The effects of community-based green exercise on health, wellbeing, and physical activity participation: a systematic review and meta-analysis of the quantitative and qualitative literature.

CARTER, Esther, DOUGLAS, Caroline and SAXTON, John M

Health Psychology Review

ISSN: 1743-7199 (Print) 1743-7202 (Online) Journal homepage: www.tandfonline.com/journals/rhpr20

The effects of community-based green exercise on health, wellbeing, and physical activity participation: a systematic review and meta-analysis of the quantitative and qualitative literature

Esther Carter, Caroline Douglas & John M. Saxton

To cite this article: Esther Carter, Caroline Douglas & John M. Saxton (10 Dec 2025): The effects of community-based green exercise on health, wellbeing, and physical activity participation: a systematic review and meta-analysis of the quantitative and qualitative literature, Health Psychology Review, DOI: 10.1080/17437199.2025.2597312

To link to this article: https://doi.org/10.1080/17437199.2025.2597312

HEALTH PSYCHOLOGY REVIEW
https://doi.org/10.1080/17437199.2025.2597312

Routledge
Taylor & Francis Group

REVIEW ARTICLE

OPEN ACCESS

Check for updates

The effects of community-based green exercise on health, wellbeing, and physical activity participation: a systematic review and meta-analysis of the quantitative and qualitative literature

Esther Carter[a,b], Caroline Douglas[a] and John M. Saxton[a]

[a]School of Sport, Exercise & Rehabilitation Sciences, University of Hull, Hull, UK; [b]Advanced Wellbeing Research Centre, School of Sport and Physical Activity, Sheffield Hallam University, Sheffield, UK

ABSTRACT

The aim of the study was to systematically retrieve and analyse current published literature and grey literature regarding the impact of community-based outdoor physical activity (PA) interventions on quantitative and qualitative measures of health and wellbeing in adults and children. A systematic review of seven databases was undertaken in February-April 2022 and September 2024. Overall, 57 outdoor community-based PA intervention studies were included. Meta-analysis results revealed a small-to-moderate positive effect for green exercise (GE) on measures of general health and mental health from pre-to-post intervention, with some evidence of greater benefits on overall health and PA compared to no exercise engagement. Quantitative and qualitative data synthesis indicated positive effects on mental wellbeing and PA engagement when interventions lasted 45 -90 minutes over 6 -13 weeks, with the greatest benefits displayed after walking and multi-activity interventions. A content analysis of qualitative findings emphasises the importance of social opportunities for GE uptake and adherence, and recommended developing low-cost, accessible, fun, and varied exercise opportunities in collaboration with community stakeholders. This comprehensive and robust evidence synthesis demonstrates the positive impact of GE engagement on mental wellbeing and PA, offering novel guidance for the creation, application, and promotion of community-based GE projects.

ARTICLE HISTORY
Received 14 November 2024
Accepted 25 November 2025

KEYWORDS
Green exercise; blue exercise; nature; physical activity; health; mental wellbeing

Introduction

There is extensive evidence of the physical health (Warburton & Bredin, 2017) and mental wellbeing (White et al., 2017) benefits of engaging in regular physical activity (PA). In addition, there is support for exposure to nature and outdoor spaces providing various physical health, mental wellbeing, and mortality benefits (Barboza et al., 2021; Twohig-Bennett & Jones, 2018). One form of PA that has received increasing research interest in the twenty-first century is 'green exercise' (GE), which is described as PA performed in the presence of a natural environment (Pretty et al., 2003). GE incorporates a range of nature-based environments, from rural locations such as forests, woodlands, and countryside to urban green spaces such as parks and pocket parks, gardens, and streets with trees

CONTACT Esther Carter E.E.Carter@shu.ac.uk
Supplemental data for this article can be accessed online at https://doi.org/10.1080/17437199.2025.2597312.

(Araújo et al., 2019; Mnich et al., 2019). Furthermore, research also examines 'blue exercise', whereby participants engage with outdoor blue spaces, such as lakes, coastal areas, rivers, and any other location with water features (Pasanen et al., 2019). Often, these environments are referred to under the same 'green exercise' umbrella or are incorporated within 'outdoor exercise' terminology (Mnich et al., 2019). There is some evidence from systematic reviews and meta-analyses (Lahart et al., 2019; Li et al., 2022) and experimental studies (Olafsdottir et al., 2020; Song et al., 2019) that GE can elicit greater psychological and psychophysiological outcomes compared to exercise conducted indoors or in non-green outdoor environments. However, the evidence on the benefits of GE over non-GE is inconclusive.

Physical inactivity and poor mental health are widespread concerns in society, with global estimates suggesting that approximately 31% of adults (Bull et al., 2024) and 81% of children aged 11–17 (Guthold et al., 2020) do not meet PA guidelines. Worryingly, 7.2% of all-cause deaths have been attributed to physical inactivity, with the burden being heaviest on middle-income (greatest absolute burden) and high-income countries (greatest relative burden; Katzmarzyk et al., 2022). Furthermore, approximately 17% of adults and 20% of children experience a common mental health disorder, such as anxiety and depression (Baker & Kirk-Wade, 2024). Despite the protective effect of exercise on the incidence of numerous chronic medical conditions (e.g., cardiovascular disease, cancer, hypertension, type 2 diabetes; Warburton & Bredin, 2017) and general mental health and depression (Schuch et al., 2018; White et al., 2017), physical inactivity is predicted to continue rising up to 35% by 2030 (World Health Organisation, 2024).

Engaging in GE may be an effective method for tackling concerns with general health and mental wellbeing. For example, reported benefits of engaging in GE include improvements in general health status (Liu et al., 2015), anthropometric and aerobic fitness measures (Messiah et al., 2017; Moslehi et al., 2019), lower blood pressure (Duncan et al., 2014) and reduced stress hormone (e.g., cortisol) levels (Olafsdottir et al., 2020). There is also support for GE eliciting positive changes in mental wellbeing, such as improved affective responses (Calogiuri et al., 2016; Corazon et al., 2019), mood and self-esteem (Rogerson et al., 2016), depression (Zhang, 2019) and anxiety (de Brito et al., 2019; Mackay & Neill, 2010). Improvements in overall mental wellbeing as a result of GE engagement can reduce health care costs (Pretty & Barton, 2020). Additionally, GE also has the potential to positively impact social inclusion and cohesion (Izenstark & Ebata, 2017; Whatley et al., 2015), loneliness (Van Den Berg et al., 2010), PA engagement (Han et al., 2015), future PA intention (Krinski et al., 2017), nature space engagement (South et al., 2021) and nature connection (Wolsko et al., 2019). GE has the potential to elicit greater health benefits in comparison with urban (Menardo et al., 2021) or indoor (Lahart et al., 2019; Thompson Coon et al., 2011) exercising environments. Therefore, encouraging engagement in GE within communities may elicit positive PA, general health, and mental wellbeing changes at a population level.

Previous systematic reviews have focused on the health impacts of specific forms of regular GE such as gardening (e.g., Malberg Dyg et al., 2020; Spano et al., 2020), conservation activities (Husk et al., 2016; Lovell et al., 2015), and walking (Hanson & Jones, 2015; Kassavou et al., 2013), or have targeted specific age groups such as adults-only (Coventry et al., 2021; Yen et al., 2021), older adults (e.g., age 60+; Gagliardi & Piccinini, 2019; Nicklett et al., 2016), or children-only (Mnich et al., 2019; Wray et al., 2020). Furthermore, these systematic reviews have only assessed one outcome measure (Yen et al., 2021) or nature environment (Derose et al., 2021), or have considered green (e.g., Masterton et al., 2020) and blue (e.g., Britton et al., 2020) environments independently. Other systematic reviews have been restricted to GE activities undertaken on a single occasion (Li et al., 2022), have only synthesised studies reported in published literature (Coventry et al., 2021; Mnich et al., 2019; Yen et al., 2021), or have exclusively focused on quantitative outcomes (Coventry et al., 2021). As such, there is a gap for a review study regarding the impact of various forms of GE, for both adults and children, in academic and grey literature sources, in order to make recommendations for wider population health, rather than for a specific sub-group.

Aside from the health benefits, it is important to consider how GE can be incorporated within real-world health promotion strategies, i.e., interventions that provide accessible, affordable, and individually-tailored health promotion via GE that participants can engage in within their own communities (Farrance et al., 2016; Masterton et al., 2020). This requires a social-ecological lens to consider socio-cultural, interpersonal, physical environment, and political factors that influence health and behaviour change (Popp et al., 2021; Sims-Gould et al., 2017) by creating multi-faceted and complex interventions (Millar et al., 2011). Therefore, the current systematic review is focused on community-based projects, as opposed to lab-based studies, with the aim of providing insights into projects and interventions that have the potential to bring real-world benefits for local communities. To our knowledge, previous systematic reviews have not synthesised both quantitative and qualitative data on successful or unsuccessful GE intervention components in relation to motivators and barriers to participation and broad-ranging health outcomes. As such, this will be an additional focus of the current systematic review. An improved understanding of *how* and *why* an intervention had a positive impact on participation and elicited (or failed to elicit) positive health and wellbeing outcomes is important for enhancing the efficacy of future community-based GE initiatives.

Therefore, the aim of this systematic review and meta-analysis was to synthesise current evidence on the impact of community-based GE on health and participation outcomes, whilst offering a novel understanding of essential components of GE interventions that motivate engagement and elicit positive health outcomes. Current quantitative and qualitative data from published literature and grey literature involving both adults and children was synthesised to gain deeper insights into: (i) the reported health benefits of community GE interventions, and (ii) the socio-ecological intervention components that successfully, or unsuccessfully, impact PA participation across the lifespan.

Method

Review protocol

The study protocol was registered on PROSPERO (CRD42022298557) and the systematic review was conducted using a checklist for the preferred reporting items for systematic reviews and meta-analysis (PRISMA; Page et al., 2021; Supplementary File 1).

Eligibility criteria

The inclusion criteria for studies were: (i) Any PA, exercise, or sport intervention undertaken in an outdoor green and/or blue environment (e.g., parks, gardens, fields, coastal areas, lakes); (ii) Conducted in a community-based setting which is accessible to the general population without a medical prescription; (iii) Includes at least one outcome measure related to health and wellbeing or PA (e.g., General health and/or quality of life; physical health [e.g., blood pressure, body composition, heart rate outcomes, aerobic fitness, balance, flexibility]; mental health [e.g., stress, anxiety symptoms, depressive symptoms, mood, self-esteem]; PA behaviours [e.g., activity level changes, engagement/adherence]; social outcomes [e.g., social/neighbourhood cohesion, loneliness]); (iv) Interventions for all ages (e.g., adults, children) and at a group or individual level (e.g., families, individuals); (v) Peer-reviewed journal article or grey literature source; (vi) All study designs, including quantitative, qualitative, and mixed methods designs; and (vii) Published in the English language.

The exclusion criteria for the studies were as follows: (i) Interventions not undertaken in a green or blue space; (ii) Interventions only including non-exercise activities (e.g., outdoor crafts); (iii) Therapy-based interventions (e.g., cognitive behavioural therapy, ecotherapy, therapeutic horticulture, care farming); (iv) Single bouts of exercise only (exercise only undertaken on one occasion); (v) Institution-based interventions (e.g., hospitals, care homes, schools); (vi) Interventions exclusively run by medical professionals (to ensure the intervention is accessible to the general population without the need of a medical prescription); (vii) Studies with no health, wellbeing, or PA-related outcome data; and (viii) Studies unavailable in the English language, due to difficulties with translation.

Search strategy

The review search terms (see Table 1) were selected based on initial scoping searches of potentially relevant papers on the EBSCOHost database in addition to previous GE systematic reviews (e.g., Coventry et al., 2021; Lovell et al., 2015; Roberts et al., 2018). Truncated terms were used throughout to account for variances in the spellings of key terms.

Screening protocol

Initial searches were undertaken in February-April 2022 with the searches re-run in September 2024. Published literature was searched via seven electronic databases: MEDLINE, APA PsycINFO, APA PsycArticles, Academic Search Premier, CINAHL, SPORTDiscus (all via EBSCOHost), and Scopus. Grey literature was searched via seven sources, as well as general web searches: Natural England, National Institute for Health and Care Excellence, Public Health England, Sport England, National Trust, ProQuest, and Walking for Health.

The first stage of the screening process involved reading all article titles to remove studies that were obviously irrelevant to the review (e.g., greenhouse gas, animal conservation, green tea consumption). Any potentially relevant articles were included for the next level of screening, which involved reading the articles at title and abstract level. The remaining articles were then screened at full text level against the inclusion and exclusion criteria.

For both published literature and grey literature, 'pearl growing' was undertaken in which the reference lists of included studies were scanned for additional studies to be assessed at full text screening. Pearl growing was also used for any systematic reviews found within the searching process, with potentially relevant studies extracted for full text screening. Other methods of additional screening included: (i) Articles published by the journals of the identified studies; (ii) Publications by authors of the identified studies; and (iii) Forward citations of the identified studies.

All stages of data screening, extraction, and synthesis were conducted by a single author due to limited time and financial resources. Although single author screening may result in more studies being missed (Mahtani et al., 2020; Waffenschmidt et al., 2019), the second and third authors were involved in a 'critical friend' approach (Smith & McGannon, 2018) to enhance the rigour of the review. For example, the lead author provided a summary of projects screened at full-text level to the second and third authors, containing projects to be included, projects to be excluded, and 'maybe' projects that could be included, but needed to be discussed. The second and third authors critically reviewed the list of projects to create a shared understanding of the types of projects to be included and excluded from the review. Furthermore, all authors were involved in the creation of the PROSPERO protocol, which was closely followed to further

Table 1. Boolean search terms used for electronic database searching.

Block	Search terms	Where terms were used
1	(green* OR blue* OR natur* or outdoor* OR 'park' OR 'parks' OR 'park-based' OR 'park based' OR garden* OR conservation OR horticultur* OR wood* OR forest*)	Title
2	AND (project* OR intervention* OR program* OR initiative* OR communit* OR citizen* OR scheme* OR pilot* OR activ*)	Title
3	AND (sport* OR exercis* OR walk* OR recreation* OR physical* OR visit* or hiking)	All text
4	AND (health* OR wellbeing OR 'well being' OR 'well-being' OR 'quality of life' OR learning)	All text
5	NOT (drug* or Parkinson*)	All text

enhance the rigour of the data screening, extraction, and synthesis process. Finally, during the re-run of searches in September 2024, all available articles were re-screened at title and full-text level by the lead author, with only one study published before the initial screening period being missed (Milton et al., 2011).

Data extraction

The quantitative, qualitative, and mixed methods studies were all stored in separate Microsoft Excel documents. Each article was read through once, before being re-read, and the data extracted. Each Excel document consisted of six pages, which were populated with the following study information: (i) Study details; (ii) Sample characteristics; (iii) Research design; (iv) Intervention details; (v) Outcome data; and (vi) Comments. Outcome data were often reported as differences in mean scores (e.g., raw scores or percentages) or association scores between variables (e.g., beta coefficient, Pearson correlation coefficient). A separate Excel document was used to store all the direct quotes included in mixed methods and qualitative studies. Quotations were organised by study, with duplicated quotes highlighted. In total, over 800 unique quotes were extracted.

To allow for comparisons between projects that differed greatly in terms of participant numbers and number of implementation locations, projects were dichotomised into 'large-scale' and 'small-scale' projects. We defined projects implemented in multiple regions or for a duration of one year or more as 'large-scale' projects. Other projects implemented in one location or for less than 12 months were classified as 'small-scale' interventions.

For quantitative studies included in the meta-analysis, all outcome data were extracted as mean scores, standard deviations, and effect sizes (where present) to allow for standardised mean difference (SMD) calculation.

Data synthesis

Meta-analysis

Data from all projects providing pre-to-post intervention mean scores or mean change scores for a GE intervention group were extracted into an Excel document under a category for overall type of measure (e.g., general health) and subcategory for specific measurements (e.g., BMI). Some studies reported data at two different time points (e.g., 3 and 6 months after baseline) and these were included as two separate data points to be analysed. Where available, the pre-to-post mean scores or mean change scores for a control group were also included in the same Excel document alongside the intervention scores from the same project. Subcategories where at least two projects were available were selected for a subgroup analysis within the meta-analysis.

Meta-analyses were conducted as follows: (1) Comparing pre-and-post scores for a GE intervention only; (2) Comparing mean change scores for a GE intervention compared to a control group. All meta-analyses were conducted using Hedges' g as the SMD to account for small-sample bias (Hedges, 1981). If studies reported other effect sizes (e.g., Cohen's d), a correction formula was used to convert to Hedges g through JASP 0.95.1 software to ensure consistency in effect size interpretation across studies. For studies that did not report effect sizes, Hedges' g was calculated from the available descriptive statistics (e.g., mean scores, standard deviations, sample size) by subtracting the two mean scores and dividing the outcome by the pooled standard deviation.

Overall, 23 studies with a total of 20,114 participants (range 6 to 8,802) provided either pre-and-post intervention scores for a GE intervention within a subcategory of general health or mental health. Studies that did not provide pre-and-post intervention scores or standard deviations (SD), or change scores with SDs, for a GE intervention were not included.

Within this sample, nine studies, with a total of 5,991 participants (range 6 to 5,460), met the criteria of presenting either pre-and-post means scores for an intervention and control group, or mean change scores for an intervention and control group within a subcategory of general health or mental health (Bang et al., 2017; Barton et al., 2011; Brown et al., 2014; Dawson, 2017; Hendker & Eils, 2021; Johnson et al., 2019; Tesler et al., 2022; Thompson, 2014; Ward Thompson et al., 2019). These studies compared a GE intervention to a control group with no exercise intervention.

In addition, two studies provided pre- and post-intervention data comparing exercise in green spaces with suburban spaces (de Brito et al., 2019; Littman et al., 2021). Furthermore, one study provided pre- and post-intervention data comparing supported GE engagement with independent GE engagement (Razani et al., 2018). Two further studies compared GE engagement in a healthy weight population vs an overweight or obese population (Haney et al., 2014; Messiah et al., 2017). However, as these comparisons only occurred in 1–2 studies, it was not possible to include these as subgroup analyses.

As such, four meta-analyses were conducted using JASP 0.95.1 software on measures of overall health (general health, aerobic fitness, systolic and diastolic blood pressure, BMI, cholesterol, PA) and mental health (general mental wellbeing, stress, self-esteem, mood). Two meta-analyses were conducted for the nine studies that compared GE engagement to a non-exercising control group on general health and mental health outcomes. Two further meta-analyses were conducted for studies that provided pre- and post-intervention general health and mental health data after GE. The aim was to understand whether engagement in GE resulted in general and mental health benefits, and whether these were greater, as compared with no exercise.

Forest plots with 95% confidence intervals (CI) were created for overall health outcomes and mental health outcomes. A random effects model was utilised with SMD scores calculated. The heterogeneity between projects was calculated using the I^2 statistic and interpreted in-line with Higgins and Thompson (2002), with I^2 statistic values of 25% representing low heterogeneity (small variance between the effects seen across different studies), 50% indicating moderate heterogeneity, and values of 75% representing high heterogeneity (large variance between the effects observed in different studies). Effect sizes were calculated using Hedges' g and interpreted in-line with recommendations from Cohen (1988) for small (0.20), medium (0.50), and large (0.80) effect sizes. Publication bias of each meta-analysis were also conducted within JASP. Funnel plots were visually inspected for asymmetry, and Egger's regression tests were conducted to assess small-study bias. PET-PEESE regressions were performed to evaluate the robustness of pooled effects and examine the potential of publication bias.

Content analysis

A content analysis approach (Miles & Huberman, 1994) was used to analyse qualitative data. The content analysis process involved three phases (Elo & Kyngäs, 2008): (i) Preparation; (ii) Organising; and (iii) Reporting. During the 'preparation' phase, all qualitative quotes (e.g., participant and exercise provider quotes, author reflections) were inserted into a Microsoft Excel document, before being uploaded to NVivo v12, and read through once to support with familiarisation of the data. During the 'organising' phase of the content analysis, quotes were grouped both deductively and inductively. Quotes were initially coded within a pre-determined unconstrained categorisation matrix based on the pre-determined overall themes of the review (e.g., *mental wellbeing outcomes*). However, the sub-themes (e.g., *affective state*) and codes (e.g., *improved mood*) were created inductively. The frequency of each code and sub-theme within a theme were summed, allowing the researcher to report a qualitative description of results and a quantifiable interpretation of the most common responses and overall trends (Vaismoradi et al., 2013). Study data that could not be included in the meta-analyses are described alongside qualitative findings analysed using the content analysis approach.

In alignment with the data extraction process, a 'critical friend' approach was utilised (Smith & McGannon, 2018) to enhance the trustworthiness of the data analysis. The lead author presented draft codes, sub-themes, and themes with justifications for the coding choices to the second author, who critically reviewed the coding and offered alternative suggestions. In addition, the lead and second author reported the updated findings to the third author, who provided feedback in the form of 'peer scrutiny' to challenge the current interpretations (Shenton, 2004). The use of critical friend and peer scrutiny approaches can enhance researcher reflexivity by allowing the lead author to reflect on which interpretations of the data were the most appropriate (Smith & McGannon, 2018).

Study quality assessment

The quality of the included studies was assessed using the mixed methods appraisal tool (MMAT; Hong et al., 2018), which has been used in previous GE reviews to assess a variety of study methods using a single tool (Mmako et al., 2020; Thomas et al., 2022). The quantitative studies were assessed in three categories (quantitative randomised controlled trails, quantitative non-randomised studies, and quantitative descriptive studies), with mixed methods and qualitative studies being assessed with one category each. For each category, the primary researcher responded using either 'yes', 'no', or 'can't tell' to different methodological quality criteria. Hong et al. (2018) discourage users from creating rating scores from studies, but to instead use the tool for an initial discussion on the quality of the studies included.

Results

In total, searching of electronic databases generated 11,190 records. After the removal of duplicates ($n = 3{,}470$), non-English articles ($n = 269$), and records from source types that would not provide outcome data (e.g., letters, trade publications etc; $n = 284$), 7,167 unique records remained for screening. A further 6,457 records were excluded after screening the titles, and another 528 studies were removed after screening both the title and abstract. The remaining 193 articles were then screened at full-text level against the inclusion and exclusion criteria. For grey literature sources, 109 articles were extracted and read at full-text level from various sources, with 12 studies included. A further 8 studies (published literature $n = 6$; grey literature $n = 2$) were included from reference list searches of included published literature and grey literature articles and one study was included from a

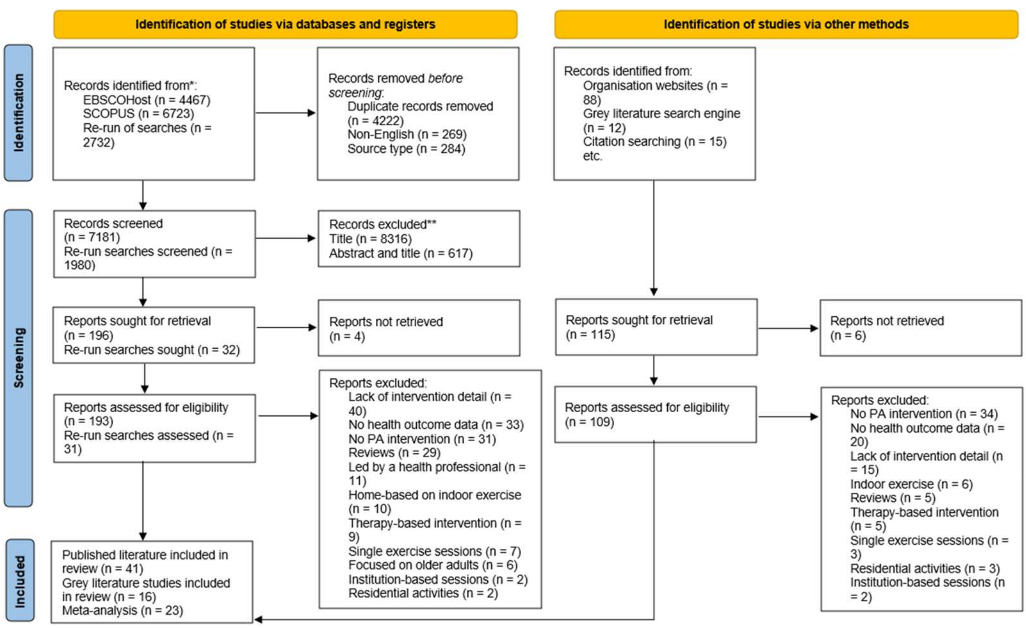

Figure 1. PRISMA flow diagram of published literature and grey literature source searches.

relevant systematic review (see Figure 1). When the literature searching process was re-run in September 2024, four additional articles were included (published literature = 3; grey literature = 1).

Study characteristics

In total, 57 studies were included in the review, with 41 from published literature sources, and 16 from grey literature sources. Overviews of each study are provided in Supplementary File 2. The sample of articles consisted of 29 quantitative (published literature = 24; grey literature = 5), 23 mixed methods (published literature = 13; grey literature = 10), and 5 qualitative studies (published literature = 4; grey literature = 1). Most studies were conducted within the UK ($n = 23$) or North America ($n = 17$). In total, 1,769 participants were engaged in small-scale interventions (male = 887; female = 876), with large-scale interventions, (e.g., Active Forests, Walking for Health) providing evidence from 137,129 participants (male = 31,996; female = 75,613; not stated = 29,431). Most studies were focused on adults-only ($n = 28$), 19 studies focused on interventions for both adults and children, and 10 specifically focused on children-only. The majority of interventions were based on combining multiple activities ($n = 30$) or walking ($n = 22$). Only five studies in the review used other exercise modalities. The most common exercise environment was green-only spaces ($n = 43$) followed by a combination of green and blue spaces ($n = 12$), with only two studies utilising blue-only spaces. The most common intervention locations were parks ($n = 18$), using more than one green and/or blue space within a project ($n = 19$), and woodlands or forests ($n = 13$).

Programme overviews

In total, 25 studies were defined as 'large-scale' projects. This includes five overarching projects: (i) Active Forests (Morris & O'Brien, 2011; O'Brien, 2019; O'Brien & Forster, 2017, 2020, 2023; O'Brien & Morris, 2009a, 2009b); (ii) Walking for Health (Coleman et al., 2012; Marselle et al., 2013, 2014; Marselle et al., 2016; Marselle et al., 2019; Phillips et al., 2011, 2012; South et al., 2012); (iii) Fit2Play (D'Agostino et al., 2018; Haney et al., 2014; Messiah et al., 2017, 2018, 2019); (iv) Green Gym (Beishon & Munoz, 2016; Smyth et al., 2022), and (v) the Communities and Nature project (Avon Wildlife Trust, 2016; Care Forum, 2015). All other projects were classified as 'small-scale' interventions ($n = 32$).

First, the 'Active Forests' is a programme funded by Sport England and Forestry England providing various greenspace activities tailored towards the forest site with the aim of increasing physical and mental wellbeing. The project is delivered at 20 sites, with example activities including walking, running, cycling, football, volleyball, table tennis, Pilates, orienteering, archery, and family fitness. Second, the 'Walking for Health' programme is a public health intervention provided across England to encourage greater PA engagement in the form of walking. The programme provides free, local walking opportunities in both urban and rural areas, aimed at a beginner level. Third, the Conservation Volunteers organisation deliver 'Green Gym' sessions in over 100 locations in the UK, with the goal of providing gardening and conservation sessions in 3–4 h durations to enable users to be active outdoors, make social connections, and learn new skills to make a difference in local nature spaces. Fourth, the 'Fit2Play' programme is an afterschool, urban park-based PA project provided for 6–22 year olds in Florida, with the goal of improving cardiovascular disease (CVD) risk factors, such as blood pressure, body mass, and aerobic fitness. The project uses the evidence-based Sports, Play and Active Recreation for Kids (SPARK) curriculum of activities to provide 60 min of sport and PA games (e.g., football, kickball, flag football) followed by 30 min of health and nutrition education. Finally, the 'Communities in Nature' (CAN) programme was launched in Bristol and the South West of England to improve the health and wellbeing of hard-to-reach communities through outdoor exercise opportunities. In total, over 700 nature projects were provided, including gardening, bush craft, wildlife identification, and walking.

Study quality assessment

The scoring of the MMAT is shown in Supplementary File 3. Most studies included in the review raised at least one quality concern. Nine studies highlighted no quality concern (Quantitative = 4/29; MM = 2/23; Qualitative = 3/5) and 14 studies highlighted only one quality concern (Quantitative = 8/29; MM = 6/23; Qualitative = 0/5).

Physical activity

A total of 29 studies measured changes in PA outcomes as a measure of participation or engagement in the GE intervention, most commonly the number of minutes or days of PA per week ($n = 16$) or step count ($n = 5$). All five studies measuring step count used an activity monitor or pedometer. All remaining studies used a self-report survey method, with the most commonly used survey being the International Physical Activity Questionnaire (IPAQ; $n = 5$). Only one study combined a self-report measure of PA and a pedometer measure of step count (Razani et al., 2018).

Multi-activity interventions

Evidence suggests multi-activity GE interventions lasting for 3–12 weeks can significantly improve time engaging in PA for adult and adolescent populations, with greater compliance in small-scale, led activities.

For example, studies highlighted significant improvements in pre-to-post intervention minutes of general PA per week (+540 mins – Glover & Polley, 2019; 49% participants increased their average PA minutes – O'Brien & Forster, 2023), minutes of moderate PA per week (+24 min; Razani et al., 2018), days of PA per week (+2.12 days; Tesler et al., 2022), and days of walking per week (+6%; Beishon & Munoz, 2016). However, Ward Thompson et al. (2019) found a significant decrease in adult and adolescent PA from baseline to Wave 2 (8 months), but a significant increase at Wave 3 (16 months) from baseline for the intervention group (+144.7 MET mins/week) compared to the control group (−104.6 MET mins/week).

High levels of adult intention to re-engage with projects were highlighted for the Active Forests programme (98% overall with 91% reported to have already re-engaged and 77% undertaking a different activity; O'Brien & Forster, 2017), Chopwell Wood Health Project (91% of first-time visitors; Snowdon, 2006), and the 'Park Hop' scavenger hunt (95.1%; Besenyi et al., 2015). In terms of engagement by target groups, the number of families (22% to 60%), participants with children under 16 (25% to 42%), women (44% to 57%), and individuals from a low income background (8 to 18%) taking part in the Active Forests programme increased over 1–3 years of participation (Morris & O'Brien, 2011; O'Brien & Morris, 2009a).

Survey results from three studies in healthy and vulnerable adults indicated that most participants attributed engagement in the intervention with improvements in PA for the Chopwell Wood Health Project (60.0%; Snowdon, 2006), Walking for Health (WfH) scheme (64.0%; Phillips et al., 2012), and Green Gym (90.0%; Beishon & Munoz, 2016). Higher compliance rates (85.7%; Godfrey et al., 2015) and attendance figures (72% average; Booth et al., 2021) were displayed for small-scale, child-focused interventions compared to the compliance figures of large-scale family interventions (34.9%; Howie et al., 2007). Lower compliance rates were present in self-led activities compared to led group-based activities (29% vs 59%; Glover & Polley, 2019). The Chopwell Wood Health Project recorded a three times greater number of adults completing the 13-week woodland programme compared to other indoor and outdoor activity schemes (91% vs 30%; Snowdon, 2006).

Walking interventions

Engaging in 8–12 weeks of walking significantly improved PA engagement in healthy adults and the proportion of people meeting PA guidelines. Engagement was greatest for women, people aged 55

+, and those taking part in led walks, but walking in urban spaces supported engagement from more deprived groups.

There was evidence of significant pre-to-post improvements for minutes walked per day (+44.2 min; Krieger et al., 2009), step count per day (+745 steps; Brown et al., 2014), minutes of PA per week (+992 MET-mins/week; Thompson, 2014), and percentage of people meeting PA guidelines (+19.3%; Krieger et al., 2009) following an 8–12-week intervention. A non-significant difference between the step count changes of a nature walk group (+745 steps), a built urban walk group (+375), and a non-exercising control group (+217) was discovered after an eight-week work-based walking intervention for adults (Brown et al., 2014). Furthermore, after one year of WfH participation, 33% of active adult participants reported an increase in PA, however, 47% reported a decrease (Phillips et al., 2012).

WfH participation was greater for women, individuals aged 55+, and those undertaking walks in green corridors (Coleman et al., 2012; Marselle et al., 2013; Phillips et al., 2012). Urban green walks had the highest engagement for the most deprived participants (21.2%), with coastal walks being popular with moderately deprived participants (55.1%) and green corridors being engaged more by the least deprived individuals (60.0%; Marselle et al., 2013). The lowest engagement occurred during October to December for walking interventions (Coleman et al., 2012; South et al., 2012).

Finally, compliance rates for walking interventions for clinical and non-clinical adult populations ranged from 42–56%, with only small, non-significant differences between nature walks (42–54%) and urban walks (43–62%; Brown et al., 2014; Littman et al., 2021). Lower compliance rates were present in self-led walks compared to led group-based walks (46% vs 77%; Coleman et al., 2012), although, these were all higher compared to a control group compliance rate (13%; Brown et al., 2014).

Other projects – Gardening and outdoor gym interventions

Gardening and outdoor gym interventions provided mixed results, with evidence of decreases and increases in exercise engagement.

A 24-week community gardening programme displayed a non-significant pre-to-post intervention increase in days of vigorous PA week (+0.6 days), but a decrease in the number of days (−0.5 days) and minutes per day (−6.0 min) spent walking compared to baseline (Connor, 2020). Finally, undertaking a six-week outdoor gym intervention resulted in a significant pre- to post-intervention improvement in step count (+4%; Johnson et al., 2019).

General health

A total of 26 studies included a health measure, such as an anthropometric measure ($n = 11$) or measure of aerobic fitness ($n = 10$), general health ($n = 11$), or systolic and diastolic blood pressure ($n = 9$). For anthropometric measures, studies most commonly assessed 1–5 body composition measures including height, weight, BMI, body fat percentage, waist-to-hip ratio, bone density, skinfold measurements, and waist, hip and midarm circumference. All Fit2Play projects used the Progressive Aerobic Cardiovascular Endurance Run (PACER) test to measure aerobic fitness. Alternatively, four studies used submaximal and maximal treadmill or cycle ergometer tests. All studies measuring general health used a single self-report survey, with the SF-12 ($n = 2$) and EQ-VAS ($n = 2$) being the most commonly used measures.

Multi-activity interventions

There was some evidence of significant improvements in measures of physical health (e.g., blood pressure, cholesterol, anthropometry, aerobic fitness) in multi-activity interventions for adults and children in programmes that ranged in duration from 40 days to 3 years.

A number of studies evaluated the Fit2Play GE afterschool recreational play intervention for children, adolescents, and young adults, including those with special educational needs (age range: 6–22) and identified significant improvements in health and wellness knowledge, blood pressure, anthropometric measures (BMI measures, body mass, and skinfold thickness), and/or fitness measures (PACER test, push-up test, sit-up test) over a 1–3 year period (D'Agostino et al., 2018; Haney et al., 2014; Messiah et al., 2017, 2018, 2019; Wiersma & Rubin, 2012). However, all three studies measuring sit and reach scores found no benefit associated with Fit2Play participation (Haney et al., 2014; Messiah et al., 2018, 2019).

A 40-day multi-activity GE intervention significantly improved blood cholesterol levels, hip girth, VO_{2max}, and dynamic stability scores but there was no change in body mass or waist circumference for healthy adults (Glover & Polley, 2019). However, no improvements in health-related quality of life (HRQOL) were present after engaging in a 9-month programme of various woodland activities (Ward Thompson et al., 2019).

Walking interventions

Improvements in physical health measures were less commonly reported following walking interventions. However, GE walking interventions have demonstrated significant improvements in self-reported health compared to a non-exercising control group (Bang et al., 2017; Lewis, 2018) and improved cardiovascular disease risk (Brown et al., 2014), blood cholesterol profile and arterial stiffness (Thompson, 2014) after 6–16 weeks in heathy adults. In contrast, evidence of increased body fat percentage and a lack of change in blood pressure (Bang et al., 2017) and waist circumference (Thompson, 2014) were also reported after these GE walking interventions.

Other projects – Surfing and outdoor gym interventions

There was some evidence of improvements in measurements of self-reported general health and objective measures of physical health (e.g., resting heart rate, anthropometry, aerobic fitness, muscular strength) after 6–12 weeks of surfing for children and outdoor gym participation for adults.

Engaging in a 6–12-week blue-space surfing intervention significantly improved self-reported health (Godfrey et al., 2015) and resting heart rate (Hignett et al., 2017), but did not significantly impact blood pressure (Hignett et al., 2017) for children and adolescents age 8–18.

Adults undertaking a six-week outdoor gym programme recorded significant improvements in body mass, body fat percentage, time to exhaustion in a Modified Bruce Treadmill test, and row strength in healthy adults (Johnson et al., 2019). However, chest strength significantly decreased. Finally, distance, rate of perceived exertion (RPE), and speed at 4 mmol/L during an incremental treadmill test, all measures of an Original Bootcamp Cologne (OBC) fitness test, and all measures of a McGill core stability test significantly improved from pre- to post-intervention after eight weeks of GE outdoor circuit training in recreationally active adults compared to no significant improvements for the non-exercising control group (Hendker & Eils, 2021).

Meta-analysis findings. When assessing the pooled SMD, in comparison to a non-exercising control group ($k = 9$), GE was associated with a moderate, significant effect in favour of improving health outcomes ($g = 0.47$, 95% CI [0.09, 0.85], $p = .017$; Figure 2). However, high levels of heterogeneity were present for the full analysis ($Q = 141.07$, $df = 16$, $p < .001$; $I^2 = 92.59\%$) with a 95% prediction interval [−1.25, 2.19]. Egger's regression test did not indicate significant funnel plot asymmetry ($t(45) = 0.92$, $p = .363$). PET-PEESE analyses revealed similar adjusted estimates (PET: $g = 0.15$, 95% CI [0.06, 0.24], $p = .003$; PEESE: $g = 0.16$, 95% CI [0.10, 0.23], $p = .363$), suggesting that the observed effects were not substantially influenced by small-study or publication bias.

When examining the subgroups, GE interventions displayed a moderate-to-large significant association with an increase in PA at post-test compared to baseline ($g = 0.768$, 95% CI [0.10, 1.44], 95% PI [−1.71, 2.29], $p = .027$; see Supplementary File 4). A large but non-significant effect was found in favour of improving diastolic blood pressure ($g = 0.952$, 95% CI [−0.09, 1.99], 95% PI [−1.03, 2.93], $p = .070$). No significant effect was present for any other measure when comparing change scores after GE to no exercise. However, findings should be considered with caution due

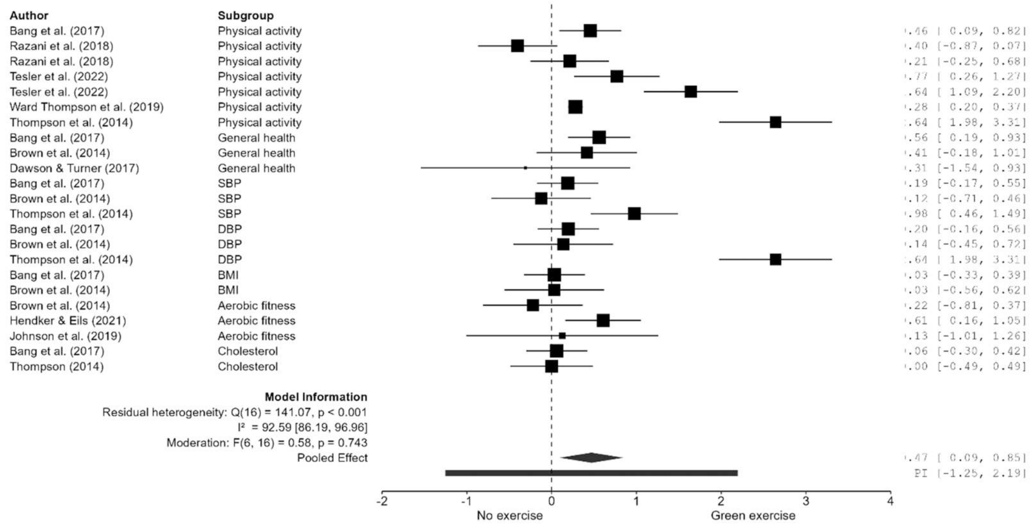

Figure 2. Meta-analysis of change scores for health measures in green exercise interventions compared to non-exercising control groups.

Note: The black bars indicate the 95% confidence interval range (CI). The black diamond represents the pooled effect size and the large black bar represents the prediction interval (PI). Scores have been transformed into positive numbers to represent improvement scores and negative numbers to represent worsening scores (e.g., reductions in blood pressure, BMI, and cholesterol transformed into positive numbers). SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index.

to the high pooled heterogeneity, which may have been caused by the small number of studies per sub-group, the differences in project types (e.g., walking and multi-activity interventions), and the differences in measurements used (e.g., PA measured via MET-min/week, number of days of PA per week, average daily step count).

When assessing the pooled SMD, GE interventions ($k = 18$) displayed a small significant effect for improving health measures from pre-to-post-test ($g = .259$, 95% CI [0.16, 0.35], $p < .001$). However, high levels of heterogeneity were present ($Q = 295.75$, $df = 40$, $p < .001$; $I^2 = 93.40\%$; see Figure 3) with a 95% prediction interval [−0.32, 0.84]. Furthermore, Egger's regression test indicated no significant funnel plot asymmetry ($t(21) = 1.10$, $p = .284$). PET-PEESE analyses yielded comparable adjusted estimates (PET: $g = 0.22$, 95% CI [−0.05, 0.48], $p = .130$; PEESE: $g = 0.27$, 95% CI [0.07, 0.48], $p = .017$). The PET test was not significant ($p = .130$) but the PEESE-adjusted effect remained significant ($p = .017$) suggesting limited evidence of small-study or publication bias.

When examining the subgroups, GE interventions demonstrated a moderate significant effect for improving PA measures from pre-to-post-test ($g = 0.694$, 95% CI [0.45, 0.94], 95% PI [0.07, 1.32], $p < .001$). A small significant effect was found in favour of improving aerobic fitness ($g = 0.317$, 95% CI [0.11, 0.53], 95% PI [−0.29, 0.93], $p = .003$). No significant effect was present for any other subgroups (see Supplementary File 5).

Mental health

In total, 34 studies assessed at least one measure of mental health, with the most common being general wellbeing ($n = 15$), stress ($n = 11$), depression ($n = 6$), and anxiety ($n = 5$). The most commonly used measure of general wellbeing was the Warwick Edinburgh Mental Wellbeing Scale (WEMWBS; $n = 6$). The Major Depressive Inventory (MDI; $n = 3$), Depression, Anxiety and Stress Scale (DASS; $n = 3$), and State Trait Anxiety Inventory (STAI; $n = 2$) were the most commonly used measures of depression and anxiety. The only psychological component that was tested

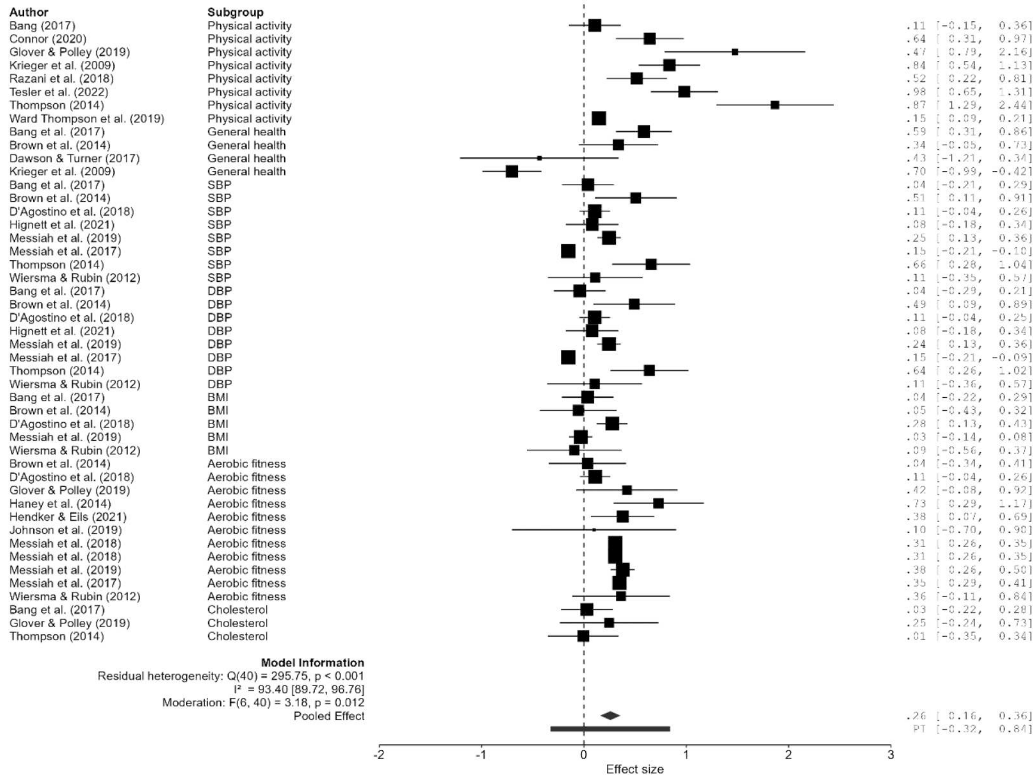

Figure 3. Meta-analysis of pre-to-post intervention health scores for green exercise programmes.

Note: The black bars indicate the 95% confidence interval range (CI). The black diamond represents the pooled effect size and the large black bar represents the prediction interval (PI). Scores have been transformed into positive numbers to represent improvement scores and negative numbers to represent worsening scores (e.g., reductions in blood pressure, BMI, and cholesterol transformed into positive numbers). SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index.

with more than one measure within a singular study was stress, which was demonstrated in two studies where the Perceived Stress Scale (PSS) was combined with a physiological measure of stress (e.g., salivary cortisol; Razani et al., 2018) or another self-report survey (e.g., List of Threatening Experiences – LTE-Q; Marselle et al., 2019).

Multi-activity interventions

A multitude of mental health measures displayed significant improvements after engagement in multi-activity interventions ranging from five weeks to 10 months, for both adults and children, including general wellbeing, affect, stress, anxiety, depression, and self-efficacy. Most commonly, improvements in stress were reported.

Multi-activity interventions conducted in green and blue spaces for healthy adults (Glover & Polley, 2019) and wetland environments in a clinical adult population (Maund et al., 2019) for 5–6 weeks significantly improved general wellbeing, stress, anxiety, depression (green and blue space intervention-only), and positive and negative affect scores (wetland intervention-only). In addition, Maund et al. (2019) demonstrated clinically relevant improvements in anxiety for individuals with diagnosed depression or anxiety, with seven participants downgrading their anxiety severity. Furthermore, those with higher pre-intervention stress, anxiety, or depression scores experienced the greatest positive post-intervention changes (Glover & Polley, 2019).

Further support for multi-activity interventions included significant improvements in general wellbeing for vulnerable adults after 12–18 weeks of engaging in Green Gym activities (Beishon &

Munoz, 2016; Smyth et al., 2022), improvements in stress for parents after three weeks of family play-based activities (Razani et al., 2018), and self-efficacy increases after 10 months participating in urban forest activities in adolescents age 15–18 (Tesler et al., 2022). An increase in park visits per week as part of the play-based activity intervention was also associated with reduced stress levels ($d = -0.53$; Razani et al., 2018).

Walking interventions

Similarly to multi-activity interventions, various measures of mental wellbeing were reported to significantly improve after 3–13 weeks of engagement, such as general mental wellbeing, affect, stress, anxiety, depression, and self-efficacy. Furthermore, general participation in the WfH scheme specifically, and the location and duration of the group walks, were also significantly associated with improvements in these measures. These benefits were reported in adult populations primarily.

Undertaking 3–13 weeks of GE walking interventions with a duration of 20–120 min significantly improved measures of general wellbeing (Brown et al., 2014; Krieger et al., 2009), anxiety (de Brito et al., 2019; Thompson, 2014), stress (Bang et al., 2017; Thompson, 2014), positive and negative affect (Marselle et al., 2016), self-efficacy (Lewis, 2018), self-esteem and total mood disturbance (Barton et al., 2011; Thompson, 2014), and quality of life and personal growth (McCaffrey & Liehr, 2015; McCaffrey & Raddock, 2013) in healthy and clinical adult populations. Greater improvements in mental wellbeing were present for adults undertaking eight weeks of work-based GE walking compared to a non-exercising group (Brown et al., 2014). Similarly, greater improvements in anxiety and positive affect were shown after 50 min of arboretum walking once per week for three weeks compared to a suburban walk for healthy adults (de Brito et al., 2019).

General participation in the WfH scheme was significantly associated with improvements in general wellbeing ($b = .12$; Marselle et al., 2014), stress ($b = -.08$ to $-.15$; Marselle et al., 2014, 2019), depression ($\beta = -0.116$; Marselle et al., 2019), and positive affect ($\beta = -0.057$; Marselle et al., 2019). The location of the WfH walks was also significantly associated with general mental wellbeing (farmland vs urban walking; $\beta = 0.13$; Marselle et al., 2013), stress (green corridors and farmland vs public spaces; $\beta = -0.17$ to -0.20; Marselle et al., 2013), and positive affect (natural spaces vs urban and suburban areas; $\beta = -0.16$ to -0.19; de Brito et al., 2019; Marselle et al., 2013) for both active and inactive adults. For WfH participants, the frequency of walks ($\beta = 0.68$; Marselle et al., 2019) and recent PA ($b = .13$; Marselle et al., 2014) were significantly associated with general mental wellbeing. Furthermore, 15-minute increases in WfH walk duration were associated with improved depression and positive affect scores (Marselle et al., 2013). Additionally, WfH walk intensity ($r = 0.38$) and perceived restorativeness ($r = 0.60$) were significantly associated with improved positive affect (Marselle et al., 2013).

Finally, for other GE walking interventions in healthy adults with durations of 2–8 weeks, significant associations were present between general participation and improvements in concentration and strain ($\beta = -.34$ to $.36$; Sianoja et al., 2017) and increases in MET-minutes per week of PA and improvements in stress ($r = -0.56$; Thompson, 2014) and both tension-anxiety ($r = -.328$) and vigour ($r = .300$) mood subscales (Thompson, 2014).

Other projects – Surfing and outdoor gym interventions

There was some evidence of a general mental wellbeing benefit of engaging in at least six weeks of surfing for children and outdoor gym interventions for healthy adults.

Undertaking a surfing intervention over a 6–12-week period significantly improved general mental wellbeing and self-esteem (Godfrey et al., 2015), with over 98% of children reporting to have enjoyed the intervention (Godfrey et al., 2015; Hignett et al., 2017). Finally, a six week outdoor gym intervention for healthy adults significantly improved general mental wellbeing (Johnson et al., 2019).

Meta-analysis findings. Comparing the change scores at pre- and post-intervention for mental health measures after engagement in GE compared to a non-exercising control group ($k = 6$) revealed that partaking in a GE intervention was associated with a moderate, non-significant effect in favour in favour of improving mental health outcomes compared to a control group ($g = 0.62$, 95% CI [−0.21, 1.45], $p = .112$).

Similarly to the general health measures, the analysis revealed a high level of heterogeneity for the full analysis ($Q = 59.87$, $df = 5$, $p < .001$; $I^2 = 88.65\%$; see Figure 4) with a 95% prediction interval [−1.90, 3.14]. The high heterogeneity may have been caused by the small number of studies per sub-group (e.g., only 2–3 projects per subgroup) and the inclusion of contrasting walking-based and multi-activity interventions. Furthermore, Egger's regression test indicated significant funnel plot asymmetry ($t(23) = 3.26$, $p = .003$), suggesting the presence of publication bias. Outputs from both the PET analysis ($g = -0.63$, 95% CI [−1.29, 0.03], $p = .072$) and the PEESE-corrected estimate were non-significant ($g = -0.02$, 95% CI [−0.39, 0.36], $p = .924$). These results indicate that the overall pooled effect may be impacted by small-study effects and publication bias.

When examining subgroups, GE interventions demonstrated moderate-to-large, non-significant effects for general mental health ($g = 0.715$, 95% CI [−1.12, 2.55], 95% PI [−2.29, 3.72], $p = .362$), stress ($g = 0.751$, 95% CI [−0.68, 2.19], 95% PI [−2.03, 3.53], $p = .236$), self-esteem ($g = 0.428$, 95% CI [−1.29, 2.14], 95% PI [−2.50, 3.36], $p = .549$), and mood ($g = 0.520$, 95% CI [−1.19, 2.23], 95% PI [−2.41, 3.45], $p = .469$; see Supplementary File 6).

When assessing the pooled SMD for mental health measures collected pre-and-post GE only ($k = 9$), a small-to-moderate significant effect was present in favour of GE improving mental health outcomes from pre-to-post intervention ($g = .58$, 95% CI [0.33, 0.83], $p < .001$). However, high levels of heterogeneity were present ($Q = 125.04$, $df = 19$, $p < .001$; $I^2 = 84.31\%$; see Figure 5), with a 95% prediction interval [−0.56, 1.72]. An Egger's regression test indicated no significant funnel plot asymmetry ($t(7) = 0.75$, $p = .480$), suggesting no evidence of small-study or publication bias. PET analysis revealed a non-significant negative adjusted effect ($g = -0.12$, 95% CI [−1.85, 1.62], $p = .899$), while the PEESE-corrected estimate yielded a small, non-significant effect ($g = 0.35$, 95% CI [−0.54, 1.25], $p = .457$), suggesting no indication of publication bias.

When examining the subgroups, a large, significant effect was present in favour of GE improving anxiety ($g = 0.963$, 95% CI [0.33, 1.60], 95% PI [−0.32, 2.25], $p = .005$) and mood ($g = 0.962$, 95% CI [0.35, 1.58], 95% PI [−0.32, 2.24], $p = .004$) from pre-to-post intervention. A small-to-moderate significant effect was found in favour GE of improving symptoms of stress ($g = 0.550$, 95% CI [0.08, 1.02], 95% PI [−0.66, 1.76], $p = .025$). No significant effect was present for any other subgroups (see Supplementary File 7).

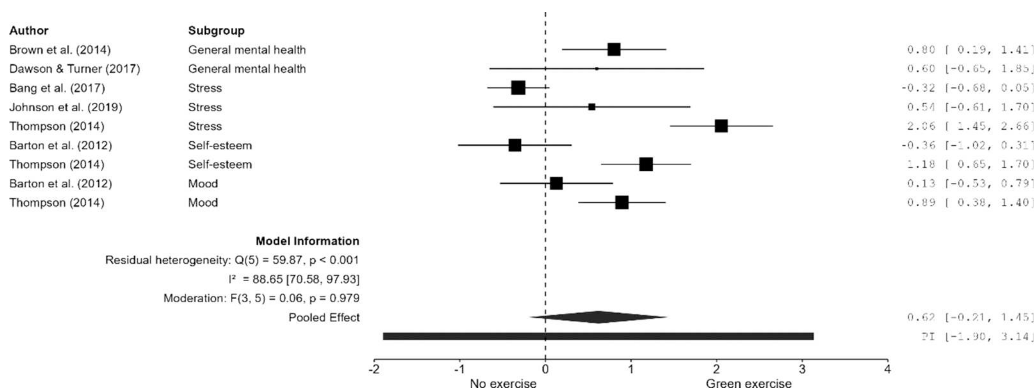

Figure 4. Meta-analysis of change scores for mental health measures in green exercise interventions compared to non-exercising control groups.

Note: The black bars indicate the 95% confidence interval range (CI). The black diamond represents the pooled effect size and the large black bar represents the prediction interval (PI). Scores have been transformed into positive numbers to represent improvement scores and negative numbers to represent worsening scores (e.g., reductions in stress and total mood disturbance transformed into positive numbers).

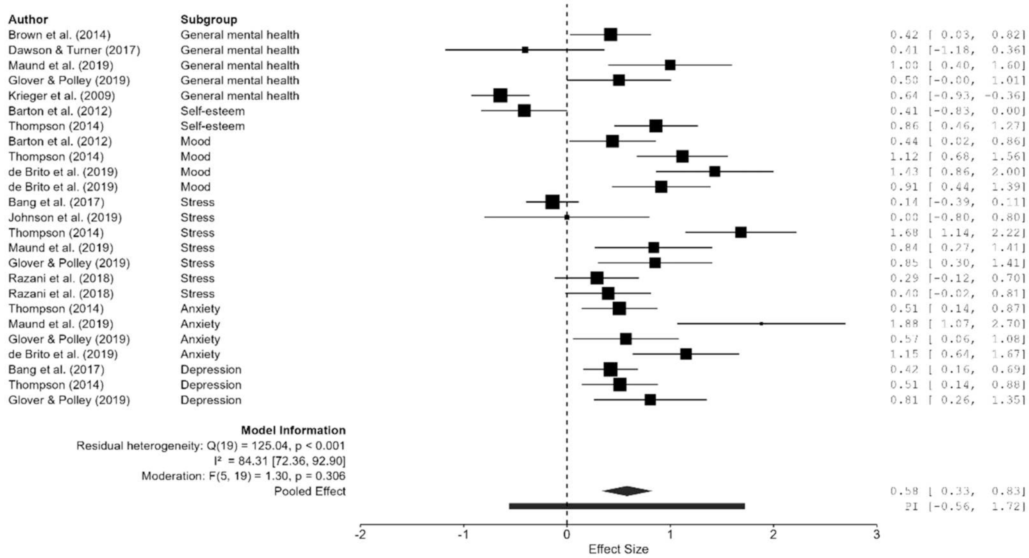

Figure 5. Meta-analysis of pre-to-post intervention mental health scores for green exercise programmes.

Note: The black bars indicate the 95% confidence interval range (CI). The black diamond represents the pooled effect size and the large black bar represents the prediction interval (PI). Scores have been transformed into positive numbers to represent improvement scores and negative numbers to represent worsening scores (e.g., reductions in stress and total mood disturbance transformed into positive numbers).

Social wellbeing

In total, 10 studies assessed the impact of GE intervention engagement on social wellbeing outcomes, most commonly general social benefits ($n = 3$), cohesion ($n = 2$), and connectedness ($n = 2$). Validated inventories included the Interpersonal Support Evaluation List (ISEL; $n = 2$) and the Sense of Community Index ($n = 1$), with four studies using non-validated author-created survey questions and three studies using surveys created by organisational or government bodies. Only one study combined more than one survey measure to understand the social wellbeing of both adults and children (Hignett et al., 2017).

Multi-activity interventions

There was some evidence of improvements in social connection, cohesion, and loneliness in healthy adults and vulnerable groups after engaging in multi-activity interventions after as little as three weeks.

A significant increase in social cohesion was present after eight months (+0.21) and 16 months (+0.20) for healthy adults engaging in the Woods In and Around Town project compared to the control site (Ward Thompson et al., 2019). For the Communities and Nature project, 75% of vulnerable participants reported an increase in inclusion and involvement with the community, and 83% reported lower feelings of isolation, with those with learning disabilities (100%) and those on low incomes (96%) demonstrating the greatest increase in social connection (Avon Wildlife Trust, 2016; Care Forum, 2015). In addition, parents provided with a park prescription for a three-week outdoor play and walking intervention significantly reduced their loneliness score (−1.03; Razani et al., 2018).

Walking interventions

Engaging in a 12–16 week walking intervention for healthy adults displayed significant increases in sense of community compared to an active control group (Lewis, 2018) and connection to neighbours (Krieger et al., 2009). No significant improvements for social wellbeing were present for WfH participants (Marselle et al., 2019).

Other projects – Surfing interventions

Children and adolescents undertaking an eight week surfing intervention reported significant improvements in friendship and social trust (Godfrey et al., 2015) and connectedness towards school, with 89% of participants reporting to have made new friends (Hignett et al., 2017) However, no significant improvement in connectedness was found towards family, nature, local community, the beach, or the world (Hignett et al., 2017).

Connection to nature

Seven studies measured changes in perceived connection to nature outcomes, using one measure per study. Validated measures of nature connection included the Inclusion of Nature in Self Scale ($n = 2$), Connectedness to Nature Scale ($n = 1$), and Nature Affinity Scale ($n = 1$). All remaining studies utilised non-validated author-created surveys.

Multi-activity interventions

Multi-activity interventions available to both adults and children improved greenspace visitor numbers and connection to local nature spaces when assessed both short-term (three weeks) and long-term (three years).

A significant increase in connectedness to nature was present for healthy adults engaging the Woods In and Around Towns programme at Wave 3 (social and physical intervention) but significantly decreased after Wave 2 (physical intervention only; Ward Thompson et al., 2019). The percentage of participants visiting a new greenspace ranged from 21% (Snowdon, 2006) to 99.6% (Besenyi et al., 2015), with a significantly greater increase in park visits after 3 months of independent outdoor exercise (+1.22 visits) compared to the supported park prescription group (+2.35 vs +0.59 visits; Razani et al., 2018).

For the Active Forests programme, the authors found an increase in the number of visitors (60% to 71%), the number of people visiting weekly or monthly (+2–16% increase; O'Brien & Morris, 2009a), the length of visits (2.0 to 2.5 h – O'Brien & Morris, 2009a; + 16–34% increase – Morris & O'Brien, 2011), and number of people undertaking multiple activities (42% to 63%; O'Brien & Morris, 2009a). However, in a later study most interviewed participants suggested they only visit an Active Forest site approximately 1–4 times per year (O'Brien, 2019).

Walking interventions

For the main sample of WfH walkers, a significantly greater connection to nature was present compared to the non-exercising control, but with no significant difference between frequent walkers and the control group (Marselle et al., 2019).

Societal impact

In total, five studies provided evidence demonstrating the cost-effectiveness of green and blue space PA interventions, with wellbeing and social valuation of £600 to over £116,000 or returning approximately £4–5 per £1 spent.

Maund et al. (2019) calculated a wellbeing valuation of £4,848 (via the Warwick Edinburgh Mental Wellbeing Scale) after six weeks of wetland activities. Although, the value of benefits ranged from £0 to £16,314 and the calculation did not include the cost of delivering the intervention. Ward Thompson et al. (2019) calculated an estimated quality-adjusted life years (QALY) of £935 for a physical intervention and £662 for a social intervention during a 2-year woodland project. In the most recent Active Forests evaluation, the estimated cost savings based on QALY analysis was approximately £3 million, when compared to medical interventions (O'Brien & Forster, 2023). A social return on investment (SROI) was calculated for the Opening Doors to the Outdoors green social prescribing programme, with social values of £4.90 to £5.36 generated for every £1 invested into the programme (Makanjuola et al., 2023). The overall social value for participants improving their PA and social trust was calculated as £116,412, or £3,085 per participant (Makanjuola et al., 2023). Finally, for the Green Gym programme, an SROI of £4.02 for every £1 spent was calculated based on three main factors: (i) Increasing physical health by 33% (worth £2.6 million); (ii) Reducing social isolation (£700,000); and (iii) Increasing wellbeing through giving back to the community (£400,000; Beishon & Munoz, 2016).

Finally, three studies provided quantitative feedback on the motivators and barriers associated with participation in GE interventions, which are detailed in Table 2.

Qualitative health and wellbeing outcomes

The qualitative health and wellbeing outcomes were coded into 6 themes with a total of 25 sub-themes: (i) Health outcomes [Health status; Improved medical conditions; Health knowledge; Fresh air]; (ii) Physical outcomes [Improvements in day-to-day skills; Improved weight and fitness; Physical challenge]; (iii) Mental wellbeing outcomes [Mental health; Affective state; Motivation; Mental activation; Enjoyment; Being away; Sense of pride and achievement; Self-improvement; Coping with adversity; Mental challenge]; (iv) Social outcomes [Engaging with others; Social support; Engaging various age groups]; (v) Physical activity and engagement [Healthier activity habits; Future exercise improvements; Improved exercise attitude and knowledge]; (vi) Other [Connection with the great outdoors; Personal development]. The most commonly cited qualitative outcomes were related to mental wellbeing ($n = 309$ quotes) and social wellbeing improvements ($n = 220$ quotes), despite there being a lack of quantitative evidence for social wellbeing benefits. Overall, the most popular qualitative sub-themes cited by participants were engaging with others ($n = 158$), connection with the great outdoors ($n = 77$), personal development ($n = 75$), sense of pride and achievement ($n = 54$), being away ($n = 53$), and enjoyment ($n = 41$). See Supplementary File 8 for further details on qualitative themes, sub-themes, codes, and example quotes.

Facilitators of successful interventions

The facilitators of successful interventions reported by participants and study authors in the qualitative data were categorised into five themes: (i) Methods of intervention creation and monitoring;

Table 2. Quantitative motivators and barriers to greenspace physical activity interventions.

Study	Motivators		Barriers	
O'Brien and Forster (2017, 2023)	Being active in nature	85–97%	Poor weather	27–53%
	Having fun	96%	Car park or forest too busy	42–43%
	Improve health	61–93%	No barriers	33%
	Improve fitness	62–86%	Forest work	27%
	Spend time with family or friends	49–78%	Long distance from home	15%
	Try something new	15–59%	Fear of getting lost	14%
	Learn a new skill	19–40%	Lack of facilities	12%
			Uneven terrain	8%
			Poor maintenance	7%
			Safety	5%
Beishon and Munoz (2016)	Being outdoors	59%	N/A	
	Give back	58%		
	Physical fitness	57%		
	Engage in environmental activities	46%		
	Meet like-minded people	40%		
	Mental wellbeing benefits	37%		

(ii) Activity creation; (iii) Activity delivery; (iv) Facilities; and (v) Impact on demographic groups. See Supplementary File 9 for further details and supporting quotes.

Key main considerations identified by researchers related to the 'methods of intervention creation and monitoring' were utilising an appropriate theoretical framework to create the intervention (e.g., Avon Wildlife Trust, 2016; Connor, 2020; Messiah et al., 2017) and creating a plan to monitor the outcomes of the intervention (e.g., Connor, 2020; de Brito et al., 2019; Phillips et al., 2012). Using co-production elements to work in mutually beneficial partnerships with local organisations and end-users to create the intervention (e.g., Krieger et al., 2009; Milton et al., 2011) and maintaining a community focus throughout the development were also recommended (e.g., Avon Wildlife Trust, 2016; Beishon & Munoz, 2016).

Key factors related to 'activity creation' included developing activities in an appropriate location, such as urban or low socio-economic areas (e.g., Connor, 2020; Johnson et al., 2019; O'Brien & Forster, 2020) and making the activity accessible for all groups (e.g., Avon Wildlife Trust, 2016; Howie et al., 2007; O'Brien & Morris, 2009a) to increase participation from target demographics. It is also important to be mindful of exercise variety (e.g., a range of activities or walk lengths, led and self-led opportunities, targeting different parts of the body; O'Brien & Forster, 2017, 2020b; South et al., 2012) and allowing for flexible activity delivery (e.g., Connor, 2020). However, some participants may prefer having structured elements within sessions (e.g., Grant et al., 2017).

In terms of the 'activity delivery', it was vital to have knowledgeable and enthusiastic staff to lead activities (e.g., Avon Wildlife Trust, 2016; Hendker & Eils, 2021; O'Brien & Forster, 2017, 2023; Snowdon, 2006; South et al., 2012) and potential referral pathways to recruit participants from target populations, such as clinical groups, low-income demographics, and family groups (e.g., Marselle et al., 2013; McCaffrey & Raddock, 2013; Razani et al., 2018; Snowdon, 2006). In addition, activity leaders should focus on providing an enjoyable experience for all users (e.g., Avon Wildlife Trust, 2016; Howie et al., 2007; Maund et al., 2019; O'Brien & Forster, 2009a, 2017) and foster a socially supportive environment to encourage regular participation (e.g., Beishon & Munoz, 2016; Connor, 2020; Phillips et al., 2011). Overall, the project should be promoted as a fun opportunity to socialise and be physically active, rather than focusing on the health-based benefits of participation (Milton et al., 2011).

Regarding 'facilities', researchers identified the importance of providing and investing in car parks, cafés, toilets, exercise equipment and routes (O'Brien & Forster, 2020a; O'Brien & Morris, 2009a) and offering either free transport to the intervention location or supported transport via lift shares and subsidised fees (Avon Wildlife Trust, 2016; Besenyi et al., 2015; Booth et al., 2021; Glover & Polley, 2019; Ward Thompson et al., 2019). Furthermore, having free or low-cost activities (e.g., Besenyi et al., 2015; Glover & Polley, 2019; O'Brien & Forster, 2009a, 2017) that are available in an accessible and safe location are vital for engagement (e.g., Connor, 2020; Godfrey et al., 2015; Howie et al., 2007).

wFinally, it is important to consider the 'impact on demographic groups' and how this may differ between populations. For example, undertaking practical conservation (Care Forum, 2015) or activities alongside younger people (Dawson, 2017) were successful for older adult populations, whereas interventions involving social interaction (Godfrey et al., 2015), new infrastructure (Morris & O'Brien, 2011), mobile apps, physical incentives, and competitions (Besenyi et al., 2015) were successful for young people. For families, providing a safe exercising environment (e.g., Hackett et al., 2020; Hignett et al., 2017), a low-cost activity and access to free events (Avon Wildlife Trust, 2016), and a flexible activity with game-like opportunities that could be completed around the families' other commitments (Besenyi et al., 2015) were seen as key factors for success. In terms of gender, incorporating play-based non-competitive games appeared successful in appealing to younger girls (Messiah et al., 2018) with women's-only sessions for adults being successful in allowing women to feel safer and less self-conscious during exercise (O'Brien, 2019).

Barriers to successful interventions and future recommendations

The barriers to successful intervention creation and future recommendations were categorised into three themes: (i) Intervention creation; (ii) Intervention delivery; and (iii) Recruitment and promotion. See Supplementary File 9 for further details and supporting quotes.

Regarding the 'intervention creation' process, two studies suggested that the use of co-production methods was a slow process (Howie et al., 2007) and some organisations were not fully committed to regularly engaging with the programme (Dawson, 2017). In addition, other issues included a lack of evidence-based practice to guide the intervention creation (Connor, 2020) and the difficulty in collecting, monitoring, and evaluating data from large-scale complex interventions (e.g., O'Brien & Forster, 2017). Therefore, future recommendations included creating interventions using models focused on the impact of social cognitions, self-efficacy, and the environment on participation (Connor, 2020; Grant et al., 2017; Tesler et al., 2022) and structuring interventions using frameworks such as 6SQuID and TIDieR, which outline the key steps to follow when designing and reporting public health interventions to increase the effectiveness and replicability of the project (Connor, 2020). Eight authors provided recommendations for measurements that could be used in future intervention studies, most commonly including measures of cost-effectiveness (Connor, 2020; Hignett et al., 2017; Maund et al., 2019; O'Brien & Forster, 2017; Snowdon, 2006), engagement (Richardson et al., 2020), intention to change (Brown et al., 2014), and non-response bias (Besenyi et al., 2015) as well as ensuring validated measures of PA and wellbeing are included (O'Brien & Forster, 2017). Recommendations for using control groups (e.g., Hignett et al., 2017) and technology to collect data (e.g., Beishon & Munoz, 2016) were also recommended. Other issues highlighted by participants included the activity being too expensive (e.g., Connor, 2020; O'Brien & Forster, 2017), too far from their home (e.g., Avon Wildlife Trust, 2016; Snowdon, 2006), in urban areas (Milton et al., 2011), or not being tailored towards their age or ability group (e.g., Phillips et al., 2011; South et al., 2012). Therefore, authors have recommended more effective planning of how interventions can be made sustainable, during the initial development (e.g., O'Brien & Morris, 2009a, 2009b), with participants suggesting additional sessions to increase their chance of engagement (e.g., Connor, 2020).

When discussing the 'intervention delivery', the authors identified various practical issues, such as difficulties maintaining staff (Howie et al., 2007; Morris & O'Brien, 2011; O'Brien & Morris, 2009a) and developing buy-in for new activities alongside well-liked events (e.g., Howie et al., 2007; O'Brien & Forster, 2017). Issues were highlighted regarding the sustainability of the intervention, as some authors referred to a short-term benefit or a ceiling effect (e.g., Phillips et al., 2012; Ward Thompson et al., 2019). The potential non-successful sustainability of the project may be due to volunteers' belief that the programme would not be able to continue without the financial and time resources provided by stakeholders (e.g., Care Forum, 2015; Grant et al., 2017; O'Brien & Morris, 2009a). From the perspective of participants, there were concerns regarding transportation (e.g., Howie et al., 2007; Phillips et al., 2011; Snowdon, 2006), social anxiety from being in large groups or overcrowded spaces (e.g., Morris & O'Brien, 2011; Snowdon, 2006) as well as common barriers to PA such as time, weather, and safety (e.g., Connor, 2020; Hackett et al., 2020). Therefore, authors recommended exercise variety and flexibility (e.g., Avon Wildlife Trust, 2016; Connor, 2020), educational opportunities (e.g., Connor, 2020; O'Brien & Forster, 2009a, 2017), and activities that participants can perform in their own time (Milton et al., 2011). Tangible support in terms of transport reimbursement (e.g., Avon Wildlife Trust, 2016; Connor, 2020; Snowdon, 2006) and appropriate staff allocation and training were recommended (e.g., Hackett et al., 2020; O'Brien & Morris, 2009a; Phillips et al., 2011). In addition, future researchers should aim to create opportunities in greenspace locations close to people's homes (Littman et al., 2021) or in public open spaces (Lewis, 2018) whilst incorporating social elements throughout the intervention (e.g., Littman et al., 2021; Makanjuola et al., 2023; Milton et al., 2011).

Finally, it is important for researchers to consider the most effective 'recruitment and promotion' strategies. There were reports that showcase events (Howie et al., 2007), contact cards (O'Brien &

Forster, 2017), and passport schemes (Howie et al., 2007) did not motivate participation from target groups. Although social media promotion was effective, it did require constant updates to optimally engage participants (O'Brien & Forster, 2017). Overall, increases in participant numbers did not necessarily translate to increased engagement from target groups, in particular, those from low-income backgrounds or from a minority ethic group (Morris & O'Brien, 2011), and low referral numbers were reported (e.g., Snowdon, 2006; South et al., 2012). In the future, methods such as text prompts (rather than emails; (Littman et al., 2021), flyers and signage (rather than posters; Connor, 2020; Snowdon, 2006), and regular advertisement on social media (Besenyi et al., 2015; O'Brien & Forster, 2017) were recommended to promote community GE initiatives. In addition, multiple studies suggested marketing the programme through the potential benefits of engagement, such as a chance to socialise, be in a peaceful location, and develop new skills, rather than focusing on PA (Connor, 2020; O'Brien & Morris, 2009a; South et al., 2012). Furthermore, to recruit participants and sustain participation in an intervention, evidence suggests that it is important to work closely with community stakeholders (Connor, 2020; Lewis, 2018), work with cross-sectoral and cross-disciplinary organisations (Barton et al., 2011), and strengthening referral pathways (e.g., Snowdon, 2006). It has been argued that this helps to drive word-of-mouth recruitment, which is the most effective promotional tool (e.g., Lewis, 2018; Milton et al., 2011). Other evidence suggests that there should be a focus on building strong relationships in small geographical areas and offering regular long-term support in areas of higher deprivation in order to build trust with members of the community (Avon Wildlife Trust, 2016). Future studies have been recommended to target interventions at minority ethinic groups, inactive individuals, women, over 55s, low socio-economic status groups, and those with disabilities or long-term health conditions (Grant et al., 2017; Littman et al., 2021; O'Brien & Forster, 2017; Snowdon, 2006).

Discussion

The first aim of the current study was to synthesise and interpret the impact of community-based GE interventions on various measures of health and wellbeing through the use of a systematic review and meta-analysis process. The second aim of the review was to develop novel insights into the successful and non-successful GE intervention components that positively, or negatively, impacted PA engagement through the analysis of qualitative feedback from project users and developers. The findings were brought together to provide guidance for future projects to successfully develop GE interventions that will positively impact health and PA outcomes.

This systematic review examined a relatively large number of studies ($n = 57$) in comparison to previous studies looking and green ($n = 14$; Mnich et al., 2019) and green and blue PA ($n = 6$; Marini et al., 2022). Although a recent systematic review by Coventry et al. (2021) examining blue and green exercise retrieved 50 relevant studies, only six studies were present in both the current review and the Coventry et al. (2021) paper (Bang et al., 2017; Brown et al., 2014; de Brito et al., 2019; Marselle et al., 2013, 2016; McCaffrey & Liehr, 2015). A major reason for the vast differences in articles retrieved is the study inclusion and exclusion criteria. The current systematic review included studies from both adult and child populations, both published literature and grey literature sources, and qualitative and quantitative outcomes in order to capture evidence across the life course and through local community initiatives that may be missed by only consulting published literature. In comparison, the review by Coventry et al. (2021) only included adult populations and published literature sources in their inclusion criteria. Furthermore, the current review focused on interventions that were accessible to all members of the community, therefore therapy-based interventions, which often require a social or medical prescription were excluded, whereas these projects featured heavily in the Coventry et al. (2021) review. Therefore, both review studies explore community-based green and blue exercise through different, but equally valid, criteria. The majority of the studies included in current the review were published within the last 10 years (75.4%), suggesting an expanded interest in the benefits of outdoor PA for promoting wellbeing.

General overview

The two most popular exercise modes for engaging participants in GE were multi-activity interventions ($n = 30$) and walking interventions ($n = 22$). Previously, these activity types have been combined into an overarching 'green exercise' label (Coventry et al., 2021), or reviews have considered walking-based studies, but not multi-activity interventions (Lahart et al., 2019). The current review therefore offers a different approach to viewing GE activities and the associated benefits by distinctly outlining two commonly cited modes of GE. Multiple-activity interventions, which combined more than one GE opportunity within a singular project, and walking interventions reported good to excellent compliance rates (multi-activity: 29–91%; walking: 42–77%), resulting in significantly improved PA levels. Therefore, researchers looking to implement GE programmes in the future should consider structuring projects based on multi-activity opportunities and/or walking activities. These modes of GE have been successful in motivating increased PA engagement, with multi-activity opportunities being particularly beneficial across the life course through engaging family groups, with walking activities being successful in engaging adults and older adults in GE in particular. This aligns with previous systematic review recommendations of incorporating combined, multi-faceted GE programmes to promote population PA (Hunter et al., 2015).

When considering the evidence from walking-based studies, findings suggest that undertaking one to two sessions of 45–90-minute walks per week for 6–13 weeks has the potential to significantly improve various measures of mental wellbeing. Furthermore, the wellbeing improvements were associated with an increased frequency and duration of walks, and walking in more 'natural' environments compared to urban green spaces (Marselle et al., 2013, 2014; Marselle et al. 2019). Although urban spaces recorded significantly lower walking durations compared with 'natural' locations (e.g., green corridors, farmlands, coastal areas), these locations attracted significantly more non-white participants, those aged 18–54, and individuals from the most deprived areas (Marselle et al., 2013) suggesting that hard-to-reach groups may be more accessible via urban greenspaces. Overall, the positive impact of walking on mental wellbeing measures is largely supported (e.g., Kelly et al., 2018), but evidence on other health measures remains mixed, with some supporting evidence of a positive impact on various physical health measures (Hanson & Jones, 2015) and other reports of small or null impact (Bowler et al., 2010). Overall, the heterogeneity of quantitative evidence for walking interventions (which has been confirmed in the current meta-analyses findings) makes it difficult to confirm conclusions. In the future, once further walking-based literature has been published, more targeted meta-analyses with greater homogeneity of outcome measures can be conducted.

In general, the durations of the multi-activity interventions varied considerably more compared to the walking interventions, with large-scale interventions providing one to two 60-minute sessions over a period of nine months to 3 years (e.g., Active Forests, Communities in Nature, Fit2Play). However, shorter-term interventions of 60 min to three hours, one to three times per week, for 5–13 weeks also provided mental wellbeing benefits, as well as improvements in blood pressure, aerobic fitness, functional fitness, and MVPA participation, which were seen less often in the walking interventions. Comparisons to previous systematic reviews prove difficult, as walking is often the most common form of PA assessed, and findings from all interventions are grouped together (e.g., Bowler et al., 2010; Lahart et al., 2019). Although, it appears that long-term engagement in outdoor activities, as shown with the Fit2Play initiative, can have positive physical health outcomes for children and adolescents (e.g., D'Agostino et al., 2018; Messiah et al., 2019). In general, studies assessing walking and multi-activity interventions lacked quantitative evidence on social wellbeing, despite qualitative evidence for walking and multi-activity interventions having positive impacts on social outcomes. This could be an interesting avenue for future research to assess, as these interventions often utilised a group-based environment.

Overall, when assessing the studies collectively using a meta-analysis of change scores between engaging in GE compared to no exercise, there was a moderate significant effect in favour of GE improving overall health outcomes which remained significant in the subgroup analyses for PA. However, no significant effect was present for any measure of mental wellbeing. The findings, tentatively suggest that engaging in any form of GE elicits some health and PA benefits compared to non-engagement in GE. Furthermore, when assessing the meta-analyses results of pre-and-post GE scores, there was only a small significant effect for GE improving overall general health, which remained significant for PA (moderate effect) and aerobic fitness (small effect) subgroups. In terms of mental health, a small-to-moderate significant effect was present for GE improving general mental health, which remained significant, with moderate-to-large effect sizes, for anxiety (large effect), mood (large effect), and stress (moderate effect). The findings suggest that engaging in GE may provide short-term improvements in general health and mental health, specifically related to anxiety, mood, stress, PA, and aerobic fitness.

However, caution should be taken when interpreting the findings from the current meta-analyses, due to issues with high heterogeneity between projects (resulting from differences in the type of GE undertaken and outcome measures completed) and the small number of studies per subgroup analysis. This is particularly true for mental wellbeing findings, which were impacted by potential small study bias and publication bias when assessing Egger's Regression tests and PET-PEESE tests. In the future, community-based GE projects should provide pre-and-post-intervention scores for GE and control groups to allow for more detailed meta-analyses to be run, including sub-group analyses comparing activity types (e.g., multi-activity projects vs walking), project users (e.g., adults vs children), and GE environments (e.g., urban vs rural) which could not be conducted in the current review due to a lack of studies with comparison data.

When assessing the raw scores across projects, the most commonly cited improvements were in relation to mental wellbeing and increases in PA engagement. Particularly, the strongest quantitative evidence was present for improving general mental health, anxiety, depression, positive and negative affect, and PA engagement in relation to minutes or days of PA. Often, effective interventions were undertaken from between 1–3 times per week over 5–13 weeks with exercise durations of between 45–60 min. Although, it should be noted that some interventions showed significant wellbeing improvements after shorter exercise durations (15–20 min; Brown et al., 2014; Sianoja et al., 2017) and intervention durations (2–3 weeks; de Brito et al., 2019; Razani et al., 2018; Sianoja et al., 2017). Coventry et al. (2021) reported mental wellbeing benefits, such as improved anxiety, affect, and depression especially for gardening and wilderness or forest therapies, which were rarely included in the current study. Regardless of exercise modality, it appears that engaging in GE can enhance feelings of mental wellbeing, aligning with the Attention Restoration Theory (ART; Kaplan, 1995), whereby the restorative nature of outdoor spaces elicits feelings of 'being away' from everyday life stressors and supporting recovery from cognitive fatigue.

In general, quantitative findings on self-reported health, objective physical health, and social wellbeing were mixed. Despite this, the qualitative findings suggest that the social elements of engaging in PA interventions are a key outcome of, and motivator for, participation. This is a novel finding of the current review, as previous green and blue exercise systematic reviews often retrieved only quantitative data, meaning that the social benefits of GE, which are often discussed in the qualitative feedback data, may be lost. Previous research on community-based PA have highlighted that outdoor activities can facilitate social connectedness (Leavell et al., 2019) which is key for continued engagement (Garrett et al., 2011). Therefore, social influences may be key constructs in motivating exercise uptake and adherence, but appear to be under-represented in the quantitative data. Future studies looking to capture the underreported social benefits of community-based GE should consider incorporating social support-based psychometric inventories, such as the Interpersonal Support Evaluation List (ISEL) used by Marselle et al. (2014, 2019) to evaluate walking-based projects, or systematic observation tools, such as the MOHAWk (Benton et al., 2022). Overall, future implementations of community-based GE programmes should incorporate social opportunities during the exercise, which will enhance social connectedness between community members, which may have the additional benefit of improving measures of mental wellbeing as a result.

Facilitators and barriers to successful GE interventions

Often, previous GE systematic review studies have not considered qualitative health outcomes or feedback from users and providers of GE interventions (Coventry et al., 2021; Lahart et al., 2019). Therefore, the analysis of qualitative feedback from GE project users and providers offers novel insights into *why* an intervention was successful or unsuccessful in motivating engagement or positively impacting health measures. When summarising the reflections of authors after the implementation of intervention studies, recommendations for creating GE projects in the future include maintaining a community-focus through the continued involvement of local organisations and end-users in the co-production of a project, finding a safe and appropriate location for the target audience, incorporating a variety of exercises, maintaining flexibility in delivery, providing incentives, and promoting social opportunities to encourage regular participation (e.g., Connor, 2020; Milton et al., 2011; O'Brien & Forster, 2017, 2020b). The use of co-production has previously been highlighted as a key component when designing park-based interventions in urban areas, with significantly greater increases in walking, wellbeing behaviours, and outdoor space usage reported in co-designed park interventions compared to non-co-designed park interventions (Anderson et al., 2024). The importance of utilising staff from similar backgrounds to the target audience was highlighted when recruiting activity leaders (e.g., Messiah et al., 2018). It is also important to consider tangible motivators for participation in a GE or PA intervention, such as having free or low-cost activities and free transport to the location (e.g., Avon Wildlife Trust, Besenyi et al., 2015; Glover & Polley, 2019). The suggestions from the authors align with research on common barriers to PA, such as lack of time, lack of motivation, fear of exercising alone, and high costs (Borodulin et al., 2016) reinforcing these as key areas for future interventions to target. It is also vital to consider how these recommendations are implemented to engage target groups in GE. The inclusion of social opportunities, flexible exercise opportunities, and GE in safe locations are key considerations for family groups (e.g., Besenyi et al., 2015; Hackett et al., 2020; Milton et al., 2011). Having low-cost activities and creating opportunities close to home, or providing free transport if opportunities are further afield, is vital for engaging low-income groups (e.g., Avon Wildlife Trust, 2016), whereas non-competitive activities or female-only sessions may encourage participation from girls and women (Messiah et al., 2018; O'Brien, 2019).

Authors also discussed non-successful intervention components that are recommended for future GE projects to avoid. A lack of evidence-based practice, ineffective co-production, or the lack of a defined target audience in the creation of the activity can prevent interventions from being effective (e.g., Dawson, 2017; Howie et al., 2007). Although having enthusiastic and welcoming staff was often highlighted as a key component of short-term intervention success, staffing could quickly become an issue in the long-term maintenance of the activity, leading to a ceiling effect of how long the activity and the associated benefits would last (Ward Thompson et al., 2019). Therefore, future GE projects should consider creating an evidence-based intervention plan and a long-term strategy for staffing resources during the development phase of a project to ensure longevity (e.g., Connor, 2020; Hackett et al., 2020; Tesler et al., 2022). Finally, the promotion of GE projects was sometimes unsuccessful in engaging participants specifically from target groups, such as women, low-income backgrounds, and minority ethnic groups (e.g., Morris & O'Brien, 2011; O'Brien & Forster, 2017). Therefore, authors recommend future GE projects to implement a multi-faceted promotional strategy, including materials such as texts, social media posts, flyers, and signage (eg., Littman et al., 2021; O'Brien & Forster, 2017; Snowdon, 2006). Furthermore, future GE interventions should implement positive word-of-mouth recruitment, which is reported as one of the most effective methods of recruitment for community-based interventions (Bock et al., 2014) through building relationships with cross-sectoral community stakeholders and improving referral pathways.

Issues and future directions

Several issues in the implementation and reporting of community-based interventions were highlighted in the current study. A common issue identified was a lack of adequate description of the exercise dose and duration of each intervention activity. Often, this was an issue for large scale interventions that implemented an observational or cross-sectional study design and were published within grey literature sources (e.g., Active Forests programme and Communities in Nature project). In general, there was a lack of information on the description of greenspace quality, which was an issue highlighted in a previous systematic review (Coventry et al., 2021). In the future, authors should consider providing clear information on the dose (e.g., minutes per week) and duration (e.g., total number of weeks) for each activity and a description of each greenspace used. Furthermore, future studies could incorporate a greater use of a realist evaluation approach to provide a distinct explanation of the nature of programmes and an exploration of how they work (Pawson & Tilley, 2004). This may allow for greater generalisable comparisons on *how* and *why* interventions worked in future review studies of GE projects, rather than only focusing on quantitative evidence of what *did* and *did not* work.

In addition, the large majority of studies only used greenspaces ($n = 43$) with two studies using only blue spaces. However, these figures should be taken with caution, as other studies may have been incorrectly categorised if the author failed to mention blue space elements within the greenspaces. In the future, it would be interesting to explore the impact of blue space elements on participants' perceptions of the outdoor environment, as exposure to blue spaces can have a positive impact on mental wellbeing and PA levels (Gascon et al., 2017).

Third, 28 studies were focused on engaging children and/or families in an exercise intervention, however, only 13 studies collected feedback on project enjoyment and perceived health benefits of engagement from children. For example, the multi-park 'Park Hop' scavenger hunt intervention (Besenyi et al., 2015), intergenerational park activities for older adults and children (Dawson, 2017), and the Active Forests project (O'Brien & Forster, 2023) only collected data from adults, despite children being included as a target audience. Future research on child-focused PA interventions should explore accessible methods for collecting feedback from children.

Issues with the research designs are also apparent. Overall, 16 studies (28.1%) included a comparison group, most often being a group undertaking normal activities or being non-attenders ($n = 7$). Furthermore, only nine studies (15.8%) undertook follow-up measures with participants, with over half of these studies ($n = 6$) following up at three months post-intervention. Future studies creating community-based GE interventions should provide a control group, to determine whether the intervention provides additional benefits compared to engaging in normal behaviour or is more beneficial than other forms of PA. Furthermore, implementing follow-up measures at least three months post-intervention (e.g., Bang et al., 2017; Beishon & Munoz, 2016; O'Brien & Forster, 2020, 2023) may determine the sustainability of healthy behaviours and benefits after the intervention period.

Strengths and limitations of the review

One of the main strengths and novelties of the current systematic review was the inclusion of both published literature and grey literature sources, data from adults and children, and systematically interpreting data from quantitative, qualitative, and mixed methods studies. By expanding the range of potential literature sources to be included in the review, the study was able to both assess the objective changes to wellbeing and the qualitative feedback from participants. The grey literature sources also provide evidence on the benefits of a PA interventions being undertaken in a 'real-world', ecologically valid community settings, which may be missed when only consulting published literature sources. Therefore, the use of grey literature sources and qualitative feedback data provided novel insights into successful and non-successful GE intervention components, which can offer useful guidance for creating future interventions to enhance beneficial outcomes, engagement, and exercise sustainability for communities.

However, several limitations should be noted. First, there is the risk of potentially relevant studies being missed during data retrieval and screening, in particular, due to using a single-reviewer approach (Mahtani et al., 2020; Waffenschmidt et al., 2019). It is also possible that relevant studies were missed due to the search terms used when searching the electronic databases, for example, by not including more specific terms related to mental or physical wellbeing (e.g., depress* or anxi*). The researchers did not follow-up with authors of studies that did not provide pre-and-post intervention scores or standard deviations, and instead only used data that was readily accessible, which may have meant further analysis opportunities were missed. Furthermore, to refine the studies being included, additional exclusion criteria were implemented, such as excluding institution-based studies (e.g., school-based or hospital-based), projects led by medical professionals, therapeutic intervention studies, and evidence provided from single bouts of outdoor exercise. These decisions were made to ensure the intervention exercise was accessible to the general community, without needing professional guidance. In addition, the review only included articles published in the English language, which may have increased the language and publication bias of the review. Overall, the protocol and criteria that were implemented could have resulted in studies with potentially useful recommendations being excluded. In the future, if resources permit, a larger number of reviewers should be utilised at all stages of data screening, extraction, and synthesis, in addition to employing a more extensive search term list and inclusion criteria, to avoid relevant studies from being excluded. Alternatively, AI software such as ASReview could be utilised to support in the screening of papers, although the use of additional reviewers is the primary future recommendation.

Finally, the small number of studies providing pre-and-post-intervention scores for GE projects and a control group prevented a more robust meta-analysis from being conducted with more detailed subgroup comparisons between GE activities, types of greenspace locations, and population groups. Each meta-analysis conducted in the current review was based on a relatively small number of studies ($k = 6$–18), limiting the statistical power of findings. Given the moderate-to-large effect sizes observed for some measures, it is likely that these results are reflective of limited data availability, rather than a true absence of effect. As the research field expands, future research could investigate variations in GE modes more meaningfully through meta-analyses with a larger body of research containing more robust findings.

Conclusion

This review synthesised quantitative and qualitative findings from published literature and grey literature sources to understand the health benefits associated with community-based GE participation and identify facilitators and barriers to successful intervention development. Meta-analysis findings tentatively demonstrated the benefit of GE engagement on overall health (including PA and aerobic fitness) and mental health (including anxiety, mood, and stress), with some evidence of greater benefits in favour of improving overall health and PA compared to no exercise engagement. However, the findings should be interpreted with caution due to high heterogeneity in study outcomes and the small sample of projects utilised. The systematic synthesis of literature highlighted that engaging in outdoor PA, in particular walking-based or multi-activity interventions, for 45–90-minute sessions over 6–13 weeks demonstrated a positive impact on quantitative measures of mental wellbeing and PA engagement. Despite a lack of quantitative support for the intervention engagement on social wellbeing, the social benefits were key motivators for the uptake and adherence to GE programmes, when assessing the qualitative outcomes. Future projects focusing on creating outdoor PA opportunities for communities should implement GE in appropriate outdoor locations accessible for target demographics, providing a low-cost, sociable, and flexible GE opportunity to increase outdoor PA engagement and the associated health, wellbeing, and PA benefits.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Anderson, J., Benton, J. S., Ye, J., Barker, E., Macintyre, V. G., Wilkinson, J., Rothwell, J., Dennis, M., & French, D. P. (2024). Large walking and wellbeing behaviour benefits of co-designed sustainable park improvements: A natural experimental study in a UK deprived urban area. *Environment International*, *187*, 108669. https://doi.org/10.1016/j.envint.2024.108669

Araújo, D., Brymer, E., Brito, H., Withagen, R., & Davids, K. (2019). The empowering variability of affordances of nature: Why do exercisers feel better after performing the same exercise in natural environments than in indoor environments? *Psychology of Sport and Exercise*, *42*, 138–145. https://doi.org/10.1016/j.psychsport.2018.12.020

Avon Wildlife Trust. (2016). *Communities and nature: Evaluation report March* 2016. https://www.avonwildlifetrust.org.uk/sites/default/files/2018-03/Communities%20and%20Nature%20Evaluation%202016.pdf.

Baker, C., & Kirk-Wade, E. (2024). *Mental health statistics: prevalence, services and funding in England*. https://researchbriefings.files.parliament.uk/documents/SN06988/SN06988.pdf.

Bang, K. S., Lee, I., Kim, S., Lim, C. S., Joh, H. K., Park, B. J., & Song, M. K. (2017). The effects of a campus forest-walking program on undergraduate and graduate students' physical and psychological health. *International Journal of Environmental Research and Public Health*, *14*(7), 728. https://doi.org/10.3390/IJERPH14070728

Barboza, P. E., Cirach, M., Khomenko, S., Lungman, T., Mueller, N., Barrera-Gómez, J., & Rojas-Rueda, D. (2021). Green space and mortality in European cities: A health impact assessment study. *Articles Lancet Planet Health*, *5*(10), 718–730.

Barton, J., Murray, D., Rmn, G., & Obe, J. P. (2011). Exercise-, nature-and socially interactive-based initiatives improve mood and self-esteem in the clinical population. *Perspectives in Public Health*, *132*(2), 89–96. https://doi.org/10.1177/1757913910393862

Beishon, J., & Munoz, N. (2016). *Green gym evaluation report* 2016. https://www.tcv.org.uk/wp-content/uploads/2012/04/green-gym-evaluation-report-2016.pdf.

Benton, J. S., Anderson, J., Pulis, M., Cotterill, S., Hunter, R. F., & French, D. P. (2022). Method for observing pHysical activity and wellbeing (MOHAWk): validation of an observation tool to assess physical activity and otherwellbeing behaviours in urban spaces. *Cities & Health*, *6*(*4*), 818–832. https://doi.org/10.1080/23748834.2020.1775383

Besenyi, G. M., Fair, M., Hughey, S. M., Kaczynski, A. T., Powers, A., Dunlap, E., Team, P. H., & G, L. (2015). Park Hop: Pilot evaluation of an inter-agency collaboration to promote park awareness, visitation, and physical activity in Greenville County, SC. *Journal of Park and Recreation Administration*, *33*(4), 69–89. https://doi.org/10.18666/JPRA-2015-V33-I4-6216

Bock, C., Jarczok, M. N., & Litaker, D. (2014). Community-based efforts to promote physical activity: A systematic review of interventions considering mode of delivery, study quality and population subgroups. *Journal of Science and Medicine in Sport*, *17*(3), 276–282. https://doi.org/10.1016/j.jsams.2013.04.009

Booth, J. V., Messiah, S. E., Hansen, E., Nardi, M. I., Hawver, E., Patel, H. H., Kling, H., Okeke, D., & D'Agostino, E. M. (2021). Objective measurement of physical activity attributed to a park-based afterschool program. *Journal of Physical Activity and Health*, *18*(3), 329–336. https://doi.org/10.1123/JPAH.2020-0162

Borodulin, K., Sipilä, N., Rahkonen, O., Leino-Arjas, P., Kestilä, L., Jousilahti, P., & Prättälä, R. (2016). Socio-demographic and behavioral variation in barriers to leisure-time physical activity. *Scandinavian Journal of Public Health*, *44*(1), 62–69. https://doi.org/10.1177/1403494815604080

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, *10*, 1–10.

Britton, E., Kindermann, G., Domegan, C., & Carlin, C. (2020). Blue care: A systematic review of blue space interventions for health and wellbeing. *Health Promotion International*, *35*(1), 50–69. https://doi.org/10.1093/heapro/day103

Brown, D. K., Barton, J. L., Pretty, J., & Gladwell, V. F. (2014). Walks4Work: Assessing the role of the natural environment in a workplace physical activity intervention. *Scandinavian Journal of Work, Environment and Health*, *40*(4), 390–399. https://doi.org/10.5271/sjweh.3421

Bull, F., Willumsen, J., Stevens, G., & Strain, T. (2024). *Global levels of physical inactivity in adults: Off track for 2030*. https://www.pure.ed.ac.uk/ws/portalfiles/portal/468295101/BullEtal2024GlobalLevelsOfPhysicalInactivity.pdf.

Calogiuri, G., Evensen, K., Weydahl, A., Andersson, K., Patil, G., Ihlebæk, C., & Raanaas, R. K. (2016). Green exercise as a workplace intervention to reduce job stress. Results from a pilot study. *Work*, *53*(1), 99–111. https://doi.org/10.3233/WOR-152219

Care Forum. (2015). *Avon Wildlife Trust (AWT) Communities and Nature (CAN) Programme independent evaluation*. https://www.avonwildlifetrust.org.uk/sites/default/files/2018-03/Communities%20and%20Nature%20Programme%20Evaluation%202015.pdf.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Coleman, R. J., Kokolakakis, T., & Ramchandani, G. (2012). *Walking for Health Attendance Study: An analysis of attendance patterns of Walking for Health participants*. https://publications.naturalengland.org.uk/publication/2181481.

Connor, N. (2020). *Exploring community gardening as a complex public health intervention: An action research study*. University of Durham.

Corazon, S. S., Sidenius, U., Poulsen, D. V., Gramkow, M. C., & Stigsdotter, U. K. (2019). Psycho-physiological stress recovery in outdoor nature-based interventions: A systematic review of the past eight years of research. *International Journal of Environmental Research and Public Health*, *16*(10), 1711. https://doi.org/10.3390/ijerph16101711

Coventry, P. A., Brown, J. V. E., Pervin, J., Brabyn, S., Pateman, R., Breedvelt, J., Gilbody, S., Stancliffe, R., McEachan, R., & White, P. C. L. (2021). Nature-based outdoor activities for mental and physical health: Systematic review and meta-analysis. *SSM - Population Health*, *16*, 100934. https://doi.org/10.1016/J.SSMPH.2021.100934

D'Agostino, E. M., Patel, H. H., Hansen, E., Mathew, M. S., Nardi, M. I., & Messiah, S. E. (2018). Effect of participation in a park-based afterschool program on cardiovascular disease risk among severely obese youth. *Public Health*, *159*, 137–143. https://doi.org/10.1016/J.PUHE.2018.02.025

Dawson, A. (2017). *Intergenerational programming on a multi-generational play park and its impact on older adults*. University of North Carolina at Charlotte.

de Brito, J. N., Pope, Z. C., Mitchell, N. R., Schneider, I. E., Larson, J. M., Horton, T. H., & Pereira, M. A. (2019). Changes in psychological and cognitive outcomes after green versus suburban walking: A pilot crossover study. *International Journal of Environmental Research and Public Health*, *16*(16), 2894. https://doi.org/10.3390/ijerph16162894

Derose, K. P., Wallace, D. D., Han, B., & Cohen, D. A. (2021). Effects of park-based interventions on health-related outcomes: A systematic review. *Preventive Medicine*, *147*, 106528. https://doi.org/10.1016/j.ypmed.2021.106528

Duncan, M. J., Clarke, N. D., Birch, S. L., Tallis, J., Hankey, J., Bryant, E., & Eyre, E. L. J. (2014). The effect of green exercise on blood pressure, heart rate and mood state in primary school children. *International Journal of Environmental Research and Public Health*, *11*(4), 3678–3688. https://doi.org/10.3390/IJERPH110403678

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Farrance, C., Tsofliou, F., & Clark, C. (2016). Adherence to community based group exercise interventions for older people: A mixed-methods systematic review. *Preventive Medicine*, *87*, 155–166. https://doi.org/10.1016/j.ypmed.2016.02.037

Gagliardi, C., & Piccinini, F. (2019). The use of nature – based activities for the well-being of older people: An integrative literature review. *Archives of Gerontology and Geriatrics*, *83*, 315–327. https://doi.org/10.1016/j.archger.2019.05.012

Garrett, S., Elley, C. R., Rose, S. B., O'Dea, D., Lawton, B. A., & Dowell, A. C. (2011). Are physical activity interventions in primary care and the community cost-effective? A systematic review of the evidence. *British Journal of General Practice*, *61*(584), 125–133. https://doi.org/10.3399/BJGP11X561249

Gascon, M., Zijlema, W., Vert, C., White, M. P., & Nieuwenhuijsen, M. J. (2017). Outdoor blue spaces, human health and well-being: A systematic review of quantitative studies. *International Journal of Hygiene and Environmental Health*, *220*(8), 1207–1221. https://doi.org/10.1016/j.ijheh.2017.08.004

Glover, N., & Polley, S. (2019). GOING GREEN: The effectiveness of a 40-day green exercise intervention for insufficiently active adults. *Sports*, *7*(6), 142. https://doi.org/10.3390/sports7060142

Godfrey, C., Devine-Wright, H., & Taylor, J. (2015). The positive impact of structured surfing courses on the wellbeing of vulnerable young people. *Community Practitioner*, *88*(1), 26–29.

Grant, G., Machaczek, K., Pollard, N., & Allmark, P. (2017). Walking, sustainability and health: Findings from a study of a walking for health group. *Health and Social Care in the Community*, *25*(3), 1218–1226. https://doi.org/10.1111/HSC.12424

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1.6 million participants. *The Lancet Child and Adolescent Health*, *4*(1), 23–35. https://doi.org/10.1530/ey.17.13.12

Hackett, K. A., Ziegler, M. C., Olson, J. A., Bizub, J., Stolley, M., Szabo, A., Heller, E., & Beyer, K. M. M. (2020). Nature mentors: A program to encourage outdoor activity and nature engagement among urban youth and families. *Journal of Adventure Education and Outdoor Learning*, *21*(1), 35–52. https://doi.org/10.1080/14729679.2020.1730203

Han, B., Cohen, D. A., Derose, K. P., Marsh, T., Williamson, S., & Loy, S. (2015). Effectiveness of a free exercise program in a neighborhood park. *Preventive Medicine Reports*, *2*, 255–258. https://doi.org/10.1016/j.pmedr.2015.03.010

Haney, K., Messiah, S. E., Arheart, K. L., Hanson, E., Diego, A., Kardys, J., Kirwin, K., Nottage, R., Ramirez, S., Somarriba, G., & Binhack, L. (2014). Park-based afterschool program to improve cardiovascular health and physical fitness in children with disabilities. *Disability and Health Journal*, *7*(3), 335–342. https://doi.org/10.1016/J.DHJO.2014.02.006

Hanson, S., & Jones, A. (2015). Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. *British Journal of Sports Medicine*, *49*(11), 710–715. https://doi.org/10.1136/bjsports-2014-094157

Hedges, L. V. (1981). Distribution theory for glass's estimator of effect size and related estimators. *Journal of Educational Statistics*, *6*(*2*), 107–128. https://doi.org/10.3102/10769986006002107

Hendker, A., & Eils, E. (2021). A group-based 8-week functional Interval-Type outdoor training program improves physical performance in recreationally active adults. *Frontiers in Sports and Active Living*, *3*, 627853. https://doi.org/10.3389/fspor.2021.627853

Higgins, J. P., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine*, *21*(11), 1539–1558. https://doi.org/10.1002/sim.1186

Hignett, A., White, M. P., Pahl, S., Jenkin, R., & Le Froy, M. (2017). Evaluation of a surfing programme designed to increase personal well-being and connectedness to the natural environment among "at risk" young people. *Journal of Adventure Education and Outdoor Learning*, *18*(1), 53–69. https://doi.org/10.1080/14729679.2017.1326829

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M. P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M. C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information*, *34*(4), 285–291. https://doi.org/10.3233/EFI-180221

Howie, F., Aldridge, V., & Parrott, E. (2007). *Wye Wood: The wider wood. A project description and evaluation*. https://cdn.forestresearch.gov.uk/2022/02/wye_wood_report.pdf.

Hunter, R. F., Christian, H., Veitch, J., Astell-Burt, T., Hipp, J. A., & Schipperijn, J. (2015). The impact of interventions to promote physical activity in urban green space: A systematic review and recommendations for future research. *Social Science and Medicine*, *124*, 246–256. https://doi.org/10.1016/j.socscimed.2014.11.051

Husk, K., Lovell, R., Cooper, C., Stahl-Timmins, W., & Garside, R. (2016). Participation in environmental enhancement and conservation activities for health and well-being in adults: A review of quantitative and qualitative evidence. *Cochrane Database of Systematic Reviews*, *5*, 1–40. https://doi.org/10.1002/14651858.CD010351.pub2

Izenstark, D., & Ebata, A. T. (2017). The effects of the natural environment on attention and family cohesion: An experimental study. *Children, Youth and Environments*, *27*(2), 93. https://doi.org/10.7721/chilyoutenvi.27.2.0093

Johnson, U., Ivarsson, A., Parker, J., Andersen, M. B., & Svetoft, I. (2019). Connection in the fresh air: A study on the benefits of participation in an electronic tracking outdoor gym exercise programme. *Montenegrin Journal of Sports Science and Medicine*, *8*(1), 61–76. https://doi.org/10.26773/mjssm.190309

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *16*, 169–182.

Kassavou, A., Turner, A., & French, D. P. (2013). Do interventions to promote walking in groups increase physical activity? A meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *10*(1), 18. https://doi.org/10.1186/1479-5868-10-18

Katzmarzyk, P. T., Friedenreich, C., Shiroma, E. J., & Lee, I. M. (2022). Physical inactivity and non-communicable disease burden in low-income, middle-income and high-income countries. *British Journal of Sports Medicine*, *56*(2), 101–106. https://doi.org/10.1136/bjsports-2020-103640

Kelly, P., Williamson, C., Niven, A. G., Hunter, R., Mutrie, N., & Richards, J. (2018). Walking on sunshine: Scoping review of the evidence for walking and mental health. *British Journal of Sports Medicine*, *52*(12), 800–806. https://doi.org/10.1136/bjsports-2017-098827

Krieger, J., Rabkin, J., Sharify, D., & Song, L. (2009). High point walking for health: Creating built and social environments that support walking in a public housing community. *American Journal of Public Health*, *99*(3), 593–599. https://doi.org/10.2105/ajph.2009.164384

Krinski, K., Machado, D. G. S., Lirani, L. S., DaSilva, S. G., Costa, E. C., Hardcastle, S. J., & Elsangedy, H. M. (2017). Let's walk outdoors! Self-paced walking outdoors improves future intention to exercise in women with obesity. *Journal of Sport and Exercise Psychology*, *39*(2), 145–157. https://doi.org/10.1123/jsep.2016-0220

Lahart, I., Darcy, P., Gidlow, C., & Calogiuri, G. (2019). The effects of green exercise on physical and mental wellbeing: A systematic review. *International Journal of Environmental Research and Public Health*, *16*(8), 1352. https://doi.org/10.3390/ijerph16081352

Leavell, M. A., Leiferman, J. A., Gascon, M., Braddick, F., Gonzalez, J. C., & Litt, J. S. (2019). Nature-based social prescribing in urban settings to improve social connectedness and mental well-being: A review. *Current Environmental Health Reports*, *6*(4), 297–308. https://doi.org/10.1007/S40572-019-00251-7/TABLES/1

Lewis, D. L. (2018). *A walk in The park: What's community got to do with it? A comparative analysis of adults' perceptions of sense of community at sentinel peak and Tumamoc Hill, Tucson, Arizona*. University of Arizona.

Li, H., Zhang, X., Bi, S., Cao, Y., & Zhang, G. (2022). Psychological benefits of green exercise in wild or urban greenspaces: A meta-analysis of controlled trials. *Urban Forestry and Urban Greening*, *68*, 127458. https://doi.org/10.1016/j.ufug.2022.127458

Littman, A. J., Bratman, G. N., Lehavot, K., Engel, C. C., Fortney, J. C., Peterson, A., Jones, A., Klassen, C., Brandon, J., & Frumkin, H. (2021). Nature versus urban hiking for veterans with post-traumatic stress disorder: A pilot randomised trial conducted in the Pacific Northwest USA. *BMJ Open*, *11*, 51885. https://doi.org/10.1136/bmjopen-2021-051885

Liu, J., Sekine, M., Tatsuse, T., Fujimura, Y., Hamanishi, S., Lu, F., & Zheng, X. (2015). Outdoor physical activity and its relation with self-reported health in Japanese children: Results from the Toyama birth cohort study. *Child: Care, Health and Development*, *41*(6), 920–927. https://doi.org/10.1111/CCH.12262

Lovell, R., Husk, K., Cooper, C., Stahl-Timmins, W., & Garside, R. (2015). Understanding how environmental enhancement and conservation activities may benefit health and wellbeing: A systematic review. *BMC Public Health*, *15*, 1–8. https://doi.org/10.1002/14651858.CD010351/full

Mackay, G. J., & Neill, J. T. (2010). The effect of "green exercise" on state anxiety and the role of exercise duration, intensity, and greenness: A quasi-experimental study. *Psychology of Sport and Exercise*, *11*(3), 238–245. https://doi.org/10.1016/j.psychsport.2010.01.002

Mahtani, K. R., Heneghan, C., & Aronson, J. (2020). Single screening or double screening for study selection in systematic reviews? *BMJ Evidence-based Medicine*, *25*(4), 149–150. https://doi.org/10.1136/bmjebm-2019-111269

Makanjuola, A., Lynch, M., Hartfiel, N., Cuthbert, A., & Edwards, R. T. (2023). Prevention of poor physical and mental health through the green social prescribing opening doors to the outdoors programme: A social return on investment analysis. *International Journal of Environmental Research and Public Health*, *20*(12), 6111. https://doi.org/10.3390/ijerph20126111

Malberg Dyg, P., Christensen, S., & Peterson, C. J. (2020). Community gardens and wellbeing amongst vulnerable populations: A thematic review. *Health Promotion International*, *35*(4), 790–803. https://doi.org/10.1093/heapro/daz067

Marini, S., Mauro, M., Grigoletto, A., Toselli, S., & Maietta Latessa, P. (2022). The effect of physical activity interventions carried out in outdoor natural blue and green spaces on health outcomes: A systematic review. *International Journal of Environmental Research and Public Health*, *19*(19), 12482. https://doi.org/10.3390/ijerph191912482

Marselle, M. R., Irvine, K. N., Lorenzo-Arribas, A., & Warber, S. L. (2016). Does perceived restorativeness mediate the effects of perceived biodiversity and perceived naturalness on emotional well-being following group walks in nature? *Journal of Environmental Psychology*, *46*, 217–232. https://doi.org/10.1016/J.JENVP.2016.04.008

Marselle, M. R., Irvine, K. N., & Warber, S. L. (2013). Walking for well-being: Are group walks in certain types of natural environments better for well-being than group walks in urban environments? *International Journal of Environmental Research and Public Health*, *10*(11), 5603–5628. https://doi.org/10.3390/IJERPH10115603

Marselle, M. R., Irvine, K. N., & Warber, S. L. (2014). Examining group walks in nature and multiple aspects of well-being: A large-scale study. *Ecopsychology*, *6*(3), 134–147. https://doi.org/10.1089/ECO.2014.0027

Marselle, M. R., Warber, S. L., & Irvine, K. N. (2019). Growing resilience through interaction with nature: Can group walks in nature buffer the effects of stressful life events on mental health? *International Journal of Environmental Research and Public Health*, *16*(6), 986. https://doi.org/10.3390/IJERPH16060986

Masterton, W., Carver, H., Parkes, T., & Park, K. (2020). Greenspace interventions for mental health in clinical and non-clinical populations: What works, for whom, and in what circumstances? *Health and Place*, *64*, 102338. https://doi.org/10.1016/j.healthplace.2020.102338

Maund, P. R., Irvine, K. N., Reeves, J., Strong, E., Cromie, R., Dallimer, M., & Davies, Z. G. (2019). Wetlands for wellbeing: Piloting a nature-based health intervention for the management of anxiety and depression. *International Journal of Environmental Research and Public Health*, *16*(22), 4413. https://doi.org/10.3390/IJERPH16224413

McCaffrey, R., & Liehr, P. (2015). The effect of reflective garden walking on adults with increased levels of psychological stress. *Journal of Holistic Nursing*, *34*(2), 177–184. https://doi.org/10.1177/0898010115594934

McCaffrey, R., & Raddock, S. (2013). The effect of a reflective garden walking program. *Journal of Therapeutic Horticulture*, *23*(1), 22–34. https://web.p.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=0&sid=bac3dfd7-da07-4adc-a0b0-ceb71743571a%40redis.

Menardo, E., Brondino, M., Hall, R., & Pasini, M. (2021). Restorativeness in natural and urban environments: A meta-analysis. *Psychological Reports*, *124*(2), 417–437. https://doi.org/10.1177/0033294119884063

Messiah, S. E., D'Agostino, E. M., Hansen, E., Sunil Mathew, M., Okeke, D., Nardi, M., Kardys, J., & Arheart, K. L. (2017). Longitudinal impact of a park-based afterschool healthy weight program on modifiable cardiovascular disease risk factors in youth. *Journal of Community Health*, *43*, 103–116. https://doi.org/10.1007/s10900-017-0393-9

Messiah, S. E., D'Agostino, E. M., Patel, H. H., Hansen, E., Mathew, M. S., & Arheart, K. L. (2018). Sex differences in fitness outcomes among minority youth after participation in a park-based after-school program. *Annals of Epidemiology*, *28*(7), 432–439. https://doi.org/10.1016/J.ANNEPIDEM.2018.03.020

Messiah, S. E., D'Agostino, E. M., Patel, H. H., Hansen, E., Mathew, M. S., & Arheart, K. L. (2019). Changes in cardiovascular health and physical fitness in ethnic youth with intellectual disabilities participating in a park-based afterschool programme for two years. *Journal of Applied Research in Intellectual Disabilities*, *32*(6), 1478–1489. https://doi.org/10.1111/JAR.12642

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.

Millar, L., Kremer, P., de Silva-Sanigorski, A., McCabe, M. P., Mavoa, H., Moodie, M., Utter, J., Bell, C., Malakellis, M., Mathews, L., Roberts, G., Robertson, N., & Swinburn, B. A. (2011). Reduction in overweight and obesity from a 3-year community-based intervention in Australia: The "it's your move!" project. *Obesity Reviews*, *12*(2), 20–28. https://doi.org/10.1111/J.1467-789X.2011.00904.X

Milton, K., Kelly, P., Bull, F., & Foster, C. (2011). A formative evaluation of a family-based walking intervention-furness families Walk4Life. *BMC Public Health*, *11*, 1–10. https://doi.org/10.1186/1471-2458-11-614

Mmako, N. J., Courtney-Pratt, H., & Marsh, P. (2020). Green spaces, dementia and a meaningful life in the community: A mixed studies review. *Health and Place*, *63*, 102344. https://doi.org/10.1016/j.healthplace.2020.102344

Mnich, C., Weyland, S., Jekauc, D., & Schipperijn, J. (2019). Psychosocial and physiological health outcomes of green exercise in children and adolescents-A systematic review. *International Journal of Environmental Research and Public Health*, *16*(21), 4266. https://doi.org/10.3390/ijerph16214266

Morris, J., & O'Brien, E. (2011). Encouraging healthy outdoor activity amongst under-represented groups: An evaluation of the active England woodland projects. *Urban Forestry and Urban Greening*, *10*(4), 323–333. https://doi.org/10.1016/J.UFUG.2011.05.006

Moslehi, E., Moslehi, Z., & Khalvati, B. (2019). Playing in form of outdoor aerobic exercise is more effective than indoor treadmill exercise on serum Orexin-A and weight loss in obese adolescent boys. *Obesity Medicine*, *15*, 100104. https://doi.org/10.1016/j.obmed.2019.100104

Nicklett, E. J., Anderson, L. A., & Yen, I. H. (2016). Gardening activities and physical health among older adults. *Journal of Applied Gerontology*, *35*(6), 678–690. https://doi.org/10.1177/0733464814563608

O'Brien, L. (2019). Active Forests Programme Reports and Publications: Pilot phase case studies. Https://Www.Forestresearch.Gov.Uk/Research/Active-Forests-Programme-Evaluation-Pilot-Phase/Active-Forests-Programme-Reports-and-Publications/.

O'Brien, L., & Forster, J. (2017). *Fun and Fitness in the Forest: Monitoring and evaluation of the three-year Active Forest pilot programme.* https://cdn.forestresearch.gov.uk/2022/02/fr_obrien_funandfitness_fullreportfinalsept2017.pdf.

O'Brien, L., & Forster, J. (2020). Sustaining and changing sport and physical activity behaviours in the forest: An evaluated pilot intervention on five public forest sites in England. *Urban Forestry and Urban Greening*, *55*, 126844. https://doi.org/10.1016/J.UFUG.2020.126844

O'Brien, L., & Forster, J. (2023). Active Forests: End of Phase 2 Report. https://forestresearch.shinyapps.io/active_forests_phase_2_report/.

O'Brien, L., & Morris, J. (2009a). Active England - The Woodland Projects - Final Report. https://cdn.forestresearch.gov.uk/2009/01/active_england_final_report.pdf.

O'Brien, L., & Morris, J. (2009b). *Active England: Bedgebury National Pinetum and Forest*. https://cdn.forestresearch.gov.uk/2022/02/active_england_bedgebury_site_report.pdf.

Olafsdottir, G., Cloke, P., Schulz, A., van Dyck, Z., Eysteinsson, T., Thorleifsdottir, B., & Vögele, C. (2020). Health benefits of walking in nature: A randomized controlled study under conditions of real-life stress. *Environment and Behavior*, *52*(3), 248–274. https://doi.org/10.1177/0013916518800798

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71

Pasanen, T. P., White, M. P., Wheeler, B. W., Garrett, J. K., & Elliott, L. R. (2019). Neighbourhood blue space, health and wellbeing: The mediating role of different types of physical activity. *Environnent International*, *131*, 105016. https://doi.org/10.1016/j.envint.2019.105016

Pawson, R., & Tilley, N. (2004). *Realist evaluation*. http://www.communitymatters.com.au/RE_chapter.pdf.

Phillips, R., Knox, A., & Langley, E. (2012). *What impact did Walking for Health have on the physical activity levels of participants?* https://publications.naturalengland.org.uk/publication/2184111.

Phillips, R., Langley, E., & Knox, A. (2011). *Walking for Health: 'inactive' walkers – barriers to participation, and activity substitution*. https://publications.naturalengland.org.uk/publication/48009.

Popp, J., Grüne, E., Carl, J., Semrau, J., & Pfeifer, K. (2021). Co-creating physical activity interventions: A mixed methods evaluation approach. *Health Research Policy and Systems*, *19*(1), 1–9. https://doi.org/10.1186/s12961-021-00699-w

Pretty, J., & Barton, J. (2020). Nature-based interventions and mind-body interventions: Saving public health costs whilst increasing life satisfaction and happiness. *International Journal of Environmental Research and Public Health*, *17*(21), 7769. https://doi.org/10.3390/ijerph17217769

Pretty, J., Griffin, M., Sellens, M., & Pretty, C. (2003). Green exercise: Complementary roles of nature, exercise and diet in physical and emotional well-being and implications for public health policy. *Essex*: *Centre for Environment and Society University of Essex*.

Razani, N., Morshed, S., Kohn, M. A., Wells, N. M., Thompson, D., Alqassari, M., Agodi, A., & Rutherford, G. W. (2018). Effect of park prescriptions with and without group visits to parks on stress reduction in low-income parents: SHINE randomized trial. *PLoS One*, *13*(2), 0192921. https://doi.org/10.1371/JOURNAL.PONE.0192921

Richardson, M., Richardson, E., Hallam, J., & Ferguson, F. J. (2020). Opening doors to nature: Bringing calm and raising aspirations of vulnerable young people through nature-based intervention. *The Humanistic Psychologist*, *48*(3), 284–297. https://doi.org/10.1037/hum0000148

Roberts, H., McEachan, R., Margary, T., Conner, M., & Kellar, I. (2018). Identifying effective behavior change techniques in built environment interventions to increase use of green space: A systematic review. *Environment and Behavior*, *50*(1), 28–55. https://doi.org/10.1177/0013916516681391

Rogerson, M., Brown, D. K., Sandercock, G., Wooller, J. J., & Barton, J. (2016). A comparison of four typical green exercise environments and prediction of psychological health outcomes. *Perspectives in Public Health*, *136*(3), 171–180. https://doi.org/10.1177/1757913915589845

Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., Hallgren, M., De Leon, A. P., Dunn, A. L., Deslandes, A. C., Fleck, M. P., Carvalho, A. F., & Stubbs, B. (2018). Physical activity and incident depression: A meta-analysis of prospective cohort studies. *American Journal of Psychiatry*, *175*(7), 631–648. https://doi.org/10.1176/appi.ajp.2018.17111194

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, *22*(2), 63–75. https://doi.org/10.3233/EFI-2004-22201

Sianoja, M., Syrek, C., De Bloom, J., Korpela, K., & Kinnunen, U. (2017). Enhancing daily well-being at work through lunchtime park walks and relaxation exercises: Recovery experiences as mediators. *Journal of Occupational Health Psychology*, *23*(3), 428. https://doi.org/10.1037/ocp0000083

Sims-Gould, J., Vazirian, S., Li, N., Remick, R., & Khan, K. (2017). Jump step - a community based participatory approach to physical activity and mental wellness. *BMC Psychiatry*, *17*(1), 1–8. https://doi.org/10.1186/s12888-017-1476-y

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: Problems and opportunities within sport and exercise psychology. *International Review of Sport and Exercise Psychology*, *11*(1), 101–121. https://doi.org/10.1080/1750984X.2017.1317357

Smyth, N., Thorn, L., Wood, C., Hall, D., & Lister, C. (2022). Increased wellbeing following engagement in a group nature-based programme: The green gym programme delivered by the conservation volunteers. *Healthcare*, *10*(6), 978. https://doi.org/10.3390/healthcare10060978

Snowdon, H. (2006). *Evaluation of the Chopwell Wood Health Project*. https://www.forestresearch.gov.uk/research/evaluation-chopwell-wood-health-project/.

Song, C., Ikei, H., Kagawa, T., & Miyazaki, Y. (2019). Effects of walking in a forest on young women. *International Journal of Environmental Research and Public Health*, *16*(2), 229. https://doi.org/10.3390/ijerph16020229

South, E. C., Lee, K., Oyekanmi, K., Buckler, D. G., Jordan, M., Tiako, N., Martin, T., Kornfield, S. L., & Srinivas, S. (2021). Nurtured in nature: A pilot randomized controlled trial to increase time in greenspace among urban-dwelling postpartum women. *Journal of Urban Health*, *98*, 822–831. https://doi.org/10.1007/s11524-021-00544-z

South, J., Guintoli, G., & Kinsella, K. (2012). *An evaluation of the Walking for Wellness project and the befriender role*. https://publications.naturalengland.org.uk/publication/4853061788893184.

Spano, G., D'este, M., Giannico, V., Carrus, G., Elia, M., Lafortezza, R., Panno, A., & Sanesi, G. (2020). Are community gardening and horticultural interventions beneficial for psychosocial well-being? A meta-analysis. *Journal of Environmental Research and Public Health*, *17*(10), 3584. https://doi.org/10.3390/ijerph17103584

Tesler, R., Endevelt, R., & Plaut, P. (2022). Urban forest health intervention program to promote physical activity, healthy eating, self-efficacy and life satisfaction: Impact on Israeli at-risk youth. *Health Promotion International*, *37*(2), 145. https://doi.org/10.1093/heapro/daab145

Thomas, T., Aggar, C., Baker, J., Massey, D., Thomas, M., D'Appio, D., & Brymer, E. (2022). Social prescribing of nature therapy for adults with mental illness living in the community: A scoping review of peer-reviewed international evidence. *Frontiers in Psychology*, *13*, 1041675. https://doi.org/10.3389/fpsyg.2022.1041675

Thompson, J. (2014). *The impact of an 8-week green-exercise programme on systemic health, and on markers associated with cardiovascular disease risk*. Cardiff Metropolitan University.

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science and Technology*, *45*(5), 1761–1772. https://doi.org/10.1021/es102947t

Twohig-Bennett, C., & Jones, A. (2018). The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. *Environmental Research*, *166*, 628–637. https://doi.org/10.1016/j.envres.2018.06.030

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, *15*(3), 398–405. https://doi.org/10.1111/nhs.12048

Van Den Berg, A. E., Van Winsum-Westra, M., De Vries, S., & Me Van Dillen, S. (2010). Allotment gardening and health: A comparative survey among allotment gardeners and their neighbors without an allotment. *Environmental Health*, *9*, 1–12. https://doi.org/10.1186/1476-069X-9-74

Waffenschmidt, S., Knelangen, M., Sieben, W., Bühn, S., & Pieper, D. (2019). Single screening versus conventional double screening for study selection in systematic reviews: A methodological systematic review. *BMC Medical Research Methodology*, *19*, 1–9. https://doi.org/10.1186/s12874-019-0782-0

Warburton, D. E. R., & Bredin, S. S. D. (2017). Health benefits of physical activity. *Current Opinion in Cardiology*, *32*(5), 541–556. https://doi.org/10.1097/HCO.0000000000000437

Ward Thompson, C., Elizalde, A., Cummins, S., Leyland, A. H., Botha, W., Briggs, A., Tilley, S., Oliveira, E. S. d., Roe, J., Aspinall, P., & Mitchell, R. (2019). Enhancing health through access to nature: How effective are interventions in woodlands in deprived urban communities? A quasi-experimental study in Scotland, UK. *Sustainability*, *11*(12), 3317. https://doi.org/10.3390/SU11123317

Whatley, E., Fortune, T., & Williams, A. E. (2015). Enabling occupational participation and social inclusion for people recovering from mental ill-health through community gardening. *Australian Occupational Therapy Journal*, *62*(6), 428–437. https://doi.org/10.1111/1440-1630.12240

White, R. L., Babic, M. J., Parker, P. D., Lubans, D. R., Astell-Burt, T., & Lonsdale, C. (2017). Domain-Specific physical activity and mental health: A meta-analysis. *American Journal of Preventive Medicine*, *52*(3), 653–666. https://doi.org/10.1016/j.amepre.2016.12.008

Wiersma, L. D., & Rubin, D. A. (2012). Development and pilot testing of active kids. *Californian Journal of Health Promotion*, *10*(1), 1–12. https://doi.org/10.32398/CJHP.V10ISI-OBESITY.1465

Wolsko, C., Lindberg, K., & Reese, R. (2019). Nature-based physical recreation leads to psychological well-being: Evidence from five studies. *Ecopsychology*, *11*(4), 222–235. https://doi.org/10.1089/eco.2018.0076

World Health Organization. (2024). *Global levels of physical inactivity in adults: Off track for 2030*. https://books.google.co.uk/books?hl=en&lr=&id=so4REQAAQBAJ&oi=fnd&pg=PA4&ots=PXnu-k-cYC&sig=t5NG8iqDk96UcC0I85KVOmMbgMA&hash;v=onepage&q&f=false.

Wray, A., Martin, G., Ostermeier, E., Medeiros, A., Little, M., Reilly, K., & Gilliland, J. (2020). Physical activity and social connectedness interventions in outdoor spaces among children and youth: A rapid review. *Health Promotion and Chronic Disease Prevention in Canada*, *40*(4), 104. https://doi.org/10.24095/hpcdp.40.4.02

Yen, H. Y., Chiu, H. L., & Huang, H. Y. (2021). Green and blue physical activity for quality of life: A systematic review and meta-analysis of randomized control trials. *Landscape and Urban Planning*, *212*, 104093. https://doi.org/10.1016/j.landurbplan.2021.104093

Zhang, Z. (2019). Outdoor group activity, depression, and subjective well-being among retirees of China: The mediating role of meaning in life. *Journal of Health Psychology*, *24*(9), 1245–1256. https://doi.org/10.1177/1359105317695428