restoration.

Conclusions

This review provides evidence to clinicians about the value of green social prescribing, and to policymakers about the value of bringing the benefits of forests, vegetation and nature into cities, and ensuring that these spaces are accessible and safe for young people to use.

Background

Urbanisation is a risk factor for poorer mental health.¹ The risks of urbanisation may be mitigated through increasing access to green space. Today, 55% of the world's population lives in urban areas, projected to increase to 68% by 2050.² Given that 16% of the 7.8 billion world population is aged 14–24 years³, there are up to 0.7 billion 14–24 year olds living in urban settings globally. Promoting good mental health in young people is vital as 20% of children and adolescents globally are diagnosed with a mental condition.⁴ Young people's mental health is an increasing concern in light of the Covid-19 pandemic⁵, along with access to green space during lockdowns.

The relationship between green space and mental health has been demonstrated in a number of systematic reviews with adults. These show an association between exposure to greenspace and/or outdoor nature-based interventions, and reduced symptoms of stress, depression and anxiety, and increased wellbeing.^{6,7} Regarding children and adolescents, previous systematic reviews have shown beneficial associations between exposure and access to greenspace, and depression and anxiety symptoms, mood, mental well-being, cognitive development, stress and emotional and behavioural difficulties.^{8,9,10,11} These reviews are limited by not seeking to clarify the extent to which research has explored if and how green space can reduce the risk of developing clinical levels of anxiety and/or depression. Furthermore, reviews have not focused on “young people” aged between 14–24. This age range is of great interest as the majority of mental health conditions develop during these years.¹²

The use of psychological theory to understand links between mental health and green space has been limited. Attention Restoration Theory has often been cited¹³. However, previous reviews identified a lack of clear definition of what

constitutes exposure to green space as an active ingredient in interventions. It is vital to explore what type and “dose” of green space may be linked to mental health.

This review takes a novel approach to examining the evidence about the role of exposure to green space or natural environments in preventing depression and anxiety in young people aged 14–24 living in urban settings. Prevention of depression and anxiety can be thought of as reduction in symptoms of these “disorders” that disrupt functioning^{14,15}, or as a reduction in processes associated with anxiety/depression (such as stress, rumination or lack of positive activity) or improvements in mental wellbeing¹⁶. We sought to include a wide range of evidence from different disciplines and using any study design, in order to understand causal mechanisms, as well as to quantify effectiveness.

Methods

Search strategy, study selection and inclusion criteria

Key terms for three main concepts were created and used in the literature search: population, exposure, and outcome. Our definition of exposure to green space encompasses (i) proximity to urban green spaces such as parks, or vegetation (for example, as measured by the normalized difference vegetation index (NDVI)¹⁷) and (ii) exposure through activities or interventions that take place in green or natural environments (e.g. walking or adventure training). We also included terms for ‘blue space’ (such as lakes), although this field of research is more recent. Following Wolpert et al (2019)¹⁸, we use a broad definition of anxiety and depression, including self-report of stress or low mood. As our focus is on prevention, we included these broad terms to identify studies that may improve mental health or reduce symptoms of mental “disorder”, as indicating reduction in risk of anxiety and depression.¹⁴ Medical Subject Headings (MeSH) were also used where possible. The search terms and strategy for each database can be found in Additional File 1. The following databases were searched; CINAHL plus, Global Health, MEDLINE, ProQuest: Dissertations and Theses, PsycINFO, Scopus and OpenGrey. All databases were searched in July 2020. Further relevant studies were added from reference lists of previously published systematic reviews. PRISMA guidelines were followed.¹⁹ The screening process and inclusion/exclusion criteria are shown in Figure1.

Data extraction and critical appraisal

Quantitative sources were assessed for quality, including risk of bias for each study, using the Effective Public Healthcare Panacea Project’s Quality Assessment Tool for Quantitative Studies²⁰; the global score (strong/moderate/weak) is derived from rating six quality criteria and a summary score for the number of criteria scored as ‘Strong’ was created (but not used to exclude studies). For other study designs, CASP tools were used²¹, and a similar summary score created. Two researchers completed quality assessments and data extractions for each paper, with benchmarking between each pair of assessors. If the global score differed, this was discussed until agreement was reached.

Role of contributors with lived experience

A panel of seven young people (aged 14 to 24) with lived experience of anxiety and/or depression participated in age-specific focus groups at two stages: 1) to help determine the scope of the review (discussing aspects of being in green or natural spaces they found helpful in terms of reducing anxiety and depression) and 2) to interpret the findings of the review and offer insights into causal pathways.

Data Synthesis

Due to the breadth of this review, there was a wide range of summary measures, and it was therefore not possible to conduct a meta-analysis. Similar studies were grouped together with a narrative synthesis for each group. Details of the characteristics and results of each table were summarised in supplementary tables, along with information about possible mediators or causal pathways, and a summary quality score. In interpreting the findings, we drew on insights from young people with lived experience.

Results

After removal of duplicates, we screened 9,208 titles and abstracts, and 702 sources were eligible for full text screening (Figure 2). After further exclusions (76% of which were due to the age range not being relevant), 89 sources were considered against four key criteria (these additional inclusion criteria are listed under 'Full-Text Screening' in Figure 1). They relate to the target age range (14-24 years), study design (experimental), exposure (neighbourhood green space) and outcome (anxiety disorder or depression). 48 sources met at least two of these criteria and were included in the review.

Study Design and Quality Assessment

The majority of studies (n=47, 98%) were quantitative. These included randomised trials (n=14), and non-randomised intervention studies (n=22), cohort studies (n=4) and cross-sectional surveys (n=7). There was strong initial agreement between the reviewers for global quality scores for these studies (90%). Areas of strength identified included approaches to dealing with confounders, use of validated outcome measures and low drop-out. This low attrition reflects that very few studies did follow-up post-intervention. Other areas in which quality was not generally highly rated were in representativeness of the sample (e.g. response rates were not reported), and blinding, which is important given the self-reported nature of outcomes. The one remaining paper was purely qualitative. Quality scores are reported for each paper in supplementary tables.

Evidence Synthesis

Studies that compare urban streets, urban parks and forests

Thirteen of the studies described experimental designs that compared (walking or being in) urban settings with neighbourhood green space or forests. These consider different environments; over the last 10 years a body of research has developed comparing exposure to forests and urban environments^{22,23,24,25,26,27,28,29,30}, complimented in more recent years by studies on urban parks.^{31,32,33,34} These studies provide evidence that a brief exposure to a green environment elicits an immediate increase in mood and reduction in state anxiety (Table 1; scales used to measure outcomes are listed in Table 7). One study reported longer-lasting effects following exposure to a forest than a park³² and estimated reductions in state anxiety are greater following visits to forests^{22,27} than parks.^{33,34} The dose of interventions ranged from 15 minutes^{24,26,27,33,34} to 3 days^{22,28}.

Studies that assess particular aspects of being in green/natural environments

A further 8 studies (7 of which were experimental), assess particular aspects of being in green or natural environments: the colour green³⁵, natural soundscapes^{36,37}, natural scenery^{38,39}, natural materials⁴⁰, indoor exposure to plants^{41,42} and to animals⁴¹, reported some positive changes in various outcome measures (see Table 2). For example, levels of anger were lower when viewing green (compared with red) scenery³⁵, listening to natural sounds was shown to be more restorative than anthropogenic sounds³⁶, and touching wood induced feelings of comfort (compared with marble).⁴⁰

Studies that compare physical activity in a green/blue environment and indoors, or evaluate physical activity programmes

Three experimental studies compared exercise in a green or blue environment with doing the same exercise indoors. The first intervention was a walking route along a canal.⁴³ Compared to an indoor walking route, this led to increased connectedness with nature, mediated by positive affect. Also, that participants tended to underestimate the positive hedonic effects of the outdoor walk. The second involved cycling on a static bike on the edge of a green field and found greater increases in vigour, but not self-esteem, when exercising in the blue environment.⁴⁴ The third paper compared horse-trekking in a green environment with riding on an indoor simulator, so involved contact with the animal as part of the intervention, and reported improvements in feelings of anxiety and depression (Table 3).⁴⁵ Two further randomised trials assessed reported improvements in mood⁴⁶ and sleep following⁴⁷ outdoor running programmes. A before-and-after study reported reductions in social anxiety following a 2-month climbing programme.⁴⁸ Finally, one study compared the effects of doing outdoor exercise on mood in an induced goal-oriented state compared with baseline state; improvements in mood occurred only in the baseline group.⁴⁹

Studies that evaluate outdoor adventure programs, and education/training/employment in green environments

A further set of observational studies (Table 3) consider the mental health benefits of outdoor adventure opportunities and indicate that wilderness excursions of 9-10 days lead to increased mindfulness and reduced stress⁵⁰ and engender greater self-esteem through group belonging.⁵¹ Studies evaluating longer (3-15 weeks) outdoor education programs also found measurable improvements in stress⁵², self-esteem⁵³ and social anxiety⁵⁴. Much shorter interventions also resulted in positive changes in the autonomy, competence, relatedness and enjoyment subscales of the Intrinsic Motivation Inventory⁵⁵ and a reduction in anxiety after a one-day experiential training session in a local park.⁵⁶ In contrast to the experimental studies, some of these evaluations included follow-up. Although benefits are not consistently sustained (intrinsic motivation one-month post-intervention⁵⁵, there were some longer-term effects on general mood at 3 months⁵² and depression symptoms (at approximately 9 months)⁵⁶. A park-based prospective cohort study compared a violence prevention and mental health promotion after-school program with other after-school clubs, using youth crime rates as a proxy for violent behaviour⁵⁷. They reported lower adjusted youth arrest rates three years post-intervention for the park-based programme. A comparison of mindfulness training in a botanical garden greenhouse with conventional (indoor) mindfulness training concluded that the green environment particularly helped beginner meditators to overcome problems with concentration and stress.⁵⁸ Two studies also evaluated employment interventions in green or natural environments.^{59,60} The first is a qualitative study of a group of young people who completed a training programme and then undertook 2-3 months' work experience in an entry-level "green job".⁵⁹ More than half of them described a positive change in their attitude towards themselves during this time, and 94% of them cited gaining new knowledge and skills as a positive aspect. The second was a before-and-after study of a one-year conservation program. Quantitative findings suggested improvements in anxiety and social functioning, while qualitative themes included new skills and training, developing friendships, co-operation and the benefits of being outdoors in terms of health and happiness.⁶⁰

In contrast to the studies of tightly controlled interventions delivered to homogeneous samples (Tables 1-3), the observational studies reviewed above (Table 4) include more complex interventions, with multiple components potentially contributing towards outcomes. There is a common thread, of exposure to a green space or natural environment, but each intervention includes additional elements, comprising either education or training (50%) or outdoor adventure (50%). Some also involve reflection on these experiences^{50,51,52}, which could be another important element. Evaluations of such interventions have studied group dynamics but have less often included mental health and subjective wellbeing as outcomes⁵⁰.

Studies of exposure to residential vegetation

Five studies (Table 5) consider the relationship between exposure to vegetation and a variety of outcomes. Exposure to vegetation is commonly measured using NDVI, 'an indicator of greenness based on land surface reflection of visible (red) and near-infrared parts of the spectrum.'¹⁷

Dzhambov et al (2018) provides a longitudinal analysis of NDVI and mental health, including symptoms of depression and anxiety, at follow-up.⁶² The authors found a relationship between exposure to neighbourhood green/blue space and mental health, as measured by the 12-item General Health Questionnaire.⁶³ Herrera et al (2018) also provide longitudinal evidence, which may offer an insight into causal pathways - they report that greater levels of residential greenness when participants were aged 16-18 years are associated with lower levels of work discontent and work overload (measures of work stress) when they reach age 20-23 years, suggesting a protective effect when transitioning to university or working life. In cross-sectional analyses the association between NDVI and mental health appears to be mediated by physical activity and restoration, though this does not hold in longitudinal analyses⁶². A later cross-sectional study found that NDVI was negatively associated with both anxiety and depression symptoms, and reported the following variables as mediators – perceived greenness, the restorative quality of the neighbourhood, dispositional mindfulness, rumination and resilience to stress.⁶⁴ Another cross-sectional study reported a negative association between NDVI and serious psychological distress (using Kessler 6 scale⁶⁶, which measures symptoms of anxiety and depression), and found that this relationship was mediated by pollution and social cohesion.⁶⁵ There is further evidence that NDVI is associated with reduced symptoms of depression (Bezold et al 2018).

Studies of young people's perceptions of green spaces

Another group of studies provided insight into how green spaces are perceived by young people, and how this could mediate the relationship between green space and mental health (Table 6). An experimental study compared perceptions of bamboo forests with those of an urban environment.²⁹ The forest was rated as providing a better environmental experience in terms of sensory perception, atmosphere, climate, space and place. An observational study compared different views in Tokyo.⁶⁷ More trees in the view increased spaciousness and monotony. Oppressiveness was reduced in views with more trees and more sky, and increased in views with more buildings. Finally, increasing distance to trees reduced perceived oppressiveness and danger. This would suggest that the optimal environment is one in which trees and sky dominate rather than buildings, but with some distance to the trees. An experimental study by Wilson et al (2016) found that walking in an urban park is perceived as being more restorative than walking on a busy street near traffic, and that perceived noise mediates perceived restoration.⁶⁸ Yang et al (2011) showed that plants cause 'psychological noise reduction'; in other words, a green environment reduces perceived noise levels.⁶⁹ Alizadeh et al (2018) examined personal preferences for different green (forests, agricultural) and natural (mountains) landscapes and predictors of these, and found that personality type and subject studies are associated with preference, suggesting that it is important to consider personal preferences if the impacts of green spaces are reliant on their use.⁷⁰ Taken together, this set of studies suggest that greener environments are preferred, and are associated with restoration, partly by reducing perceived noise levels.

Narrative Synthesis

There is good evidence that a 15-minute walk in a forest or park can improve mood and state anxiety (compared to an urban environment).^{26,27} It is not clear, however, whether this corresponds to a reduced risk of developing anxiety or depression. The impacts of different components of nature can be broken down, and such studies provide evidence of the restorative qualities of viewing or listening to nature, with associated improvements in mood and relaxation.^{36,37,38,39} There is less good evidence about the social and psychological processes, such as activation or rumination, resulting

from the opportunities for physical activity and restoration afforded by green space, or how these link to psychological disorders. There is limited evidence about how young people perceive green spaces, and how this affects their use of green space.

Insights from young people with lived experience

Based on the literature and input from young people with lived experience of anxiety and depression, we suggest a tentative psychological pathway to explain how the restorative qualities of green spaces might lead to increased mindfulness and interrupted rumination⁷², and how a reduction in negative stimulation could enable restoration and possibly a reduction in the risk of anxiety disorder and depression. Our panel confirmed that the absence of technology in green spaces, which was mentioned in some of the evaluations of adventure programs, allowed mindfulness, interrupted rumination and restoration to take place. They also suggested that an absence of traffic encouraged mindful walking. Both observations demonstrate that it may be as much what is absent in green spaces as what is present (e.g. nature) that provides restoration. The panel related to the relaxing effect of being in green spaces, and felt that this enabled problem-solving, thereby providing a link to another factor which is beneficial for young people's mental health.

What works for different groups

Few studies compared results for males and females, despite clear differences in the epidemiology of mental health disorders in adulthood which emerge during adolescence. One exception, Kardjono (2017), suggests that a 4-week hiking programme reduced social anxiety for males, but induced preintervention anxiety for females.⁵⁴ In an evaluation of a climbing programme, while Ozen (2015) found that a climbing intervention reduced social anxiety overall, with no differences between men and women.⁴⁸ Of the thirteen experimental studies described in Table 1, eight included only males. The one study that included only females reported similar results, suggesting that exposure to forests or parks have similar effects for males and females.²⁷ In terms of age groups, most of the experimental studies (Tables 1-3) were carried out with student samples of very similar ages, so results cannot be compared by age. Educational or adventure programmes were positively evaluated for both school-age teenagers and students (Table 4).

Few studies in this review considered ethnicity as a moderator. While 61% of the experimental studies (Tables 1-3) were carried out in Asia, the predominantly observational studies (Tables 4-6) have a global spread. Included studies did not consider effectiveness in different socio-economic groups. Many of the experimental studies used students as participants, who are unlikely to represent all socio-economic groups. Two US studies reported ethnic and socio-demographic diversity within their sample, but neither of these studies report results for different groups.^{57,59}

It is notable that much of the experimental research considered in this review focuses on forests as the exposure or intervention. Some studies reported elevated state-anxiety immediately prior to a walk in a forest, which suggests that this can be an unfamiliar or even threatening environment.

One study found some evidence that young people's preferences for mountains, forest and agricultural landscapes is linked to personality type.⁷⁰ We also found some evidence that the impacts of exposure to green spaces and outdoor exercise might be moderated by personality type²⁶ or by psychological state.⁴⁹ For example, those with high-trait anxiety levels experienced a greater reduction in feeling of "depression–dejection" after walking through forest areas than those with normal and low-trait anxiety levels²⁶, and differences in goal-orientation explain why individuals do not all respond in the same way to exercise.⁴⁹

Discussion

We synthesised a wide range of evidence about the role of access to green space in preventing anxiety and depression amongst 14–24 year olds. We found evidence that exposure to forest environments leads to greater momentary mental wellbeing compared to being on an urban street, and that urban parks can deliver similar benefits to forests. These studies did not provide evidence about longer-term outcomes such as symptoms or diagnoses of anxiety or depression. However, the evidence from observational studies that residential exposure to vegetation is associated with reduced risk of depressive symptoms for young people is crucial in terms of implementing change that will have broad reach and lasting benefits.⁶¹ Observational studies also provide some insights into causal mechanisms, such as links between green space and restorative properties leading to reduced rumination.^{62,64} While adolescents spend more of their time further from home than children, young people are less likely to own cars or have access to private gardens. Neighbourhood green space and vegetation is therefore crucial to their well-being (as recognised in the Sustainable Development Goals).⁷³

The importance of green space is partly because it enables many other activities that benefit mental health. It is hard to disentangle the impacts of green space and mediators such as physical activity or social interaction. The psychological processes by which green space may reduce the risk of anxiety or depression are unclear. Many of the included studies cite Kaplan and

Kaplan's Attention Restoration Theory (1989).⁷⁴ This contested theory⁷⁵ suggests green space engages indirect attention and thus provides rest for directed attentional capacity, and therefore presumably interrupts unhelpful rumination or worry. The papers reviewed suggest that green spaces promote mindfulness, mediated by physical activity and restorative qualities. We hypothesize that this in turn reduces rumination⁷¹ and improves psychological outcomes. Others have suggested that greenspace reduces the tendency to ruminate and thereby increases adaptive coping through enhanced psychological resilience.⁷⁶ Similar benefits might be afforded by the practice of mindfulness⁷⁷, but this requires training and effort. It seems that green environments encourage 'effortless mindfulness', and this is supported by one study that found a green setting when learning mindfulness was particularly helpful for beginners.⁵⁸ An evaluation of a hiking programme encouraged participants to reflect on the natural surroundings and engage in 'active mindfulness'. It has been found that regular mindfulness can promote trait mindfulness⁷⁸, providing a possible pathway to a sustained reduction in the risk of psychological disorders.

Recommendations for research

In order to understand if exposure to green space prevents anxiety and depression amongst people aged 14–24 years, it is essential that more studies examine longer-term follow-up. Further research must explore the "dose" and frequency of exposure associated with longer-lasting impacts indicative of prevention of anxiety and/or depression. Another recommendation for future research is to measure changes in psychological processes such as rumination and activation that are key to anxiety and depression, and to utilise psychological theory to underpin explorations of the impact of green space on mental health.

The studies used a wide variation of interventions/exposures, considering different types of green space, different durations and varying activities. To allow an improved dialogue with mental health science, these interventions could adopt a more structured way of reporting the contents of the exposure, similar to those laid out in the TIDieR guidelines.⁷⁹ Systematic reporting would then allow investigations into impacts of green space on mental health to be more readily evaluated, replicated and potentially implemented.

We identified a gap in the literature on 14–24 year olds in terms of factors, such as perceptions, that promote use of local green spaces; such evidence is crucial to ensure that built environment professionals take into account the needs of this age group in both policy and decision-making. More generally, there seems to be a lack of qualitative work with this age

group to understand the benefits of green spaces for mental health, and what the causal mechanisms might be. Although it was included in our search terms, we found few studies about the benefits of blue spaces for young people's mental health. This reflects the finding of our earlier scoping review, in which only 2% of sources related to blue spaces, but this is a rapidly growing area of research, and its importance was underscored by comments from our PPI panel about the beneficial effects of blue spaces. Future studies should also consider the role of demographic variables, previous experiences (e.g. with outdoor activities) and individual preferences (for different environments).

Recommendations for practice

Recommendations for practice should be interpreted with some caution, as there is limited evidence regarding prevention itself. Recommendations might include consideration of social prescribing of adventure interventions for young people at risk of anxiety and depression. Although evaluations of such interventions provide some limited evidence of sustained effects on general mood and feelings of depression^{52,56}, there is as yet no clear evidence about the dose or frequency required to have a lasting impact, which may be a barrier to prescribing. Outdoor adventure opportunities should also be integrated into educational curricula. High-quality longitudinal studies are still needed to estimate the long-term effects of regular exposure to green space on clinical measures of anxiety and depression. However, based on the studies we reviewed and the insights of our panel, we conclude that access to green space is likely to enhance other interventions to improve mental health, such as physical activity^{43,45}, mindfulness practice⁵⁸ and problem-solving. It also has multiple additional benefits⁸⁰ in terms of health and wellbeing for the rest of the urban population, improving thermal comfort and biodiversity in cities, and reducing pollution and risk of flooding, all of which have implications for the future health of today's young people.

Limitations

We have taken a novel approach to reviewing the evidence about exposure to green spaces and mental health for young people, drawing on a wider range of literature than previous reviews, and including the views of young people themselves. While this approach has helped bridge a gap (from immediate psychological responses to changes in clinically measurable depression or anxiety disorders), we acknowledge several limitations. Firstly, the search terms and databases we used may have missed relevant papers. Secondly, screening was carried out by one researcher. Thirdly, though we set out to include all study designs, the review is heavily weighted towards quantitative research. This is partly due to the limited qualitative research on this topic with young people, but also partly due to the additional exclusion criteria at the full text screening stage, which sought to select the most relevant sources from a large number of eligible studies. Nevertheless, it is worth noting that many of the included studies applied quantitative approaches to qualitative descriptions of attitudes or feelings, and some used mixed methods.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was funded by a Wellcome Trust Mental Health Priority Area 'Active Ingredients' commission awarded to IB at the University of the West of England, Bristol. For the purpose of open access, the author has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission. The funder did not influence the reporting of results.

Authors' contributions

IB, DS and FM developed the aims and research questions. IB, DS, FM and RH developed the inclusion and exclusion criteria. The literature search was completed by RR and DS. Title screening was completed by IB following piloting by IB and FM. Full text screening, quality assessment and data extraction were completed by RR, IB, DS and RH. Data synthesis was carried out by IB. RR and IB wrote the first draft of the paper. All authors contributed to editing the manuscript. The authors had the final responsibility for the decision to submit.

Acknowledgements

The authors thank Pauline Shaw, Subject Librarian at UWE, Bristol, for her advice with the literature searches and all the public contributors for their insights.

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Tables

Table 1. Main characteristics and results of studies that compare urban streets, urban parks and forests.

Author	Location	Sample	Type of Study	Intervention	Outcome measures ¹	Results	Mediators/causal pathways	QA ²
Franek et al 2013	Czech Republic	4 studies using psychology undergraduates. Age range across studies = 19.6-20.7 yrs.	Repeated measures experimental designs and one study is an observational survey.	Walking routes with and without greenery.	Walking speed measured in all studies. Study 4 measured emotional reactions using model by Mehrabian and Russell.	Significant effects of type of section on perceived emotional reactions on the environment: pleasure $p < .001$, arousal $p < .001$, dominance $p < .001$. Significant effects of type of section on perceived fascination $p < .001$, being away $p < .001$, compatibility $p < .001$, coherence $p < .001$.	Study 4 investigated potential causal pathways for Studies 13, with environmental factors affecting participants desire to leave.	2
Hassan et al 2018	China	60 university students (50% male). Mean age = 19.6 yrs.	Randomised controlled crossover trial.	15 mins walk predetermined courses in a bamboo forest and a city area (control).	Semantic differential method (SDM), State-Trait Anxiety Inventory (STAI).	Significantly higher scores were observed for the adjectives "comfortable," "relaxed," and "natural" ($p < 0.01$) after walking in the bamboo forest than after walking in the city area. Total state anxiety scores were significantly reduced after bamboo forest walking compared with the city area walking (bamboo forest: 35.0 ± 7.39 and city area: 41.9 ± 9.78 ; $p < 0.01$).	Blood pressure was significantly reduced - relaxing effect.	3
Lee et al 2011	Japan	12 healthy students. Male only. Mean age = 21.2 yrs.	Within groups 3-day field experiment.	15 mins viewing a broad-leaved forest and an urban environment.	Profile of Mood States (POMS).	Significant differences were found between the forest and urban sites for the tension-anxiety subscale (forest: 42.4 ± 1.5 ; urban: 61.8 ± 3.4 ; $p < 0.01$).	Forests have a positive effect on autonomic nervous system and reduces salivary cortisol. Sympathetic nervous system suppressed in the forest.	3
Lee et al 2014	Japan	48 Japanese participants. Male only. Mean age = 21.1 yrs.	Randomised controlled trial in 4 different prefectures with 12 participants in each. 2 groups of 6 completed intervention and control.	Self-paced walking in forest for ~12-15 mins.	STAI, POMS - Shortened Version, 13-scale questionnaire using SDM, measure of feeling 'refreshed'.	STAI levels were largely decreased after forest walking (33.2 ± 6.9) compared with after urban walking (45.2 ± 8.9 ; $p < 0.01$). After forest walking, significantly decreased values were found in POMS subscale of tension-anxiety (T-A, 35.6 ± 4.0 at the forest site and 41.6 ± 7.6 at the urban site; $p < 0.01$). Significantly higher scores were observed	Forest walking significantly increased parasympathetic nervous activity and decreased sympathetic nervous activity compared with urban walking. Forest-oriented stimulations facilitate the relaxation of central and autonomic nervous activities to suppress the secretion of stress hormones.	3

						for the “refreshed” feeling after forest walking (65.5 ± 10.7) compared with those for urban walking (50.4 ± 13.2 ; $p < 0.01$).		
Lyu et al 2019	China	60 healthy university students. Male only. Mean age = 21.8 yrs (experimental group), 21.6 yrs (control).	Randomised controlled trial. Participants either exposed to a bamboo forest (3 groups of 15 participants at different forest settings) or an urban environment (1 group of 15 participants).	Bamboo forest therapy program in a bamboo forest or exposure to a city urban environment over the course of 3-days.	POMS.	Scores of negative moods for tension-anxiety, depression-dejection, fatigue, confusion and anger-hostility significantly decreased after the bamboo forest program ($p < 0.05$). No difference was found in the scores of any of these negative moods after the urban program.	Systolic blood pressure was significantly lower after a three-day bamboo forest therapy session. The SpO ₂ (peripheral oxygen saturation) of participants was higher after the bamboo forest program than before the program.	4
Mao et al 2012	China	20 healthy university students. Male only. Mean age = 20.79 yrs.	Randomised controlled trial. Participants divided into 2 groups of 10.	2 walking trails for 1.5 hrs (with 10 min break) through a forest or an urban site.	POMS.	For the forest bathing condition, the scores in the negative subscales, such as tension, depression, anger, fatigue, and confusion, were lowered ($p < 0.05$); however, the positive score for vigour was increased.	Serum cortisol concentration was significantly lower in subjects exposed to a forest environment than in those exposed to an urban environment. These findings indicate that subjects staying in a forest environment showed a reduced stress response.	3
Song et al 2014	Japan	17 Japanese students. Male only. Mean age = 21.2 yrs.	Within subject's design. Participants completed the walking course in an urban park and city environment.	15 mins predetermined walking course in an urban park compared with nearby city area.	STAI, POMS.	Total STAI score was 14.3% lower after the urban park walk compared with that after the city area walk (urban park: 41.6 ± 7.0 (mean \pm standard deviation), city area: 48.6 ± 6.3 ; $p < 0.05$). Scores for the negative subscales of POMS tension-anxiety and fatigue were significantly lower after walking in the urban park than after walking in the city area ($p < 0.05$). There were no significant differences in the scores for depression, anger-hostility, and confusion.	The physiological measures suggested a beneficial effect of walking in an urban park, similar to that expected from a forest setting/yoga/massage, which may explain the psychological outcomes.	2
Song et al 2015	Japan	23 university students.	Controlled clinical trial. Participants	15 mins walking through an	SDM, STAI, POMS.	Significantly higher SDM scores were observed following	No significant differences in	3

		Males only. Mean age = 22.3 yrs.	took part in both conditions.	urban park and 15 mins walking through the city.		the urban park walk than those following the city area walk for the following three adjectives: "comfortable", "natural", and "relaxed" (p <0.01). The total STAI score was 19.3% lower after the urban park walk than after the city area walk (urban park: 39.0 ± 6.3; city area: 48.4 ± 7.5; p <0.01). Differences were also detected in the POMS scores for the negative subscales of tension-anxiety, anger-hostility, fatigue, and confusion being significantly lower after walking in the urban park than after walking in the city area (p <0.05).	walking speed. The intervention induced physiological relaxation. Compared with those after a brief walk in the city area, parasympathetic nervous activity was significantly enhanced, sympathetic nervous activity was significantly suppressed, and heart rate was significantly lower during a brief walk in the urban park.	
Song et al 2018	Japan	585 Japanese participants. Males only. Mean age = 21.7 yrs.	Cross-over trial on 2 consecutive days. Control was a walk in an urban environment.	15 min forest walk.	STAI, POMS - shortened version.	Scores for tension-anxiety subscale on POMS were significantly lower after walking through forest areas compared to city areas (forest, 36.1 ± 5.4; city, 41.3 ± 7.7; p <0.01).	Participants with high-trait anxiety levels had a more effective reduction in the feeling of depression-dejection after walking through forest areas compared with those with normal and low-trait anxiety levels (participants with high-trait anxiety, N = 325; participants with normal and low-trait anxiety, N = 260; p < 0.05).	4
Song et al 2019	Japan	60 Japanese students. Females only. Mean age = 21 yrs.	Randomised controlled trial with 12 participants at each site (6 sites total). Cross-over trial on 2 consecutive days.	15 min walk in a forest area and city area.	STAI, POMS.	The state anxiety score of the STAI was 34.8 ± 7.2 after walking in a forest area, significantly lower than 45.3 ± 7.1 after walking in a city area (p <0.01). Participants felt significantly more "comfortable," "relaxed," and "natural" when walking in forests than when walking in city areas (all p <0.01). Significant differences between the forest and city areas were observed for all the POMS subscales rated after walking and for the total mood	Walking in a forest was associated with significantly higher parasympathetic nervous activity and lower sympathetic nervous activity and heart rate.	4

						disturbance score. The subscale scores for the tension-anxiety subscale in forest and city areas were 1.1 ± 1.8 vs. 2.9 ± 2.8 .		
Tsunetsugu et al 2013	Japan	48 Japanese participants. Males only. Mean age = 21.1 yrs.	Cross-over trial over 2 days.	Viewing 4 forest sites from a seated spot for 15 mins.	POMS, 13-scale questionnaire using SDM techniques, Measure of feeling 'refreshed'.	For the POMS scores, viewing the scenery in the urban areas increased tension-anxiety ($p=0.00$). The landscapes of the forests were evaluated as being significantly more "comfortable" ($p=0.00$, $r=0.51$), "soothing" ($p=0.00$, $r=0.53$), and "natural" ($p=0.00$, $r=0.59$). Viewing the scenery in the forests induced significantly higher refreshment ($p=0.00$, $r=0.55$).	Physiological outcomes agreed with psychological outcomes. Suggests forest areas have positive effects in terms of relaxation. Just viewing forest landscape, not necessarily walking, has positive effect on mood and anxiety.	3
Wallner et al 2018	Austria	60 healthy pupils from 3 schools in Vienna. Mean age = 16.6 yrs. 30 males, 30 females.	Mixed repeated measures controlled trial. Between subjects variable was the school. Within subjects variables was the site.	Exposure to 3 different settings at lunchtime with 7 days in between each. Settings included an inner urban small park, a larger park with some trees, and a large forest.	Wellbeing measured using The Nitsch Scale, cognitive performance test.	Significant differences between 3 green space types for dimensions recuperation, tension/relaxation, state of mood, readiness for action, and readiness for exertion. For forest, significantly less decrease of wellbeing after return to classroom compared to small or large urban park (readiness for action: $p < 0.001$; readiness for exertion: $p = 0.027$; state of mood: $p < 0.001$; tension/relaxation: $p < 0.001$). Concentration performance (d2-R test) significantly higher after green space exposure for all sites ($p < 0.001$). Increase post small urban park 7.5 (SD 9.7), post large urban park 15.5 (SD 11.7), post forest was 5.3 (SD 11.0). Highest performance increase found for large park; this increase was significantly higher ($p = 0.008$) than the	Findings may support stress reduction and attention restoration theories.	3

						increase after stays in the other green spaces.		
Zeng et al 2020	China	120 university students aged 19-24 yrs. 60 males, 60 females. (15 males and 15 females in each group).	Randomised controlled trial. Participants divided into 4 groups and exposed to 1 of 4 environments.	Viewing (15 mins in morning) and walking (15 mins in afternoon) in a bamboo forest or urban environment.	SDM.	Following the three-day bamboo forest therapy, participants showed a significant difference in their environmental evaluation (SDM) relative to those at the urban city site. In terms of sensory perception, atmosphere, climate, place, and space, the subjects reported a better environmental experience in the bamboo forests.	Physiological indices supported the SDM questionnaire results.	3

1. References for measures are given in Supplementary Material 8.

2. Quality assessment score out of 6

POMS, Profile of Mood States; *POMS*, Profile of Mood States - Shortened Version; *SDM*, semantic differential method; *STAI*, State-Trait Anxiety Inventory.

Table 2. Main characteristics and results of studies that assess particular aspects of being in green/natural environments.

Author	Location	Sample	Type of Study	Intervention	Outcome measures ¹	Results	Mediators/causal pathways	QA ²
Akers et al, 2012	UK	14 healthy participants. Males only. Mean age 20.7 yrs.	Controlled clinical trial. Within subjects.	5 mins simulated cycling whilst viewing outdoor environment video in various colours.	Profile for Mood States (POMS).	No differences reported for anxiety or depression subscales of POMS. Anger was higher during red colour video compared to green (38.6 ± 1.3 vs 37.0 ± 0.0 , $t_{13}=4.6$, $p=0.0005$, $\eta^2=0.619$, $d=1.741$) and compared to grey (38.6 ± 1.3 vs 37.1 ± 0.5 , $t_{13}=4.0$, $p=0.001$, $\eta^2=0.552$, $d=1.523$).		3
Benfield, 2014	USA	133 university participants. 72 females, 61 males. Mean age = 19.09 yrs.	Randomised controlled trial. Participants assigned to 1 of 4 conditions.	Watching a stress inducing video followed by listening to a soundscape (either natural sounds, natural sounds with voices, natural sounds with motorized noise, or no sound as a control).	Brief Mood Introspection Scale (BMIS).	Significant BMIS change by sound condition was shown for Pleasant-Unpleasant sub-scale ($F=7.62$, $p<.001$, partial $\eta^2=.150$) and Positive-Tired subscale ($F=6.36$, $p<.001$, partial $\eta^2=.126$); a marginal interaction between sound condition and affective restoration was also shown for the Negative-Relaxed subscale ($F=2.18$, $p=.094$, partial $\eta^2=.048$). The natural sound condition showed greater recovery from the upsetting video compared to both the control and anthropogenic sound conditions. For the Pleasant-Unpleasant score, participants in the natural condition were the only ones to show improved affect from post video ($M=38.89$, $SD=8.22$) to post-recovery ($M=44.31$, $SD=6.95$).		2
Buttelmann and Röpcke, 2014	Germany	71 undergraduate students. 65 females. Mean age = 22 yrs, range = 18.829.8 yrs.	Controlled clinical trial. Participants allocated to 1 of 4 conditions but not randomly allocated.	Sitting in a room with either a dog, fish, plant or nothing (control) for 5 mins.	State-Trait Anxiety Inventory (STAI) - German adaptation, Pet Attitude Scale (PAS), Audience Anxiousness Scale (AAS).	A reduction effect was found in all three experimental conditions: in the fish group, induced anxiety was reduced on average by 58.2%; in the dog group by 56.2%; and in the plant group by 45.6%. There were significant differences in the decrease in induced anxiety between groups (one-		1

						way ANOVA, $F(3,67)=8.232$, $p \leq 0.001$, $\eta^2 = 0.271$). Engaging in contact with a dog, a fish, or a plant for an intervention time of no longer than 5 minutes can result in anxiety alleviation in a non-clinical setting.		
Chan, 2015	China	'Mostly young students' (study 1) and 'mostly healthy students and staff' (study 2). Study 3 (patients and relatives) are excluded.	Within subject's design. No control group.	Viewing nature videos on a PC screen. Videos of water, forest, mountains, sunrise, sunset. Experiencing coloured lights in a tent.	Relaxation level as measured on a 5-point self-report scale.	The majority reported a positive relaxing effect after viewing the films; 89% scored the relaxation effect of watching the natural films as fairly strong/strong. Most common descriptors were 'relaxing' (33%), followed by 'comforting' (15%) The most relaxing colours were green (15/65=23%), purple (20%), blue (17%) The least relaxing colours were red (31/62=50%), blue (18%), green (7%)		0
Chang, 2008	Taiwan	110 participants - students and faculty members from a university.	Within subjects. No control group.	Viewing 12 images on a screen, 10 secs each. E.g. mountain, wilderness, gardens, sunset, view from window, water.	Perceived Restorativeness Scale (PRS).	Viewing natural environments with features of 4 restorative components improved psychological responses. The images ranked first on the PRS Fascination component and second on Compatibility. The images proposed as examples of the four restorative components were generally rated as hypothetically selected, although not cleanly enough to be treated as representing those components.		2
Hassan, 2017	China	40 healthy agricultural university students. 20 males. Mean age = 19.6 yrs.	Controlled clinical trial.	Viewing a bamboo plant in a room vs viewing an empty pot (control).	STAI.	Participants' mean anxiety score decreased after viewing the bamboo plant compared with control ($p < 0.01$) STAI score females, bamboo view: 32.7 ± 6.7 ; control view: 37.9 ± 7.4 . STAI score males, bamboo view: 34.0 ± 6.7 ; control view: 39.2 ± 7.1 .	Viewing a plant indoors can lower blood pressure which in turn help to can reduce anxiety - links to the autonomic nervous system.	1
Ikei, 2018	Japan	19 healthy female	Within subjects. No	Touching wood (experimental)	Semantic differential method	Participants feeling "slightly comfortable"	Increases in parasympathetic	2

		university students. Mean age = 21.2 yrs.	control group.	or marble (control) slabs with soles of feet.	(SDM).	after touching Hinoki and “indifferent to slightly uncomfortable” after touching marble. Touching Hinoki induced significantly more comfort than touching marble (p <0.01).	activity shown. Physiological relaxation effects shown when touching the wood.	
Tedja and Tsai, 2015	Taiwan	66 architecture university students. Mean age = 20.25 yrs. Age range 18-33.	Within subjects. No control group reported.	Listening to 15 secs soundscape videos. Sounds were of indoor and outdoor water sounds.	Participants rated perception/emotion. Scales divided into attractiveness and serenity. One of the sub-scales for serenity was ‘anxious-peaceful’ - participants had to rate on a 7-point bipolar scale. (e.g. -3 = anxious, 3 = peaceful, 0 = middle point).	92% of the participants had a positive impression of a soft, quiet, and mid frequency sound (gentle stream) due to the listening impression of relaxation and comfort. 77% of the participants had a negative impression of a loud, intense, and broadband sound (rain on glass roof), due to the listening impression of noisiness and agitation. 62% of the participants preferred the sound of rain on water due to the listening impression of quiet over rain on different materials such as woods, metal, glass, tent, and pavement.	Gentle stream and fountain noises can be used for restoration and relaxation.	0

1. References for measures are given in Supplementary Material 8.

2. Quality assessment score out of 6.

AAS, Audience Anxiousness Scale; *BMIS*, Brief Mood Introspection Scale; *PAS*, Pet Attitude Scale; *POMS*, Profile of Mood States; *PRS*, Perceived Restorativeness Scale; *SDM*, semantic differential method; *STAI*, State-Trait Anxiety Inventory - German Adaptation.

Table 3. Main characteristics of studies evaluating physical activity programmes activity in a green/blue environment.

Author	Location	Sample	Type of Study	Intervention	Outcome measures ¹	Results	Mediators/causal pathways	QA ²
Flowers et al, 2018	UK	60 undergraduate students. Mean age = 19.9 yrs.	Randomised controlled trial. Mixed methods.	Indoor vs Green: Indoor - stationary cycling 15 mins in lab with view facing blank screen and grey wall; Green - stationary cycling on the edge of a large sports field consisting of flat grass-covered area interspersed with trees and hedge perimeter.	Profile for Mood States (POMS) - Shortened Version, Rosenberg's SelfEsteem Scale.	There was a marginally significant interaction effect of treatment x time on vigour (p=0.043); the green-control group experienced a greater improvement in vigour (M=2.00, 95% CI 1.06-2.94) than the indoor control group (M=0.60, 95% CI -0.461.66). The interaction of time x treatment had no significant effect on self-esteem.		2
Kalak et al, 2012	Switzerland	51 healthy high school pupils. Mean age 18.3; female 53%.	Randomised controlled trial. Experimental group (morning running) and control group (morning no exercise).	Vigorous physical exercise (planned and continuous cross country running, beginning on running track then into forest, for 30-37 minutes without interruption at a speed such that conversation is not possible) at 7am every school day morning for 3 weeks (total 15 sessions). Control group mustered at same place and time but did not run.	Perceived Stress Scale (PSS), coping with stress questionnaire, Curiosity and Exploration Inventory.	Analyses done of Group effects (test v control) and Time (beginning of 3 weeks, end of 3 weeks). Main analysis was group x time interaction. Significant findings for somatosensory amplification (p < .01) and insomnia severity (p < .001) only.		4
Legrand and Thatcher, 2011	France	55 first year university students from a sport and physical education department in north eastern France. Mean age = 21.1 yrs. 62% male.	Students randomly allocated to conditions but no control group.	Walking outside on a track by the university campus for 15 minutes. In telic condition, individual feedback was given after the first lap of the track (600m) on pace and it needing to be constant. In the para-telic condition no feedback was given on pace/ability.	Mood measured with the TensionEffort Stress Inventory (TESI), meta-motivational state measured using the Telic State Measure (TSM).	Following exercise, para-telic group had higher scores of pleasant mood states (p < .01). Post hoc analyses within each group - walking resulted in significant increase in pleasant mood states for the participants who were in the	-	2

						para-telic state, $p < .02$, but not for those who were in the telic state. Unpleasant mood states also revealed a significant group x time interaction ($p < .01$). The mean score for unpleasant mood states did not differ significantly between the two groups at initial assessment but significant after walking ($p = .03$).		
Matsuura et al, 2011	Japan	26 students with no disabilities. Males and females. Aged 19-25 yrs.	Controlled clinical trial. No separate group for control.	Horse trekking for 30mins along route outside between fields/forest/road/meadow vs 30mins on indoor riding simulator.	State-Trait Anxiety Inventory (STAI), POMS.	No significant interactions between exercise and time in 'tension-anxiety' and 'depression-dejection' subscales. There were effects of time. Depression-dejection scores were lower in horse trekking condition compared to riding simulator exercise. Anxiety-absent scores and anxiety-present scores were lower after horse trekking than after exercise with riding simulator ($p < 0.01$). Horse trekking had a greater psychological effect than the riding simulator exercise.	Authors note that change of landscape, wind, and conversation with other riders are associated with horse trekking but not with using a riding simulator. Emotional wellbeing is also expected through interaction with a horse. Larger variations in physiological measures were found than in psychological measures, and these might be on the causal pathway eg. changes in parasympathetic nervous activity.	4
Nisbet and	Canada	150 university students. 85	Randomised controlled	Outdoor walking route along a canal vs an indoor	Positive and	ANOVA showed that	The studies showed that	2

Zelinski, 2011 - study 1	female, 56 male, 9 unspecified. Mean age = 20.8 yrs.	trial.	walking route. Walk lasted ~17 mins. Participants were also randomly assigned to be experiencers or forecasters of emotions.	Negative Affect Schedule (PANAS), Inclusion of Nature in Self (INS) scale.	experiencers and forecasters did not differ significantly in their ratings of positive affect but did differ in their ratings of negative affect: forecasters reported significantly less negative affect than experiencers, $F(1, 145) = 4.02, p = .05$. The interaction for negative affect was not significant. Participants failed to fully anticipate the hedonic benefits of contact with nearby nature. INS scores were higher for experiencers who walked outdoors ($M = 4.44, SD = 1.64$) than for experiencers who walked indoors ($M = 3.05, SD = 1.61, t(70) = 3.63, p < .01, d = 0.86$).	walking outdoors facilitated a sense of nature relatedness; the feeling of relatedness seems to have been mediated by the positive affect produced by walking in nearby nature. Feeling more related to nature can make you want to spend more time in nature.	
Nisbet and Zelinski, 2011 - study 2	80 university students	Within subject's design.	Same as study 1 but walks were along different routes.	Same as study 1.	Participants who walked outdoors underestimated the substantial hedonic benefits of the walk, and participants who walked indoors overestimated their postwalk moods. Outdoor walks again produced greater state nature relatedness (INS score: $M = 4.18$ for outdoor participants and $M = 3.45$	Same as study 1.	2

						for indoor participants), and this effect was again mediated by positive affect (Sobel Z= 3.15, p< .01; bootstrapping path = 0.62; 95% CI = [0.22, 1.18]).		
Ozen, 2015	Turkey	30 university students. 17 male, 13 females.	Rock climbing was practised by participants for two months (two days in weekdays and one day at the weekend). There was no separate control group reported.	Recreational rock climbing either on artificial walls or real rock surfaces. The participants climbed in groups.	Anxiety measured using the Social Anxiety Scale for Adolescents (SAS-A).	Results suggest a significant improvement in social anxiety levels of students participating in the rock-climbing course. There were no gender differences.	Social cohesion as rock climbing was completed in groups, and physical activity.	2
Walter et al, 2013	Germany	23 apprentices at Karlsruhe Institute of Technology, Germany; 52% female, stratification of gender (50% female in experimental, 55% control group); mean age 19.43 (± 1.85) years.	Randomised controlled trial. Stratified for gender.	Aerobic endurance intervention conducted over 10 weeks during winter months. Participants in the intervention group participated in instructed outdoor running training twice a week. The control group participants were instructed not to alter their physical activity and exercise patterns during the control period; a continuous endurance method was applied to experimental group - initial duration of 30 min was continuously increased to 60 min over the 10 weeks, and intensity was progressively increased by adding short intervals of 2min above the individual training heart rate after week 6.	Mood.	Mood assessments: compliance with completing assessments reduced over time. Acute effects at T1 no significant effects. Acute effects across T1-T3 no significant effects. Medium term mood changes - no significant effects. For the mean values across the whole intervention period (T1-T3), energetic arousal, valence and calmness increased immediately after a training session (E: +10.4%; V: +17.8%; C: +6.2%) but results were not significant (and arousal and calmness		4

						effect sizes were low). Valence findings were "marginally significant" at p= 0.07.		
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1. References for measures are given in Supplementary Material 8.

2. Quality assessment score out of 6.

BAGE, Belief About Green Exercise questionnaire; *INS*, Inclusion of Nature in Self scale; *PANAS*, Positive and Negative Affect Scale; *POMS*, Profile of Mood States - Shortened

Version; *PSS*, Perceived Stress Scale; *SAS-A*, Social Anxiety Scale for Adolescents; *STAI*, State-Trait Anxiety Inventory; *TESI*, Tension-Effort Stress Inventory; *TSM*, Telic State Measure.

Table 4. Main characteristics and results of studies evaluating outdoor adventure programmes, and education/training/employment in green environments.

Author	Location	Sample	Type of Study	Intervention	Outcome measures ¹	Results	Mediators/causal pathways	QA2
D'Agostino et al (2020)	USA	The intervention was offered in areas with a population that was 48% male, 60% Hispanic, and 29% non-Hispanic black. In all, 33% of households were single parent and 33% were low income. The program served a mean (SD) of 501 (37) youths per year; total population 34,046.	Prospective cohort study.	Fit2Lead: a park-based violence prevention and mental health promotion afterschool programme	Juvenile arrest rate (per 10,000 youths ages 12 to 17 years across all targeted zip codes), and change in arrest rates (all offenses) per year among youth ages 12 to 17 years across matched zip codes for 3 years before and after program implementation (2013-2018).	Adjusted Difference-in-Differences Poisson Regression Estimates of the Association of Program Implementation with Youth Arrest Rates Within 36 Zip Codes in Miami-Dade County, Florida. After programme implementation - incidence rate ratio (IRR) (95%CI) 0.84 (0.84-0.85) p <.001. Programme present - IRR (95%CI) 2.05 (1.65-2.56) p<.001 Program present × after program implementation - IRR (95%CI) 0.81 (0.76-0.85) p <.001.		2
Falxa-Raymond et al 2013	USA	12 males, 4 females, 16/20 were BAME, basic education status.	Qualitative.	Completing a training programme and then 2-3 month's work experience in an entry-level "green job".	Flexible open-ended questions through semi-structured interview, transcripts processed using NVivo software.	Thematic analysis revealed key themes; motivations, knowledge/skills, attitudes, significance of environmental work, and challenges faced. Motivations included: inspired by significant others both before (88%) and during work placement (69%), interest in environment (69%), being an "outdoor person", contributing to environmental benefits (19%), work pride. Attitudes included: Change in attitude toward self, positive (56%) or neutral (25%); toward work, 31% appreciated the freedom offered, 13% negative toward work; toward the environment - 81% had a positive outlook toward the environment following the job, and 56% had greater awareness of local environment.		7/9 ³
Kanters et al 2002	USA	Medical students from cohorts 1997 (n=26), 1998 (n=57), 1999 (n=52).	Cohorts 1999 received the intervention. Cohorts in 1997 and 1998 were	Outdoor experiential training activities conducted at park close to	Profile for Mood States (POMS).	There were significant between-group differences for early semester anxiety-tension (F = -16.75, p <.001), early semester	The activities were designed to create group cohesiveness and foster social support.	2

			control groups.	campus during the year.		vigour activity (F = 8.96, p <.01), exam period depression-dejection (F- 4.99, p <.05), and exam period fatigue-inertia (F = 6.09, p <.05). Outdoor experiential training had a significant effect on several mood states. Measures of anxiety-tension, vigour activity, and depression-dejection mood states before the freshman semester were significantly lower for subjects in the intervention group than those reported for the control group.		
Kardjono et al 2017	Indonesia	62 male and 16 female freshman students (analysed separately) from the Physical Education and Health Department at the Indonesian University of Education. Ages typically ranged from 18 to 20 years.	Controlled trial.	4-week Hiking Program, with a frequency of hiking 3 times in one week difficulty of the hiking was gradually increased subjects were encouraged to enjoy and learn about nature and to freely meditate.	The Liebowitz Social Anxiety Scale (LSAS).	For men, there was a reduction in anxiety in both groups, but it was stronger in the intervention group (p <0.05). For women, there was a larger reduction in anxiety in the intervention group, but this was due to elevated levels before the intervention. There was no evidence of an effect (p <0.25).	Suggested mediators are fresh air, natural scenery, 'active meditation'	1
Lymeus, 2019	Sweden	Students (n=159 recruited, but data used from 139). Participants experienced stress or concentration problems in their daily lives as students, and with no or little meditation experience.	Randomised controlled trial.	Restoration skills training (ReST) in a botanical garden greenhouse compared with traditional indoor mindfulness training	Perceived Restorativeness Scale (PRS), Perceived Stress Scale (PSS), Swedish Core Affect Scale (SCAS) and the Toronto Mindfulness Scale (TMS).	ReST seems to help people with stress and concentration problems to meditate effortlessly and learn important restoration skills. ReST was also attended by generalized attentional performance improvements similar to those achieved with CMT. The ReST course confers sustained psychological health benefits with regard to dispositional mindfulness and self-perceived cognitive functioning. Regarding chronic stress, the benefits were less consistent and less sustained. The main finding is that the ReST approach to		2

						mindfulness mindfulness training appears to support beginning meditators with concentration problems and stress better than conventional mindfulness training.		
MacKenzie et al 2018	New Zealand	22 high school students. Mean age=15.7 yrs. 59% male.	Within subjects. No separate control group.	5-day outdoor adventure- based science course at a residential school near a lake, state park and ski area.	Self-report intrinsic motivation and self determination measured with the Short Flow State Scale (SFSS) and the Intrinsic Motivation Inventory.	The analysis of variance showed main effects for steps per day, flow, intrinsic motivation, autonomy, competence, relatedness, enjoyment, value and learning climate were significant ($p < .001 - p < .05$). Post-hoc comparisons indicated that steps per day, flow, intrinsic motivation, autonomy, competence, relatedness, enjoyment, and learning climate were all significantly higher in the OASC setting compared to both pre and post school settings.	The current results complement literature identifying psychological benefits of outdoor adventure, such as increased outdoor skill- based self-efficacy, autonomy, and positive academic attitudes and motivation.	3
McAnally et al 2018	New Zealand	104 boarding school students. Males only. Mean age=14.43 yrs.	Cohort study. Students from 2 schools assessed during week 2 and 15 of school year.	Tihoi school - outdoor education programme where students do 3 days of outdoor activities (kayaking, rock climbing etc) per week as well as 4 days of normal school classes. St Pauls - main school with no outdoor programme.	Satisfaction with Life Scale, Rosenberg Self- Esteem Scale, Strengths and Difficulties Questionnaire (SDQ), Remote Associates Test, School achievement, Gratitude questionnaire.	Life satisfaction St Paul's boys did not show any change in scores over time whereas life satisfaction increased among the boys at Tihoi. St Paul's boys did not show any change in their self-esteem scores over time whereas self-esteem increased among the boys at Tihoi. The outdoor education group out-performed the normal school group on the creative thinking task at both time-points (2 and 15 weeks into the school year), but there was no difference between the groups on the change in scores over time. We also found that boys attending the Tihoi programme had improvements in self- reported life satisfaction, self- esteem, and gratitude over the study period.	Social cohesion and physical activity were important parts of the programme.	2
Mutz and	The Alps	12 pupils from	Pre-post	9-day hike	Perceived	Perceived stress	A major focus of	3

Müller 2016 - study 1		a German high school (14yrs). 5 females, 7 males.	design. No control group.	across the Alps ~175km. The hike focuses on values of self direction, initiative, leadership and personal responsibility.	Stress Questionnaire (PSQ), General Self-efficacy Scale (GSES), Mindful Attention and Awareness Scale (MAAS), subjective wellbeing (SWB).	partially decreased after intervention. The PSQ subscale on "worries" decreased (effect size =-0.47, p=0.069). A moderate to large change is demonstrated for the PSQ subscale "demand", where participants report significantly lower values after the completion of the hike (effect size =-0.66, p=0.022). Results also reveal a large increase in mindfulness (effect size= 1.32, p=0.001) among participants. SWB was affected substantially by the excursion: The mean life satisfaction score increased significantly (effect size=0.58, p=0.034). The increase in happiness was also considerable but failed to reach significance by a narrow margin (effect size=0.47, p=0.064).	the excursion was around social cohesion and leadership.	
Mutz and Müller 2016 - study 2	Norway	Experimental group - 15 undergraduate students from a German university. Ages 19-25yrs. 8 male. Control group - 7 students.	Pre-post design. Experimental group and control group (did not participate in excursion).	Summer excursion 8 days exploring wilderness and being in nature. Hiking, climbing, fishing, swimming in lakes, camping etc.	Same as study 1.	Intervention was associated with moderate to large changes in almost all aspects of mental health measured. First, participants indicate reduced stress according to the PSQ subscales "worries" (effect size -0.53, p =0.030) and "demand" (effect size = - 0.92, p =0.002). Participants scored higher in mindfulness (effect size = 0.54, p =0.027) and self-efficacy (effect size = 0.90, p =0.002) after the intervention. Mean life satisfaction score increased significantly by 0.67 points (effect size = 0.68, p =0.010). Participants reported a large gain in momentary happiness after the excursion (effect size = 1.48, p <0.001).	Same as study 1.	3
Oppert et al 2014	South Africa	76 grade 10 students. Males only. Ages 15-16 yrs.	Pre-post design with follow-up. No control group.	'The Journey'- a 23-day outdoor adventure education	The Bar-On Emotional Quotient Inventory (Bar-On EQ-I), The	The results of the MANOVA univariate tests show that all EQ facets differed significantly over time (p <0.05). The results		3

				programme. The students participate in different activities and reflect on their participation. It facilitates the development of emotional intelligence.	Bar-On Emotional Quotient Inventory Youth Version (Bar-On EQ-I;YV).	indicate a significant difference in total EQ scores from pre- to post1 (medium effect size), and from pre- to post2 (medium effect size), which suggests that participation in the intervention results in an increase in emotional intelligence skills. Participation in the intervention results in a sustainable increase in overall emotional intelligence, but with regard to the sustainability of the subskills acquired, the effect on certain skills is more lasting (i.e. intrapersonal skills, adaptability and general mood) than on others (i.e. interpersonal skills and stress management).		
Scarf et al 2018	New Zealand	173 youth aged 15-19 yrs. Experimental n=100, control=73.	Control group did not go on the voyage. Outcomes measured on day 1 and final day of the voyage.	10-day voyage on a sailboat around New Zealand. Tasks and activities were completed during the trip.	Self-esteem using the Self-Description Questionnaire III (SDQ III), Life Effectiveness self-concept sub-scale, group belonging.	Voyage participants experienced an increase in self-esteem from Time 1 to Time 2, $t(99)=5.143, p < .001$, while control participants did not, $t(72)=1.283, p = .204$. Voyage participants ($n=97, M=18.155, SD=2.977$) reported higher levels of group belonging than did control participants ($n=72, M= 14.486, SD=3.548$), $F(1, 167)=53.236, p < .001, \eta^2p=.242$. Study 1 revealed that participants' sense of belonging to their Watch Group predicted increases in self-esteem following the 10-day voyage. Study 2 replicated this result and showed that the relationship between group belonging and self-esteem remained when controlling for self-efficacy and group esteem.	Group work and social cohesion were important aspects of the trip.	1
Wolf and Housley 2017	USA	218 Washington Conservation Corps (WCC) members pre-test, 240 post-test. Ages	Cohort. No separate control group.	Everyday work settings in urban forests, wildlife habitats, parks. Work	PSS, health overview, personal effectiveness measured using The Review of	WCC participants reported less perceived stress compared to others in their national age cohort both before and after their service year.	Employment, social cohesion and physical activity.	3

	1834 yrs with the majority 22-24 yrs.		involved park improvements, ecological restoration and biological monitoring.	Personal Effectiveness with Locus of Control (ROPELOC).	Paired sample t-tests indicated a significant decline in perceived stress during the conservation work period. In terms of health, WCC participants were more likely to report feeling tired, worn out, and with more aches and pains in the last month of their employment compared to service onset. Themes discovered: profession interests and satisfaction, communication and teamwork, sensory experiences, overcoming challenges and learning new skills, ecosystems knowledge, and life transformations.	
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. References for measures are given in Supplementary Material 8.

!. Quality assessment score out of 6.

}. Quality assessment score out of 9 (the number of yes's for CASP qualitative quality assessment).

Bar-On EQ-I, The Bar-On Emotional Quotient Inventory; *Bar-On EQ-I-YV*, The Bar-On Emotional Quotient Inventory Youth Version; *GSES*, General Self-efficacy Scale; *LSAS*, The Liebowitz Social Anxiety Scale Mindful Attention and Awareness Scale; *NEP*, The New Ecological Paradigm; *PRS*, Perceived Restorativeness Scale; *PSQ*, Perceived Stress Questionnaire; *PSS*, Perceived Stress Scale; *POMS*, Profile of Mood States; *ROPELOC*, The Review of Personal Effectiveness with Locus of Control assessment; *SDQ*, Strengths and Difficulties Questionnaire; *SDQ, III* Self-Description Questionnaire III; *SCAS*, Swedish Core Affect Scale; *SFSS*, Short Flow State Scale; *TMS*, Toronto Mindfulness Scale.

Table 5. Main characteristics and results of studies of exposure to residential vegetation.

Author	Location	Sample	Type of Study	Intervention	Outcome measures ¹	Results	Mediators/causal pathways	QA ²
Dzhambov, 2018	Bulgaria	109 medical university students aged 18-35 yrs (mean= 21 yrs).	Cross-sectional survey with 1year follow up.	Normalised difference vegetation index.	General Health Questionnaire (GHQ12) - Bulgarian translation, The Normalized Difference Vegetation Index (NDVI).	Living close to blue space (<300 m) was associated with lower GHQ-12 in both the cross-sectional and longitudinal analyses. Blue space also correlated with improved mental health, but physical activity and restorative quality mediated this association only in the cross-sectional analysis.	Residential noise, air pollution and annoyance from environmental pollution.	2
Dzhambov, 2019	Bulgaria	581 undergraduate medical students. 529 included for analyses. Mean age=21.74 yrs.	Cross-sectional survey.	Normalised difference vegetation index and Tree Cover Density map 2015.	Generalized Anxiety Disorder 7-item (GAD7) scale and the Patient Health Questionnaire 9-item (PHQ-9), NDVI, Mindful Attention Awareness Scale (MAAS), Perceived Restorativeness Scale (PRS).	The models for anxiety and depression indicated that higher greenspace, both objective and perceived, was consistently associated with better mental health. The associations between NDVI and both anxiety and depression showed a pattern of increasing magnitude from smaller to larger buffers, while the opposite pattern held for relationship between tree cover and depression. More greenspace was consistently associated with reduced scores on the anxiety and depression scales. Restorative quality was related to lower rumination, higher resilience, and lower anxiety and depression. Higher restorative quality was associated with lower rumination and better mental health.	Perceived greenness, restorative quality of the neighbourhood, dispositional mindfulness, rumination, and resilience to stress.	2
Wang et al, 2019	USA	Adults, teenagers and children in 81,102 households.	Secondary analysis of the California Health Interview Survey.	NDVI.	The Kessler 6 (K6) Scale, NDVI.	Strong evidence for decreased odds of serious psychological distress with increased greenness surrounding residence in teens, even after adjusting for major socio-demographic factors and neighbourhood socio-economic status.		2

. References for measures are given in Supplementary Material 8.

. Quality assessment score out of 6.

GAD-7, Generalized Anxiety Disorder 7-item scale; *GHQ-12*, General Health Questionnaire - Bulgarian translation; *K6*, The Kessler 6 Scale; *MAAS*, Mindful Attention Awareness Scale; *NDVI*, The Normalized Difference Vegetation; *PRS*, Perceived Restorativeness Scale.

Table 6. Main characteristics and results of studies of young people's perceptions of green spaces

Author	Location	Sample	Type of Study	Intervention	Outcome measures ¹	Results	Mediators/causal pathways	QA ²
Alizadeh et al 2018	Iran	384 volunteer high school students (192 girls, 192 boys). Mean age=16.3 yrs. Range=15-18 yrs.	Crosssectional survey.	15 scenes of mountains, forest, and agricultural landscapes were shown to participants in random order.	Preferences were recorded using a 7point Likert scale, Cattell Sixteen Personality Factor Questionnaire (16PF).	There were some associations between both personality type and subjects studied and preferences for environments, but the percentage of variance explained by these variables was low.		2
Asgarzadeh et al 2014	Japan	20 architecture and design students and graduates. 50% females.	Repeated measures observational survey.	15 scenes (3 evaluation locations for 5 building compounds) on a Tokyo street.	Perceptions of oppressiveness, and spaciousness, dangerousness, and pleasantness, monotony, beauty, strength, heaviness and fuzziness. Each question used a semantic differential rating system from 1-7.	Significant associations between distance variables (distance to trees and distance to buildings) with perceptions of oppressiveness and danger. Being farther from trees lowered oppressiveness (-0.25 ; $p < 0.01$) and dangerousness (-0.15 ; $p < 0.05$). The second model included tree-related variables (solid angle of trees, increased distance from trees), and building's solid angle as independent variables: with a greater solid angle view of trees, spaciousness increased (0.43 ; $p < 0.01$), monotony (-0.45 ; $p < 0.01$) and fuzziness (ambiguity) decreased (-0.54 ; $p < 0.01$). The third model included ground surface, trees, sky, and total building's solid angles as independent variables, and suggested that trees (-1.13 ; $p < 0.01$) and view of sky (-0.43 ; $p < 0.01$) can decrease oppressiveness. Oppressiveness (-0.33 ; $p < 0.05$) and perceived spaciousness of the environment (-0.45 ; $p < 0.05$) also decreased significantly with dominant views of ground surface. Oppressiveness increased significantly when the solid angle of the visible buildings increased but with the presence of trees, the building's oppressiveness was reduced.		2
Wilson et al 2016	USA	112 undergraduate students in a	Within-person randomised trial.	One-mile (approx.	Short-version Revised Restoration	Higher levels of perceived restoration in	Higher levels of perceived noise and danger in the	4

		general education class.		20mins) paved walking trail through an urban park (compared with sidewalk next to busy highway).	Scale (SRRS).	the natural environment (p<0.05).	street environment (p<0.05). Perceived noise was a strong predictor of perceived restoration, but perceived danger was not an independent predictor.	
Yang et al 2011	China	40 randomly selected participants from a forestry university. 20 male, 20 female. Mean age=23 yrs.	Nonrandomised experiment.	Participants were exposed to simulated noises and videos of noisy street scenes and adjacent green spaces via video glasses.	Subjective emotional evaluation questionnaire completed after each scene.	90% of the subjects believed that landscape plants could contribute to noise reduction. Participants believed that hedges are the most effective barrier (80%), and overestimated the sound reduction effect of hedges. Landscape plants provide excess noise attenuating effects through subjects' emotional processing - "psychological noise reduction".	There was a highly significant asymmetry between the EEG activity of the vegetation scene and traffic scene groups.	0

References for measures are given in Supplementary Material 8.

Quality assessment score out of 6.

16 PF, Cattell Sixteen Personality Factor Questionnaire; SRSS, Short-version Revised Restoration Scale.

Table 7. References for outcome measurement tools.

Measurement tool	Full Reference
16 PF	Cattell HE, Mead AD. The sixteen personality factor questionnaire (16PF). In G. J. Boyle, G. Matthews, & D. H. Saklofske (Eds.), <i>The SAGE handbook of personality theory and assessment</i> (Vol. 2, pp. 135-159 (135136,138-139,141,144- 152)). Los Angeles, California, London: SAGE, 2008.
AAS	Leary MR. Social anxiousness: The construct and its measurement. <i>Journal of Personality Assessment</i> 1983; 47: 66-75.
ANT	Fan J, McCandliss BD, Sommer T, Raz A, Posner MI. Testing the efficiency and independence of attentional networks. <i>Journal of Cognitive Neuroscience</i> 2002; 14: 340-7.
Bar-On EQ-I	Bar-On R. How important is it to educate people to be emotionally intelligent, and can it be done? In: R. Bar-On., J. G. Maree, & M.J. Elias (Eds), <i>Educating people to be emotionally intelligent</i> , p. 1-16. Johannesburg, South Africa: Heinemann, 2007.
Bar-On EQ-I-YV	Bar-On R, Parker JDA. Bar-On Emotional Quotient Inventory: Youth version. technical manual. Toronto, Canada: Multi-Health Systems, 2000.
BMIS	Mayer JD, Gaschke YN. The experience and meta-experience of mood. <i>Journal of Personality and Social Psychology</i> 1988; 55: 102-111.
Cognitive performance test	Brickenkamp R, Schmidt-Atzert L, Liepmann D. d2-R. Test d2-Revision. Aufmerksamkeits- und Konzentrationstest; (d2-R. Test d2-Revision. Attention and concentration test.); Hogrefe: Göttingen, Germany, 2010.
Coping with stress questionnaire	Erdmann G, Janke W. Stressverarbeitungsfragebogen [coping with stress- questionnaire]. Göttingen, Germany: Hogrefe, 2008.
Curiosity and Exploration Inventory	Kashdan TB, Rose P, Fincham FD. Curiosity and exploration: Facilitating positive subjective experiences and personal growth opportunities. <i>Journal of Personality Assessment</i> 2004; 82: 291-305.
Emotional Reactions Scale	Mehrabian A, Russell JA. <i>An approach to environmental psychology</i> . Cambridge, MA: MIT, 1974.
GAD-7	Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. <i>Archives of Internal Medicine</i> 2006; 166: 1092-1097.
GHQ-12	Mutafova M, Maleshkov CH., 2001. <i>Expected Life-Expectancy in Good Health</i> . Heron Press, Sofia, 2001.
Gratitude questionnaire	McCullough ME, Emmons RA, Tsang J. The grateful disposition: A conceptual and empirical topography. <i>Journal of Personality and Social Psychology</i> 2002; 82: 112-127
GSES	Schwarzer R, Jerusalem M. Generalized self-efficacy scale. In Weinman J, Wright S, Johnston M.(Eds.), <i>Measures in health psychology: A user's portfolio. Causal and control beliefs</i> (p.35e37). Windsor, UK: NFERNELSON, 1995.
Intrinsic Motivation Inventory	McAuley E, Duncan T, Tammen VV. Psychometric properties of the intrinsic motivation Inventory in a competitive sport setting: A confirmatory factor analysis. <i>Research Quarterly for Exercise and Sport</i> 1987; 60: 48- 58.
INS	Schultz PW. Inclusion with nature: The psychology of human-nature relations. In P. Schmuck & W. P. Schultz (Eds.), <i>Psychology of sustainable development</i> , 62-78. Norwell, MA: Kluwer, 2002.
K6	Kessler RC, Barker PR, Colpe LJ, et al. Screening for serious mental illness in the general population. <i>Archives of General Psychiatry</i> 2003; 60,2: 184189.34.
K-CPT	Conners C. <i>Conners' Kiddie Continuous Performance Test</i> . Toronto, Ontario, Canada: Multi-Health Systems, 2001.
LSAS	Liebowitz MR. Social phobia. <i>Modern Problems in Pharmacopsychiatry</i> 1987; 22.
MAAS	Brown KW, Ryan RM. The benefits of being present: mindfulness and its role in psychological wellbeing. <i>Journal of Personality and Social Psychology</i> 2003; 84: 822e848.
Measure of feeling 'refreshed'	Mackay C, Cox T, Burrows G , Lazzarini T. "An inventory for the measurement of self-reported stress and arousal". <i>British Journal of Social and Clinical Psychology</i> 1978; 17: 283- 284.
NDVI	Ekkel ED, de Vries S. Nearby green space and human health: Evaluating accessibility metrics. <i>Landscape and Urban Planning</i> 2017; 157: 214-220.
PANAS	Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS Scales. <i>Journal of Personality and Social Psychology</i> 1988; 54: 1063-1070.
PAS	Templer DI, Salter CA, Dickey S, Baldwin R, Veleber DM. 1981. The construction of a pet attitude scale. <i>Psychological Record</i> 1981; 31: 343- 348.
Peds-QL	Varni JW, Seid M, Kurtin PS. PedsQL™4.0: Reliability and validity of the Pediatric Quality of Life Inventory™ Version 4.0 generic core scales in healthy and patient populations. <i>Medical Care</i> 2001; 39: 800-812.
PHQ	Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. <i>Journal of General Internal Medicine</i> 2001; 16: 606-613.

POMS	McNair DM, Lorr M. An analysis of mood in neurotics. <i>Journal of Abnormal and Social Psychology</i> 1964; 69: 620-627.
POMS - Shortened	Yokoyama, K. POMS Shortened Version—Manual and Commentary on Cases; Kaneko Syoboh: Tokyo, Japan, 2005.
PRS	Hartig T, Korpela KM, Evans GW, Gärling T. A measure of restorative quality in environments. <i>Scandinavian House and Planning Research</i> 1997; 14: 175-194.
PSQ	Levenstein S, Prantera C, Varvo V <i>et al.</i> Development of the perceived stress questionnaire: a new tool for psychosomatic research. <i>Journal of Psychosomatic Research</i> 1993; 37: 19e32.
PSS	Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. <i>Journal of Health and Social Behaviour</i> 1983; 24: 385-96.
Remote Associate's Test	Mednick SA. The associative basis of the creative process. <i>Psychological Review</i> 1962; 69: 220-232.
ROPELOC	Richards GE, Ellis LA, Neill JT. "The ROPELOC: Review of Personal Effectiveness and Locus of Control: A Comprehensive Instrument for Reviewing Life Effectiveness." Paper presented at Self-Concept Research: Driving International Research Agendas, Sydney, August 6-8, 2002.
Rosenberg's Self Esteem Scale	Rosenberg M. Society and the adolescent self-image. Princeton, NJ: Princeton University Press, 1965.
SAS-A	Aydin A, Tekinsav-Sutcu S. Validity and reliability of Social Anxiety Scale for Adolescents (SAS-A). <i>Turkish Journal of Child and Adolescent Mental Health</i> 2007; 14: 7989.
Satisfaction with Life Scale	Diener E, Emmons R, Larsen J, Griffen S. The satisfaction with life scale. <i>Journal of Personality Assessment</i> 1985; 49: 71-75.
SCAS	Västfjäll D, Friman M, Gärling T, Kleiner M. (2002). The measurement of core affect: A Swedish self-report measure derived from the affect circumplex. <i>Scandinavian Journal of Psychology</i> 2002; 43: 19-31.
SDM	Osgood CE. The nature and measurement of meaning. <i>Journal of Psychology Bulletin</i> 1952; 49: 197-237.
SDQ	Goodman R, Meltzer H, Bailey V. The strengths and difficulties questionnaire: A pilot study on the validity of the self-report version. <i>International Review of Psychiatry</i> 2003; 15: 173-177.
SDQ-III	Marsh HW, O'Neill R. Self description questionnaire III: The construct validity of multidimensional self- concept ratings by late adolescents. <i>Journal of Educational Measurement</i> 1984; 21: 153-174.
SFSS	Jackson S, Martin A, Eklund R. Long and short measures of flow: The construct validity of the FSS-2, DFS-2, and new brief counterparts. <i>Journal of Sport and Exercise Psychology</i> 2008; 30: 561-587.
SRRS	Han KT. A reliable and valid self-rating measure of the restorative quality of natural environments. <i>Landscape and Urban Planning</i> 2003; 64: 209-232
STAI	Hidano N, Fukuhara M, Iwawaki M, Soga S, Spielberger CD. State-Trait Anxiety Inventory-Form JYZ. Tokyo: Jitsumu-Kyoiku Syuppan, 2000.
TESI	Svebak, S. The development of the tension and effort stress inventory (TESI). In J. H. Kerr, S. Murgatroyd, & M. J. Apter (Eds.), <i>Advances in reversal theory</i> (pp. 189-204). Amsterdam: Swets & Zeitlinger, 1993.
The Nitsch Scale	Nitsch JR. The self-condition scale. Die Eigenzustandsskala (EZ-Skala)— Ein Verfahren zur hierarchisch-mehrdimensionalen Befindlichkeitsskalierung. In Beanspruchung im Sport; Nitsch, J., Udris, I., Eds.; Limpert: Bad Homburg, Germany, 1976; 81-102.
TMS	Lau MA, Bishop SR, Segal ZV <i>et al.</i> The Toronto Mindfulness Scale: Development and validation. <i>Journal of Clinical Psychology</i> 2006; 62: 1445-1467.
TSM	Svebak S, Murgatroyd S. Meta-motivational dominance: A multimethod validation of reversal theory constructs. <i>Journal of Personality and Social Psychology</i> 1985; 48: 107-116.

Figures

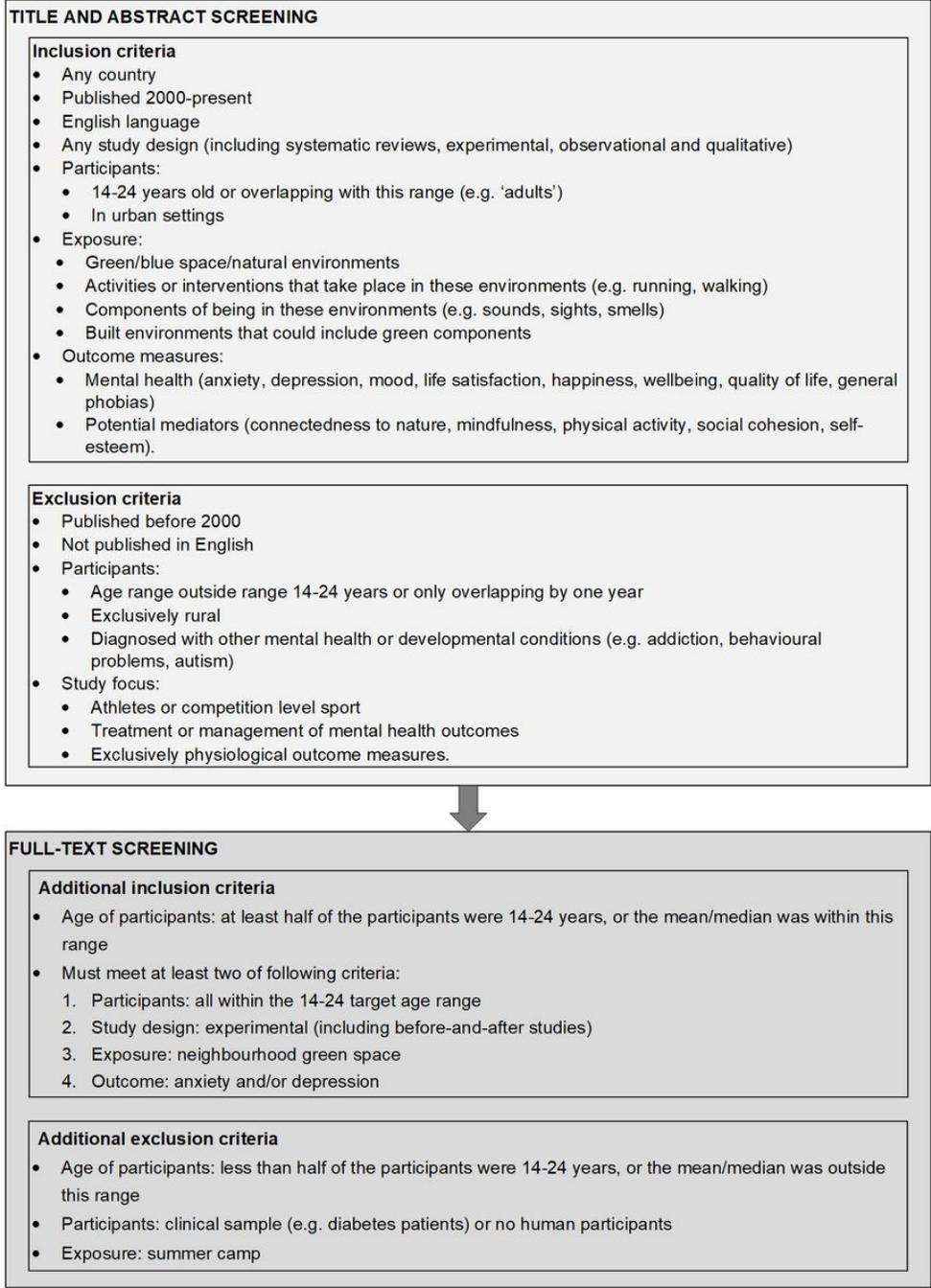
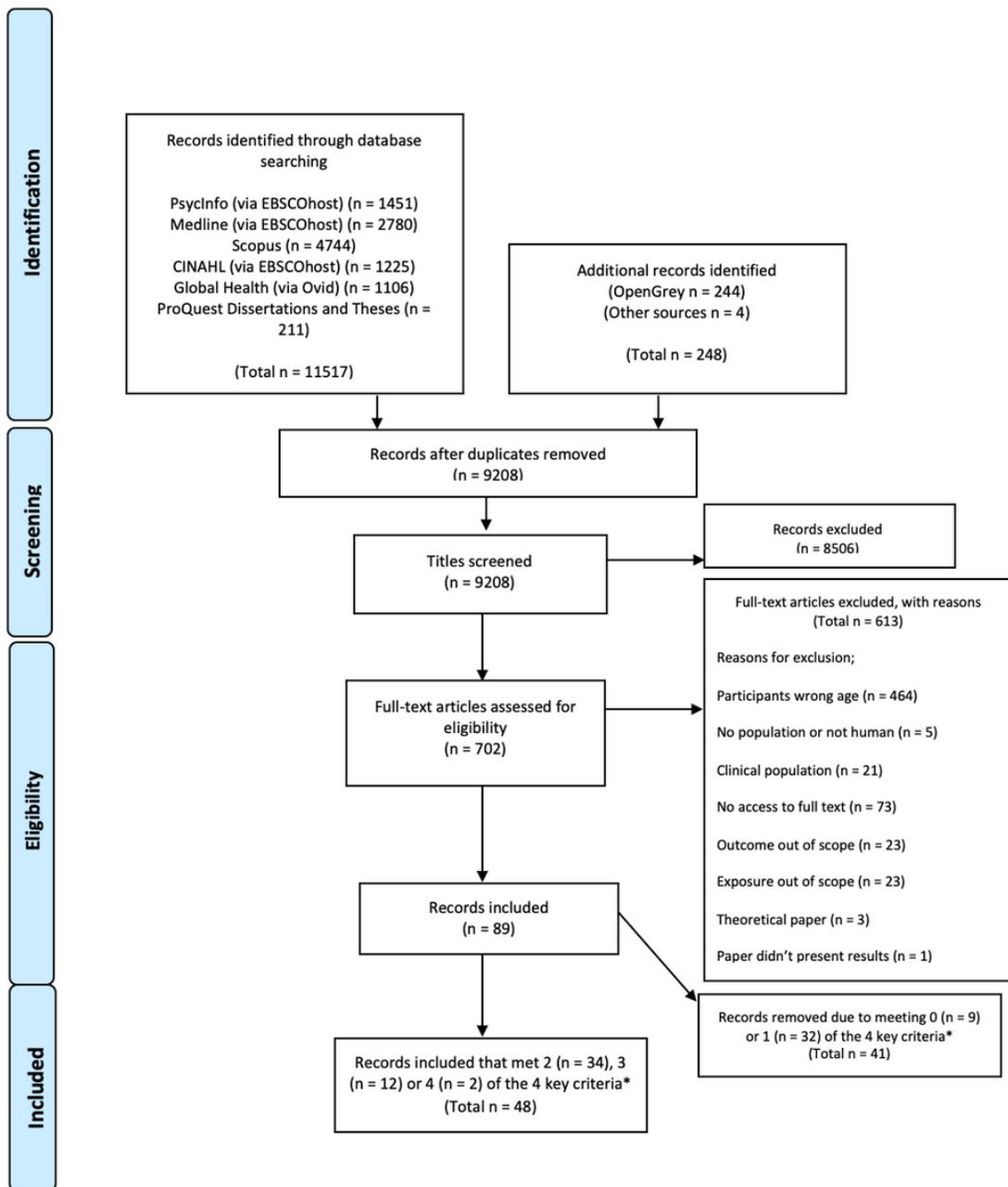


Figure 1
 Screening process and inclusion/exclusion criteria



*4 key criteria included; all participants aged 14-24 years old; exposure measured was neighbourhood space; experimental design; outcome measured was anxiety and/or depression.

Figure 2

Flow diagram of literature search and selection (following PRISMA guidelines).

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