Outdoor Community Ambulation Interventions to Improve Physical and Mental Health in Older Adults: A Systematic Review and Meta-Analysis

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Limited community ambulation, defined as independent mobility outside the home, predicts adverse outcomes in older adults. We performed a systematic review and meta-analysis to examine outdoor community ambulation intervention effectiveness in older adults. We searched six databases until October 2021. Studies with an evaluative research objective, older adult population, and outdoor community ambulation interventions were eligible. After reviewing 23,172 records, five studies were included. The meta-analysis found no significant difference in walking endurance and depression outcomes between outdoor community ambulation and comparison interventions. For outcomes not suitable for meta-analysis, studies showed no significant difference in walking activity, anxiety, and general and health-related quality of life, and possible improvements in gait speed and lower extremity function and strength. Most evidence was of low to very low certainty. Considering the limited evidence base, the design, implementation, and evaluation of outdoor community ambulation interventions in older adults should be prioritized in primary research.

Keywords: outdoor walking, physical activity, green exercise, natural environment, mobility, walking endurance, depression

Globally, the population share of older adults is growing faster than any other age demographic (World Health Organization, 2002). Preventing frailty, disability, and loss of independence are among the top global public health priorities for healthy aging (World Health Organization, 2002). Community ambulation, defined as “independent mobility outside the home, which includes the ability to confidently negotiate uneven terrain, private venues, shopping centers, and other public venues” (Lord et al., 2004), is an important marker of frailty (Portegijs et al., 2016), disability (Jette et al., 1998), loss of independence (World Health Organization, 2002), social isolation and poor mental health (Herbolsheimer et al., 2017), as well as reduced health-related quality of life (Fujita et al., 2006; Sirois et al., 2013). Since nearly half of older adults report infrequent outdoor walking (Statistics Canada, 2009), improving community ambulation presents a key opportunity for averting these downstream outcomes and enabling healthy aging.

Challenges with community ambulation among older adults arise from the interaction between individual-level factors (e.g., gait, balance, leg strength, fear or anxiety, and self-efficacy) and environmental factors (e.g., transportation, distance to destination, physical barriers, physical or attentional load, and neighborhood walkability) (Duvall & De Young, 2013; Kassavou et al., 2015; Lord et al., 2010; World Health Organization, 2001). According to the theoretical framework by Patla and Shumway-Cook, walking interventions that target both individual and environmental factors through the eight dimensions of community ambulation, including ability to manage distances, temporal characteristics, ambient conditions, terrain, physical load, attentional demands, postural transitions, and density (i.e., the number of people and objects in the immediate surroundings) (Patla & Shumway-Cook, 1999; Shumway-Cook et al., 2003; World Health Organization, 2001), may be more effective at improving community ambulation in older adults than simply walking over level ground or performing impairment-focused exercises (Brach & VanSwearingen, 2013; Giannouli et al., 2016; van Lummel et al., 2015). In addition, practicing walking in natural outdoor environments has been associated with greater improvements in mental health and well-being than indoor practice (Brach & VanSwearingen, 2013; Thompson Coon et al., 2011).

Although a number of systematic reviews and meta-analyses have evaluated the effectiveness of interventions aimed at increasing walking and physical activity in mixed populations (Fritschi et al., 2012; Kassavou et al., 2015; Ogilvie et al., 2007), it remains unclear (a) whether outdoor walking interventions have incorporated the eight dimensions of community ambulation (hereby referred to as “community ambulation interventions”) and (b) whether such interventions have been effective at improving...
outcomes relevant to older adults, including balance, mobility, strength, mental health, self-efficacy, and health-related quality of life. To address this need, we conducted a systematic review and meta-analysis to identify, characterize, and synthesize the impacts of outdoor community ambulation interventions in older adults.

Methods

We followed the Cochrane Collaboration Handbook for Systematic Reviews of Interventions (the “Cochrane Handbook”) while conducting the review and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses reporting guidelines (Liberati et al., 2009; Moher et al., 2009) (see Supplementary Material 1 [available online]). We also used a prospectively registered protocol to guide the review process (Moher et al., 2016; Shamseer et al., 2015; PROSPERO registration ID: CRD42017078339).

Information Sources and Search Strategy

We searched six multidisciplinary academic bibliographic databases, including MEDLINE (Ovid), EMBASE (Ovid), CINAHL (EBSCO), SPORTDiscus (EBSCO), AgeLine (EBSCO), and the Cochrane Library from inception to October 2021, using terms related to the concepts of outdoor walking and older adults. The search strategies were drafted by an experienced academic research librarian with expertise in rehabilitation sciences, with input from senior authors, who are academic scientists with training in physical therapy and rehabilitation. A second librarian peer-reviewed the search strategy using the Peer Review of Electronic Search Strategies checklist (Sampson et al., 2009). The search strategy was finalized in MEDLINE and then translated to the other databases using each platform’s command language, controlled vocabulary, and appropriate search fields. A validated trials filter consisting of Medical Subject Headings, EMBASE subject headings (EMTREE), and textwords was added to the MEDLINE and EMBASE search strategies (Fraser et al., 1998; Grimshaw et al., 2007). The searches were not restricted by language, participant age, and publication status, date, or type (see Supplementary Material 2 [available online]). The final searches were exported by the second librarian, who removed duplicates using the Bramer algorithm, validated for use with EndNote citation management software (version X7; Thompson Reuters, Los Angeles, CA; Bramer et al., 2016). To ensure literature saturation, searches were supplemented by free searches on Google and hand searching of reference lists of relevant literature reviews (Barclay et al., 2015; Saitta et al., 2019).

Study Selection Process

Following the removal of duplicates, titles were screened by the lead author. The abstracts of a random sample of the excluded titles (5%) were checked to ascertain the quality of the title screening process. Records that passed title screening were imported into a web-based systematic review management software, Covidence (www.covidence.org), to remove any residual duplicates and facilitate the next steps in the selection process. Prior to commencing screening, all reviewers were trained on the review protocol and the eligibility criteria by the lead and senior authors. Training involved reviewing the same subset of abstracts and full-text articles and discussing selection decisions. All abstracts and full-text articles of the included citations were then reviewed in duplicate by a pair of independent reviewers, with the lead author reviewing all abstracts and full-text articles. Researchers disagreed on the include/exclude status of 8% of full-text articles screened. Disagreements on study eligibility were discussed with the review team, reasons for disagreement were explored, and final decisions on study eligibility were made by consensus of the lead and senior authors. Upon review completion, the log of the excluded full-text articles was checked by the lead author to ensure that studies were not excluded inappropriately. Corresponding authors of potentially relevant studies were also contacted to clarify study eligibility (e.g., the presence and type of second mobility task, whether all intervention activities occurred outdoors, availability of data on an older adult subgroup).

Eligibility Criteria

Study eligibility was defined using the population, intervention, comparison, outcome, study design, and temporality criteria, described in detail next.

Types of Participants

Studies were eligible if they considered community-dwelling older adults (aged ≥65 years) as the target population or as an identified subgroup.

Types of Interventions and Comparison Groups

We included interventions that took place in outdoor settings, defined as settings within built or natural environments, outside of buildings. We defined community ambulation interventions as those that involved multisection practice of over-ground walking with at least one other mobility task related to the eight dimensions of community ambulation specified by Patla and Shumway-Cook (Patla & Shumway-Cook, 1999; Shumway-Cook et al., 2003; World Health Organization, 2001); such tasks may include shifting or changing the position of the body, transferring from one surface to another, walking on uneven terrains (e.g., hills, ramps, obstacle courses, or sets of stairs), walking progressively increasing distances, as well as practicing functional strength or balance exercises. We did not exclude interventions that involved walking with assistive devices, such as walking poles (e.g., Nordic Walking) or walkers. We also did not exclude complex interventions where community ambulation may have been one of several components (e.g., behavior change counseling, use of technology). We considered supervised and unsupervised individual and group-based interventions. Studies were not required to have a control group.

Types of Outcome Measures and Temporality

We did not specify selection criteria for an identified set of outcomes and rather, considered any outcomes related to physical or mental health evaluated using quantitative methods. We were particularly interested in outdoor walking activity, which could be measured in terms of outdoor walking frequency, duration, distance traveled, or the number of steps taken (e.g., collected through self-report, accelerometer, or global positioning system data). Additional outcomes could include participant changes in balance, strength, endurance, depressive symptoms, social participation, and health-related quality of life. We did not impose any temporality criteria and considered both immediate and longitudinal or sustained effects.

Types of Study Designs

We considered all impact evaluations using quantitative or mixed methods, including randomized, nonrandomized, and noncontrolled (single group) designs. As such, studies that did not evaluate
the impact of a community ambulation intervention on outcomes or that reported only baseline or qualitative results were excluded.

**Types of Publications**

We considered studies written in English and other languages for which translation options were available (i.e., French, Spanish, and Italian). We excluded case studies and case series, letters to the editor, literature reviews, conference abstracts, research protocols, dissertation theses, and other nonoriginal, unpublished, or non-peer-reviewed works. To ensure comprehensiveness and currency of the literature, we looked for completed peer-reviewed publications related to any retrieved conference abstracts, letters to the editor, protocols, and dissertations.

**Risk of Bias Assessment**

The included studies were critically appraised for risk of bias using the Cochrane Collaboration Risk of Bias tool for randomized and nonrandomized studies (Jørgensen et al., 2016) by two independent reviewers in duplicate. This tool rates the risk of bias of each included study as “low,” “unclear,” or “high” using the following domains: random sequence allocation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other sources of bias. Disagreements were resolved by the lead and senior authors. Based on the risk of bias appraisal results, the lead author assessed the overall strength and certainty of the evidence for each outcome using the GRADE system (Guyatt et al., 2008; Schünemann et al., 2013). The risk of publication bias could not be assessed using graphical or quantitative methods, as <10 articles were included in the review (Page et al., 2021).

**Data Collection**

Data were extracted from the included articles by two independent reviewers in duplicate and cross-checked by the lead author. The data extraction form was developed in Microsoft Excel and piloted on one article by the lead author and the two independent reviewers to standardize the data collection process. Data items of interest included overall study sample size; number of participants in each intervention and control group; study design, location, and setting; distributions of participant characteristics; features of the intervention of interest and the comparison intervention (if applicable); outcome definitions and measurement; and effect size estimates for each outcome reported.

**Statistical Analysis**

We performed meta-analyses for outcomes where at least three unique effect size estimates were available from the included studies and where the means and SDs of intervention effects could be obtained (from the publications or corresponding authors) or estimated (Deeks et al., 2021). As we anticipated heterogeneity related to study methodological, population, and intervention characteristics, we selected the random-effects inverse-variance approach (Deeks et al., 2021). The random-effects approach assumes that there is a distribution of intervention effects, rather than a single “true” effect, and therefore provides a more conservative estimate that represents the average intervention effect (Deeks et al., 2021). The inverse-variance method weights individual study effect estimates according to their precision level (Deeks et al., 2021).

Continuous outcomes that used similar measures were combined using mean differences (MD) and 95% confidence intervals (CIs). Where different measures were used to define a similar outcome construct, standardized mean differences were used to estimate the pooled effect size. If studies provided SE, SDs were calculated using a standard formula \( SD = SE \times \sqrt{N} \) (Higgins et al., 2021).

Statistical heterogeneity was quantified using the \( I^2 \) statistic, which describes the percentage of heterogeneity that is attributable to between-studies variation, rather than chance (Deeks et al., 2021). We planned to explore heterogeneity using subgroup analyses across methodological, population, and intervention features; however, these analyses could not be conducted because at least three effect size estimates were not available for each subgroup (Deeks et al., 2021). One study provided effect size estimates for intention-to-treat and per-protocol analyses (including only adherent participants) (Arbillaga-Etxarri et al., 2018). For the primary analysis, we selected outcome values from intention-to-treat analyses, and we explored the influence of alternative outcome values in a sensitivity analysis (Deeks et al., 2021; Higgins et al., 2021).

Meta-analysis was conducted using Cochrane Review Manager (RevMan) software (version 5.4; Copenhagen, Denmark).

Intervention effects for outcomes that could not be pooled in meta-analyses were converted into summary statistics of similar format (MD and 95% CI) for presentation purposes and described narratively. In one randomized controlled trial (RCT), both the intervention (physical and cognitive training [PTCT]) and the comparison group (physical training [PT]) met the definition of an outdoor community ambulation intervention in our review (Siplá et al., 2021). As we were interested in understanding the specific effects of community ambulation on outcomes, we only considered the before-and-after estimates for each of the PTCT and the PT groups in the narrative synthesis, rather than between-group differences (which would reflect changes attributable to the addition of cognitive training). Notably, there were no significant between-group differences reported in this study, suggesting that the effects of PTCT and PT alone on outcomes were comparable. The exclusion of the before-and-after estimates of this study from the meta-analysis also substantially reduced statistical heterogeneity, which further supports the decision to present this study narratively. Another parallel-group study had three arms—forest walking, Qigong exercise program, and no intervention (Yi et al., 2021). However, as direct comparisons between the forest walking program and the Qigong program were not reported, we only considered the comparison between the forest walking program (which met the definition of an outdoor community ambulation intervention) and the “no intervention” comparison group.

**Results**

The electronic database search yielded 23,172 citations, with another 11 added through hand searching. Following the removal of duplicates and exclusions at each stage, 15,676 titles, 2,734 abstracts, and 847 full-text articles were reviewed. Five studies met all the prespecified eligibility criteria and were included in the systematic review (Figure 1). Studies were most commonly excluded because their objective was unrelated to evaluating the impact of the intervention (n = 130); interventions did not take place outdoors (n = 192), meet the definition of a community ambulation intervention (with a second mobility task) (n = 147), or involve walking practice (n = 91); publication type was ineligible (n = 104); and interventions were not implemented in an older adult population (n = 72). We provide a brief overview of 10 exemplary excluded studies in Supplementary Material 3 (available online). These studies were published prior to 2018, and each met all but one of the selection criteria.
Figure 1 — Preferred Reporting Items for Systematic reviews and Meta-Analyses flow diagram depicting study searching and selection processes.
### Table 1  Characteristics of the Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Study design</th>
<th>Population</th>
<th>Intervention</th>
<th>Control group</th>
<th>Attrition rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbillaga-Etxarri et al. (2018)</td>
<td>Spain</td>
<td>Parallel-group RCT</td>
<td>COPD patients ≥45 years (mean age: 69 years) (n = 407)</td>
<td><em>Urban training (NCT01897298)</em> Participants received motivational interviewing and maps of outdoor walking trails of validated intensity levels (low, moderate, and high); intensity elements included stairs, ramps, and varied terrain on boulevards, beaches, and parks. Participants were instructed to walk unsupervised ≥1 trail/day for ≥5 days/week for 12 months, increasing walking intensity levels. Trainer-supervised group walks were offered once per month. (n = 202)</td>
<td>Usual care General health counseling and the European Lung Foundation physical activity guidelines brochure (recommending ≥30 min moderate physical activity ≥5 days per week). Both the intervention and the control group received usual pharmacological and nonpharmacological treatment for COPD (including pulmonary rehabilitation). (n = 205)</td>
<td>32% intervention 27% control</td>
</tr>
<tr>
<td>Barclay et al. (2018)</td>
<td>Canada</td>
<td>Parallel-group RCT (pilot and feasibility study)</td>
<td>Community-dwelling older adults with self-reported limited outdoor walking aged ≥65 years (mean age: 76 years) (n = 9)</td>
<td><em>Getting older adults outdoors (GO-OUT) (NCT03292510)</em> Participants first received a 5-hr workshop (see control group). Participants then walked supervised in groups in city parks and practiced walking tasks designed to improve community ambulation (e.g., walking over curbs, slopes, and uneven surfaces, while carrying objects, and with distractions). Task difficulty was increased over time. Balance and functional strengthening exercises were performed during the warm-up and planned walks. Intervention components were informed by the Patla and Shumway-Cook community ambulation theoretical framework. Sessions lasted 60 min, with 2 sessions/week, over 9 weeks (May–July). (n = 6)</td>
<td>Educational workshop Participants received a 5-hr workshop with didactic and applied instruction on physical activity for older adults and safe outdoor walking. (n = 3)</td>
<td>0% intervention 0% control</td>
</tr>
<tr>
<td>Sipilä et al. (2021)</td>
<td>Finland</td>
<td>Parallel-group RCT°</td>
<td>Community-dwelling sedentary 70- to 85-year-olds (mean age: 74 years) (n = 314)</td>
<td><em>Promoting safe walking among older people (PASS-WORD): Physical and cognitive training intervention among older community-dwelling sedentary men and women (ISRCTN52388040)</em> The physical training intervention started with a 1-hr motivational lecture on physical activity. The physical training intervention involved supervised group outdoor walking on a 400-m circular walking lane (in the wintertime, walking occurred on an indoor 200-m oval track). Dynamic balance exercises of increasing difficulty were performed while walking. The PT group received physical training alone, while the PTCT group received physical training and a cognitive computer-based task. Sessions lasted 45 min, once per week, over 12 months. On another day in the week, participants performed resistance exercises in indoor senior gyms. Participants were also recommended a home-based training regimen to perform 2–3 times/week. (PTCT: n = 155, PT: n = 159)</td>
<td>No relevant comparison group that did not involve outdoor community ambulation°</td>
<td>8% PTCT 7% PT</td>
</tr>
</tbody>
</table>

(Ahead of Print)
<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
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</tr>
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</table>
| Temprado et al. (2019)       | France        | Parallel-group trial with semirandom allocation  | Community-dwelling sedentary or moderately active 65- to 85-year-olds (mean age: 71 years) (n = 41)                                               | Nordic walking  
Participants walked with poles under supervision in groups in a natural park. In the first 2 weeks, participants walked on flat trails to learn basic techniques. Participants then walked uphill and downhill on other park trails.  
Sessions lasted 60 min, with 3 sessions/week, over 12 weeks (total of 36 sessions). Session intensity was increased after the first weeks of adaptation.  
(n = 20)                                                                 | Multicomponent circuit training  
Supervised indoor gym-based circuit exercise, involving 10–11 stations performed in a prescribed order and a fixed work-to-rest ratio. Stations focused on muscular resistance for arms and legs, dynamic balance, eye-hand coordination, multi-limb coordination, spatial orientation, reactivity, stepping, and whole-body coordination.  
Sessions lasted 60 min, with 3 sessions/week, over 12 weeks (total of 36 sessions).  
(n = 21)                                                                 | 0% intervention  
10% control |
| Yi et al. (2021)              | South Korea   | Parallel-group nonrandomized trial               | Community-dwelling older adults aged ≥65 years not diagnosed with dementia (mean age: 77 years) (n = 49)                                          | Forest walking  
Supervised group sessions involving band gymnastics (20 min), physio-cognitive play (clapping and line dance, 30 min), and active walking on varied terrain in an urban forest (50 min).  
Sessions lasted 120 min, and there were 2 sessions/week, over 6 weeks (total of 12 sessions). Session difficulty was increased every three sessions.  
(n = 18)                                                                 | No intervention  
The participants in the control group received no intervention or treatment related to activities in the forest.  
(n = 31)                                                                 | 0% intervention  
16% control |

Note: Sample sizes represent the number of individuals allocated to each intervention group. Attrition rate represents the proportion of individuals that did not present for postintervention assessments (i.e., lost to follow-up). COPD = chronic obstructive pulmonary disease; PT = physical training; RCT = randomized controlled trial; PTCT = physical and cognitive training.

aSipilä et al. (2021) conducted a parallel-group RCT that compared a physical and cognitive training (PTCT) and a physical training (PT) program. To ensure that the effect estimates obtained from this study reflected changes attributable to community ambulation, only before-and-after estimates were considered for each of the PTCT and PT groups, rather than between-group differences (which would reflect changes attributable to the addition of cognitive training). bYi et al. (2021) has another intervention group that did not involve walking (Qigong exercise program); however, direct comparisons between the forest walking program and the Qigong program were not made. We only consider the forest walking program and the “no intervention” comparison group in this review.
Characteristics of the Included Studies

The detailed study methodological, population, and intervention characteristics are presented in Table 1. The studies were published between 2018 and 2021 and were conducted in Canada (Barclay et al., 2018), Finland (Sipilä et al., 2021), France (Temprado et al., 2019), South Korea (Yi et al., 2021), and Spain (Arbillaga-Etxarri et al., 2018). Three studies used a parallel-group RCT design (Arbillaga-Etxarri et al., 2018; Barclay et al., 2018; Sipilä et al., 2021), though as described previously, we did not consider between-group differences for one RCT (Sipilä et al., 2021).

The five included studies analyzed a total of 820 older adults (sample size range: 9–407 individuals) with 560 in the outdoor community ambulation group and 260 in the control group. One study focused on people with chronic obstructive pulmonary disease (Arbillaga-Etxarri et al., 2018), two studies focused on sedentary older adults (Sipilä et al., 2021; Temprado et al., 2019), one study focused on older adults with self-reported limited outdoor walking (Barclay et al., 2018), and one study focused on a general population of community-dwelling older adults without a dementia diagnosis (Yi et al., 2021). The mean participant age ranged from 69 to 77 years across study samples.

Intervention settings included an outdoor circular walking lane (Sipilä et al., 2021), a forest accessible to urban residents (Yi et al., 2021), city parks (Arbillaga-Etxarri et al., 2018; Barclay et al., 2018; Temprado et al., 2019), and other urban environments (e.g., boulevards, beaches) (Arbillaga-Etxarri et al., 2018). In addition to walking, other outdoor mobility tasks included navigating stairs, ramps, hills, and other surfaces (Arbillaga-Etxarri et al., 2018; Barclay et al., 2018; Temprado et al., 2019; Yi et al., 2021) and performing functional balance and strengthening exercises (Barclay et al., 2018; Sipilä et al., 2021; Yi et al., 2021). One intervention was individualized and unsupervised, with an optional once per month supervised outdoor walking group (Arbillaga-Etxarri et al., 2018), while the remaining interventions were all supervised by a trainer and practiced in groups (Barclay et al., 2018; Sipilä et al., 2021; Temprado et al., 2019; Yi et al., 2021). All comparison interventions did not involve walking and included a brochure on general health and physical activity recommendations (Arbillaga-Etxarri et al., 2018), no intervention (Yi et al., 2021), an educational workshop (Barclay et al., 2018), and multicomponent circuit training (Temprado et al., 2019). Interventions were delivered over 1–5 sessions per week (45 min–2 hr per session) for a period of 6–52 weeks. In all studies, outcomes were measured at baseline and at 0–3 weeks following intervention completion.

Assessment of the Risk of Bias

The results of the risk of bias assessment for each study are summarized in Figures 2 and 3. Two studies were rated as having
an overall moderate risk of bias (Temprado et al., 2019; Yi et al., 2021), and three studies were rated as having an overall low risk of bias (Arbillaga-Etxarri et al., 2018; Barclay et al., 2018; Sipilä et al., 2021). Random allocation was not apparent in two parallel-group designs (Temprado et al., 2019; Yi et al., 2021). Concealment of intervention group assignment from study participants was not possible in all but one study, which did not reveal the study objective and the existence of other intervention arms to the participants (Arbillaga-Etxarri et al., 2018). Loss to follow-up was estimated to be over 30% in one study, suggesting the possibility of attrition bias (Arbillaga-Etxarri et al., 2018). A published protocol was not available for two studies (Temprado et al., 2019; Yi et al., 2021); as such, the risk of selective reporting could not be inferred. One study did not report falls incidence results, though this measure was listed as a secondary outcome in the published protocol (Sipilä et al., 2021).

**Meta-Analysis of Intervention Effects**

**Walking Endurance**

Three studies were pooled to estimate the effect of outdoor community ambulation interventions on walking endurance, measured using the 6-min walk test (6MWT) (Arbillaga-Etxarri et al., 2018; Barclay et al., 2018; Temprado et al., 2019). There was no significant difference between the effects of outdoor community ambulation and comparison interventions on 6MWT performance, with a pooled MD of −0.61 m (95% CI [−22.48, 21.27], I² = 0%, very low certainty evidence; Figure 4). This finding remained robust with low heterogeneity in a sensitivity analysis, which considered the per-protocol measurement for the Arbillaga-Etxarri et al. (2018) study (MD: 9.55, 95% CI [−13.53, 32.63], I² = 0%, very low certainty evidence). Certainty of the evidence was downgraded due to methodological limitations of the included studies (nonrandom allocation, lack of blinding of participants, and possible attrition bias in one study each), and imprecision in the pooled effect size (wide CI, small sample size in two studies, lack of power to detect between-group differences in one study). Sipilä et al. (2021), which was not pooled in the meta-analysis, observed significant increases in 6MWT performance within each of the PTCT and PT groups from baseline to postintervention (PTCT: 33.30 [95% CI: 24.60, 42.00]; PT: 37.10 [95% CI: 27.20, 46.90]).

**Depression Scores**

Three studies reported the effect of outdoor community ambulation interventions on self-reported depression scores, measured using the Geriatric Depression Scale (Barclay et al., 2018; Yi et al., 2021) and the Hospital Anxiety and Depression scale (Arbillaga-Etxarri et al., 2018). There was no significant difference between the effects of outdoor community ambulation and comparison interventions on depression scores, with low heterogeneity (standardized mean differences: −0.13, 95% CI [−0.46, 0.20], I² = 18%, very low certainty evidence; Figure 5). There was a modest but statistically significant improvement in depression scores in the intervention group, relative to the control group, when the per-protocol measurement was considered for the Arbillaga-Etxarri et al. (2018) study in a sensitivity analysis (standardized mean differences: −0.36, 95% CI [−0.61, −0.12]; I² = 0%, very low certainty evidence). Certainty of the evidence was downgraded due to methodological limitations of the included studies (nonrandom allocation, lack of blinding of participants, possible attrition bias in one study each) and imprecision in the pooled effect size (wide CI, small sample sizes in two studies, lack of power to detect between-group differences in one study).

**Narrative Synthesis of Intervention Effects**

Table 2 presents the effects of outdoor community ambulation interventions on outcomes for which meta-analysis was not suitable. Most outcome estimates were of low to very low certainty. Sipilä et al. (2021) observed statistically significant increases in gait speed, lower extremity function, and strength (as measured by leg extension power, knee extension force, and grip force) from baseline to postintervention within both the PTCT and PT groups.
<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>No. of studies</th>
<th>Study</th>
<th>Follow-up(a) (weeks)</th>
<th>No. of intervention/control(b)</th>
<th>Mean difference [95% CI](c)</th>
<th>Certainty(d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steps per day (accelerometer)</td>
<td>2</td>
<td>Arbillaga-Etxarri et al. (2018)</td>
<td>52</td>
<td>132/148</td>
<td>−24 [−741, 693]</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barclay et al. (2018)</td>
<td>12</td>
<td>6/3</td>
<td>−3,813 [−7,038, −589]</td>
<td></td>
</tr>
<tr>
<td>Gait speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-m WT (m/s)</td>
<td>2</td>
<td>Sipilä et al. (2021): PTCT</td>
<td>52</td>
<td>141/−</td>
<td>0.1 [0.0, 0.1](\d)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sipilä et al. (2021): PT</td>
<td>52</td>
<td>144/−</td>
<td>0.1 [0.0, 0.1](\d)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Barclay et al. (2018)</td>
<td>12</td>
<td>6/3</td>
<td>0.1 [−0.3, 0.5]</td>
<td></td>
</tr>
<tr>
<td>Lower-extremity function</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SPPB</td>
<td>1</td>
<td>Sipilä et al. (2021): PTCT</td>
<td>52</td>
<td>141/−</td>
<td>0.6 [0.4, 0.8](\d)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sipilä et al. (2021): PT</td>
<td>52</td>
<td>146/−</td>
<td>0.7 [0.5, 0.9](\d)</td>
<td>Low</td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-leg stance (s)</td>
<td>1</td>
<td>Temprado et al. (2019)</td>
<td>12–14</td>
<td>20/19</td>
<td>−16.4 [−16.6, −16.2](\d)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TUG (s)</td>
<td>12–14</td>
<td>20/19</td>
<td>0.3 [−2.9, 3.5]</td>
<td>Low</td>
</tr>
<tr>
<td>FSST (no. of reps)</td>
<td>1</td>
<td>Temprado et al. (2019)</td>
<td>12–14</td>
<td>20/19</td>
<td>−0.8 [−1.5, −0.1]</td>
<td>Low</td>
</tr>
<tr>
<td>Berg Balance Scale</td>
<td>1</td>
<td>Barclay et al. (2018)</td>
<td>12</td>
<td>6/3</td>
<td>−2.5 [−2.7, −2.3]</td>
<td>Very low</td>
</tr>
<tr>
<td>Strength</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg extension power (W)</td>
<td>1</td>
<td>Sipilä et al. (2021): PTCT</td>
<td>52</td>
<td>123/−</td>
<td>18.9 [14.8, 23.1](\d)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sipilä et al. (2021): PT</td>
<td>52</td>
<td>132/−</td>
<td>24.5 [20.6, 28.3](\d)</td>
<td>Low</td>
</tr>
<tr>
<td>Knee extension force (N)</td>
<td></td>
<td>Sipilä et al. (2021): PTCT</td>
<td>52</td>
<td>130/−</td>
<td>38.7 [31.5, 46.0](\d)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sipilä et al. (2021): PT</td>
<td>52</td>
<td>140/−</td>
<td>44.2 [36.0, 52.3](\d)</td>
<td>Low</td>
</tr>
<tr>
<td>Grip force (N)</td>
<td>1</td>
<td>Sipilä et al. (2021): PTCT</td>
<td>52</td>
<td>138/−</td>
<td>17.9 [10.3, 25.5](\d)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sipilä et al. (2021): PT</td>
<td>52</td>
<td>146/−</td>
<td>9.1 [1.4, 16.9](\d)</td>
<td>Low</td>
</tr>
<tr>
<td>Hand grip strength (kg)</td>
<td>1</td>
<td>Temprado et al. (2019)</td>
<td>12–14</td>
<td>20/19</td>
<td>−1.4 [−2.1, −0.7]</td>
<td>Low</td>
</tr>
<tr>
<td>30-s arm curl test (no. of reps)</td>
<td>1</td>
<td>Temprado et al. (2019)</td>
<td>12–14</td>
<td>20/19</td>
<td>−0.2 [−0.9, 0.5]</td>
<td>Low</td>
</tr>
<tr>
<td>30-s chair stand test (no. reps)</td>
<td>2</td>
<td>Temprado et al. (2019)</td>
<td>12–14</td>
<td>20/19</td>
<td>3.3 [2.5, 4.1](\d)</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barclay et al. (2018)</td>
<td>12</td>
<td>6/3</td>
<td>0.2 [0.1, 0.3]</td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAD (self-report)</td>
<td>1</td>
<td>Arbillaga-Etxarri et al. (2018)</td>
<td>52</td>
<td>132/148</td>
<td>0.2 [−0.4, 0.9]</td>
<td>Moderate</td>
</tr>
<tr>
<td>Self-confidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASCQ (self-report)</td>
<td>1</td>
<td>Barclay et al. (2018)</td>
<td>12</td>
<td>6/3</td>
<td>1.5 [0.8, 2.2]</td>
<td>Very low</td>
</tr>
<tr>
<td>Social participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHAMPS participation (hr/week)</td>
<td>1</td>
<td>Barclay et al. (2018)</td>
<td>12</td>
<td>6/3</td>
<td>−2.6 [−3.2, −2.0]</td>
<td>Very low</td>
</tr>
<tr>
<td>Quality of life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQ-5D (self-report)</td>
<td>1</td>
<td>Yi et al. (2021)</td>
<td>6</td>
<td>15/23</td>
<td>0.04 [−0.1, 0.1]</td>
<td>Low</td>
</tr>
</tbody>
</table>

(continued)
Another study found that compared with indoor circuit-based training, outdoor Nordic Walking was associated with lower extremity function, and strength were observed in two studies, with respect to walking endurance, depression scores, and other outcomes that could not be pooled in a meta-analysis (Arbillaga-Etxarri et al., 2018; Yi et al., 2021) and the interventions included activities of the largest study (weighted at over 70% in the meta-analysis) led two trials involving the practice of walking and another intervention consisting of indoor walking on cobblestone mats (Li et al., 2015) and the other of indoor walking over firm or unstable surfaces (Kovacs & Williams, 2004). A 2015 Cochrane systematic review and meta-analysis included five randomized trials aimed at improving community ambulation in stroke survivors (Barclay et al., 2015). The populations of interest were predominantly younger (Lord et al., 2008; Park et al., 2011) and the interventions included activities not specific to outdoor walking practice, such as provision of information to increase walking confidence (Logan et al., 2004), treadmill training in virtual reality environments (Yung et al., 2008), and script-guided imagery practice of walking tasks (Dickstein et al., 2008; Park et al., 2011).

Table 2 (continued)

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>No. of studies</th>
<th>Study</th>
<th>Follow-upa (weeks)</th>
<th>No. of intervention/controlb</th>
<th>Mean difference [95% CI]c</th>
<th>Certaintyd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health-related quality of life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT (self-report)</td>
<td>1</td>
<td>Arbillaga-Etxarri et al. (2018)</td>
<td>52</td>
<td>132/148</td>
<td>0.1 [−1.1, 1.2]</td>
<td>Moderate</td>
</tr>
<tr>
<td>CCQ (self-report)</td>
<td>1</td>
<td>Arbillaga-Etxarri et al. (2018)</td>
<td>52</td>
<td>132/148</td>
<td>−0.1 [−0.3, 0.1]</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Note. ASCQ = Ambulatory Self-Confidence Questionnaire; CAT = COPD Assessment Test; CCQ = Clinical COPD Questionnaire; CHAMPS = Community Health Activities Model Program for Seniors; CI = confidence interval; COPD = chronic obstructive pulmonary disease; FSST = Four Square Step Test; GDS = Geriatric Depression Scale; HAD = Hospital Anxiety and Depression Scale; PT = physical training group; PTCT = physical and cognitive training group; SPPB = Short Physical Performance Battery; 10-m WT = 10-m walk test; TUG = Timed Up-and-Go.

aTime of postintervention outcome measurement, counting from baseline. bSample sizes reflect the number of individuals included in the analysis of each outcome. cMean differences reflect pre-post change scores in intervention relative to the control group, except Sipilä et al. (2021), which reflects within-group changes from baseline only. dGRADE Working Group certainty of the evidence grades: high (we are very confident that the true effect lies close to that of the estimate of the effect); moderate (we are moderately confident in the effect estimate; the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different); low (our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect); and very low (we have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of the effect).

Significant at p < .05 (as reported in the original publication).

Discussion

In this systematic review and meta-analysis of five studies, we synthesized the effects of outdoor community ambulation interventions in older adults. Meta-analysis could only be performed for the outcomes of 6MWT (three studies) and depression scores (three studies). We found no significant differences between the outdoor community ambulation and comparison interventions with respect to walking activity, anxiety, and general and health-related quality of life (Arbillaga-Etxarri et al., 2018; Yi et al., 2021). One pilot study was not sufficiently powered to assess intervention effectiveness with regard to walking activity, balance, strength, ambulatory self-confidence, social participation, or health-related quality of life. However, preliminary results suggest that the outdoor community ambulation intervention was feasible, safe, and acceptable, meriting evaluation of effectiveness in a larger trial (Barclay et al., 2018).

The evidence for most outcomes was graded as low or very low due to methodological limitations and imprecision in the effect estimates of the included studies.

A statistically significant association between outdoor community ambulation interventions and reduction in depression scores, relative to control, was observed in a sensitivity analysis. This finding is likely owed to the substitution of intention-to-treat analysis estimates of the largest study (weighted at over 70% in the meta-analysis) to the per-protocol analysis estimates (focusing on individuals that self-reported either intent to adhere to intervention procedures at baseline or recalled adhering to intervention procedures at follow-up) (Arbillaga-Etxarri et al., 2018). However, since adherence was not quantified in this study (e.g., in terms of the number and duration of outdoor walking sessions) and was not considered by the other included studies, a robust conclusion about the effect of outdoor community ambulation interventions on depression scores in older adults cannot be made. An average standardized reduction of 0.36 (95% CI [−0.61, −0.12]) in depression scores postintervention may also not constitute a clinically meaningful difference (Masson & Tejani, 2013; Puhan et al., 2008; Smid et al., 2017).

Overall, considering the inability to combine data for most outcomes due to a low number of included studies, the low certainty of the evidence of effect, the lack of long-term postintervention follow-up, and the fact that all the included studies were published after 2018 suggests that the evidence base on outdoor community ambulation interventions is immature. For instance, a 2013 review profiled two trials involving the practice of walking and another mobility task in older adults (Ross et al., 2013). However, both interventions were set in controlled indoor conditions, with one intervention consisting of indoor walking on cobblestone mats (Li et al., 2005) and the other of indoor walking over firm or unstable surfaces (Kovacs & Williams, 2004). A 2015 Cochrane systematic review and meta-analysis included five randomized trials aimed at improving community ambulation in stroke survivors (Barclay et al., 2015). The populations of interest were predominantly younger (Lord et al., 2008; Park et al., 2011) and the interventions included activities not specific to outdoor walking practice, such as provision of information to increase walking confidence (Logan et al., 2004), treadmill training in virtual reality environments (Yung et al., 2008), and script-guided imagery practice of walking tasks (Dickstein et al., 2008; Park et al., 2011).
Finally, a recent mixed-methods systematic review of park-based physical activity interventions for persons with disabilities described five quantitative evaluations (Saitta et al., 2019); however, none of the populations included older adults, and only one of the interventions employed a walking component (Grazuleviciene et al., 2016).

Older adults may find the enjoyment and social nature of physical activity more motivating for sustained engagement than the possibility of improved health outcomes (Nielsen et al., 2014; Prins et al., 2016). Outdoor physical activity may be more effective at achieving these aims than physical activity in indoor settings (Prins et al., 2016; Thompson Coon et al., 2011). There has been considerable interest in the recent literature in developing outdoor urban environments that are conducive to physical activity among older adults, including, for example, designing accessible and scenic walking routes (Prins et al., 2016, 2019), and installing exercise equipment within urban parks (Levinger et al., 2018, 2019, 2020; Sales et al., 2015, 2017). Our review highlights a need for high-quality primary evidence on the immediate and long-term effectiveness of outdoor interventions that focus on developing the skillset necessary for older adults to effectively manage outdoor environments (including distances, temporal characteristics, ambient conditions, terrain, physical load, attentional demands, postural transitions, and density; Patla & Shumway-Cook, 1999; Shumway-Cook et al., 2003; World Health Organization, 2001). Upon completion of such evaluations, the present review should be updated to synthesize best practices.

**Strengths and Limitations**

A strength of our study included employing a comprehensive peer-reviewed search strategy of multiple scholarly databases, not limited by study design, publication status, language, or publication year, as well as the use of a prospectively registered protocol to guide the review process. Several limitations should also be acknowledged. First, some studies were excluded because they were conducted in mixed-age populations, but did not report subgroup analyses. As such, the evidence base may not be lacking the interventions of interest, but rather, their evaluations in older age subgroups. Nonetheless, older adults comprise a unique demographic with unique mobility limitations that would merit targeted intervention efforts. Second, in addition to community ambulation, some of the included studies provided pedometers (Arbillaga-Etxarri et al., 2018; Barclay et al., 2018); resistance training (Sipilä et al., 2021; Yi et al., 2021); gym- and home-based training (Sipilä et al., 2021); and motivational interviewing, education, and health promotion (Arbillaga-Etxarri et al., 2018; Barclay et al., 2018; Sipilä et al., 2021) as part of the intervention. At this stage, it may not be possible to tease out the impacts of outdoor walking and mobility training from other intervention components. Finally, given the low number of included studies, we also could not practically assess publication bias and thus, cannot rule out its risk. It is possible that the low number of eligible studies may, in part, be explained by negative evaluation findings that have not been published.

**Conclusion**

In this systematic review and meta-analysis of five studies, we synthesized the effects of outdoor community ambulation interventions in older adults. The meta-analysis found no significant difference between the effects of outdoor community ambulation and comparison interventions on walking endurance (6MWT) and depression scores, with low to very low certainty evidence. Considering the immature evidence base, primary studies aimed at designing, implementing, and evaluating theory-informed outdoor community ambulation interventions are warranted to optimize prevention of age-related disability.

**Acknowledgments**

N.M. Salbach and R. Barclay are senior authors. Contributions of authors are study conceptualization and design: D. Bhatia, N.M. Salbach, and R. Barclay; funding: N.M. Salbach and R. Barclay; literature search strategies: H. Loewen and E. Nekolaichuk; citation screening: D. Bhatia, N.M. Salbach, O. Akinmolade, K. Alsbury-Neal, R.B. dos Santos, P. Eftekhari, C. Scheller, R. Schorr, S. Scodras, and R. Barclay; data extraction and critical appraisal: D. Bhatia, R.B. dos Santos, and R. Schorr; analysis: D. Bhatia. D. Bhatia drafted the first version of the manuscript; and all authors contributed critically to subsequent revisions and approved the final version. All authors had full access to the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. R. Barclay is the guarantor of the study and the corresponding author. R. Barclay attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. Funding for this project is provided by Research Manitoba and the Heart & Stroke Foundation. The funder had no role in the design of the study, in the collection, analysis and interpretation of the data, or in writing the manuscript. Senior authors N.M. Salbach and R. Barclay authored one of the studies included in this systematic review. This study was identified through the systematic search strategy and screened in accordance with the prespecified eligibility criteria.

**References**


