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## Nature hiking for Veterans with posttraumatic stress disorder: Pilot study design and findings

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|-------------------------------|---|
| Journal:                      | <i>BMJ Open</i>   |
| Manuscript ID                 | bmjopen-2021-051885   |
| Article Type:                 | Original research   |
| Date Submitted by the Author: | 02-Apr-2021   |
| Complete List of Authors:     | Littman, Alyson; VA Puget Sound Health Care System, Seattle Epidemiologic Research and Information System and Seattle-Denver Center of Innovation; University of Washington, Epidemiology<br>Bratman, Gregory N; University of Washington<br>Lehavot, Keren; University of Washington School of Public Health, Department of Veterans Affairs Puget Sound Health Care System<br>Engel, Charles C; University of Washington School of Public Health, Department of Veterans Affairs Puget Sound Health Care System<br>Fortney, John ; University of Washington<br>Peterson, Alexander; VA Puget Sound Health Care System, Seattle Epidemiologic Research and Information Center<br>Jones, Alex; Outdoors for All<br>Klassen, Carolyn; Seattle Epidemiologic Research and Information Center<br>Brandon, Josh; Spirit of America<br>Frumkin, Howard; University of Washington |
| Keywords:                     | Adult psychiatry < PSYCHIATRY, TRAUMA MANAGEMENT, COMPLEMENTARY MEDICINE  |
|                               |   |

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## Nature hiking for Veterans with posttraumatic stress disorder: Pilot study design and findings

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## ABSTRACT

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3 **Objectives:** To evaluate feasibility and acceptability of a group-based nature recreation intervention (nature  
4 hiking) and control condition (urban hiking) for military Veterans with post-traumatic stress disorder (PTSD).

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7 **Design and setting:** A pilot randomized controlled trial conducted in the U.S. Pacific Northwest.

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9 **Participants:** Veterans with PTSD due to any cause.

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12 **Interventions:** Twenty-six participants were randomized to a 12-week intervention involving either six nature  
13 hikes (n=13) or six urban hikes (n=13).

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16 **Primary and secondary outcome measures:** Feasibility was assessed based on recruitment, retention and  
17 attendance. Questionnaires and post-intervention qualitative interviews were conducted to explore intervention  
18 acceptability. Questionnaires assessing acceptability and outcomes planned for the future trial (e.g., PTSD  
19 symptoms) were collected at baseline, 6-, 12- (immediately after the final hike) and 24-weeks follow-up.

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25 **Results:** Of 415 people assessed for eligibility/interest, 97 were interested and passed preliminary eligibility  
26 screening, and 26 were randomized. Mean completion of all questionnaires was 91% among those in the nature  
27 hiking group and 68% in those in the urban hiking group. Over the course of the intervention, participants in the  
28 nature and urban groups attended an average of 56% and 58%, respectively, of scheduled hikes. Acceptability of  
29 both urban and nature hikes was high; over 70% reported a positive rating (i.e., good/excellent) for the hike  
30 locations, distance, and pace. Median PTSD symptom scores (PTSD Checklist-5) improved more at 12- and 24-  
31 weeks among those in the nature vs. urban hiking group.

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41 **Conclusions:** This pilot study largely confirmed the feasibility and acceptability of nature hiking as a potential  
42 treatment for Veterans with PTSD. Adaptations will be needed to improve recruitment and increase hike  
43 attendance for a future randomized controlled trial to effectively test and isolate the ways in which nature  
44 contact, physical activity, and social support conferred by the group impact outcomes.

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49 **Trial registration:** Clinicaltrials.gov (NCT03997344)

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54 **Key words:** posttraumatic stress disorder, Veterans, nature, hiking, pilot randomized controlled trial

### Strengths and limitations of the study

- The intervention, nature hiking is highly acceptable, and has the potential to be scaled, providing additional and/or alternative treatment options for individuals with PTSD.
- This randomized controlled pilot trial included an active control group (urban hiking) that could permit, in a future large-scale trial, distinguishing benefits due to physical activity and social cohesion (present in both interventions) from the environment (which differs between the interventions).
- We used population-based recruitment methods to understand eligibility in a population selected because of presumed PTSD based on medical record data.
- Because of its small size and focus on feasibility, the trial was not designed to be large enough to determine the effectiveness of nature hiking on outcomes.

**Funding:** This work was funded by Recreational Equipment, Inc. (REI; Award/Grant number is not applicable) and supported by equipment and outfitting contributions from Outdoor Research.

**Competing interests:** The authors have no competing interests to report.

## Introduction

Posttraumatic Stress Disorder (PTSD) is a common, chronic mental health condition that affects up to 30% of military Veterans (1–3). PTSD is frequently comorbid with anxiety, depression, and substance misuse. It increases the risk of suicide as well as obesity, physical inactivity, and cardiovascular and metabolic disorders (1–12).

Clinical practice guidelines recommend treatment with several evidence-based psychotherapies and medications (13), but many patients who need PTSD treatment do not receive it (14). Barriers to obtaining treatment include concerns about medication side effects, desire for self-management approaches, stigma about receiving mental health care, and a lack of confidence in mental health treatment in general (14–17). These and other factors adversely impact engagement, contributing to low initiation of (14,18–22) and high drop-out rates from treatment (20,23,24). Furthermore, while the recommended PTSD treatments improve PTSD symptoms *on average*, approximately 60% of patients still have symptoms at or above diagnostic thresholds for PTSD (25). Thus, identifying a wider range of approaches that are acceptable and effective is key to reducing the burden PTSD places on individuals and their communities.

An increasing number of organizations encourage nature contact (“green prescriptions”) to promote psychological well-being and treat symptoms of mental health disorders (26), though rigorous evidence supporting a benefit is lacking. A number of studies have evaluated the effects of nature-based recreation in populations composed of adults primarily or exclusively with PTSD (27–34). The interventions evaluated vary in content, duration, and structure (35). Though quantitative and qualitative data suggest improvements, methodological issues, including inconsistent outcome measures, low retention for follow-up, absence of control groups, and insufficient statistical power make it difficult to attribute benefits to the program or to understand the mechanisms underlying apparent benefits (36). Adequately powered studies designed to

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2  
3 distinguish between benefits due to physical activity (PA) and those due to the physical and social environment  
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5 (e.g., nature) are needed.  
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10 Nature hiking may offer therapeutic value for people with PTSD, as it involves PA, nature contact, and, when  
11 done with others, the potential for forming social connections. Research suggests that each of these elements  
12 could improve outcomes in people with PTSD. PA improves anxiety and depression, stress regulation, sleep, and  
13 cognitive functioning (10,11,37). PA also decreases pain interference and may desensitize individuals to the  
14 physiologic arousal of PTSD. Benefits that have been observed in non-PTSD samples have prompted interest in  
15 evaluating the impact of PA in people with PTSD (37–43). Findings in patients with PTSD have generally been  
16 positive, but only eight studies have involved randomized controlled trial designs (4,40,43–49), and five of the  
17 RCTs were pilot studies or included fewer than 30 people (40,43–45,49). The types of PA studied (yoga, aerobic  
18 activity, strength training, or a combination), the primary etiology of the PTSD (sexual trauma, combat, other or  
19 a combination), the duration of treatment (ranging from 2 to 12 weeks), sample characteristics (female-only vs.  
20 predominantly men) and whether PA was studied as a stand-alone treatment or as an adjunct to evidence-based  
21 psychotherapies have varied widely across studies. Notably, no studies explicitly investigated the PA setting as a  
22 component of treatment, with many using facility-based PA or failing to specify the location of the PA.  
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41 This is an important omission, because the environment in which PA takes place may play an important role in  
42 the benefits it provides. PA in natural settings improves subjective well-being; decreases stress, anxiety, and  
43 depression; and promotes adaptive shifts in emotion regulation (35,50–52). Attention Restoration Theory (ART)  
44 and Stress Recovery Theory (SRT) provide a theoretical foundation for the observed benefits of nature contact  
45 on health (53,54). ART theorizes that nature contact improves cognitive function through a replenishment of  
46 “directed attention”, a capacity that is overly taxed in urban environments due to the need to block out  
47 distracting stimuli (e.g., noise) to focus on a specific task or cognitive process. This depleted attention capacity  
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3 can be restored in natural environments through the engagement of “soft fascination”, with implications for  
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5 both cognitive and emotional well-being. SRT posits that many types of nature exposure enhance psychological  
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7 well-being through an activation of the parasympathetic nervous system in ways that reduce stress and  
8  
9 sympathetic nervous system arousal (55,56).  
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14 In addition to PA and the physical environment in which it takes place, social factors may also play a role in the  
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16 benefits of nature hiking. Recent research suggests that increased social cohesion and connectedness may  
17  
18 mediate benefits of nature-based recreation (57). Social support forged through group activity could be  
19  
20 particularly relevant for Veterans, as camaraderie and solidarity are critical components of military culture, and  
21  
22 ones that are frequently lost in the return to civilian life (58). Social support is associated with reduced PTSD  
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24 symptoms and improved treatment response (59), and may directly impact stress response, by increasing  
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26 personal resources (60), and/or may indirectly impact PTSD symptom severity and response to treatment  
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28 through buffering the potentially harmful impacts of stressful events (61).  
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34 Guided by prior research and gaps in the literature, our goal was to design and conduct a pilot study to test the  
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36 feasibility and acceptability of a nature-based PA intervention for PTSD symptoms in military Veterans,  
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38 regardless of PTSD etiology. The intervention (nature hiking) and the active control (urban hiking) were group-  
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40 based and involved similar amounts of PA, to ensure control of the potential benefits of the group-based social  
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42 support and of PA. Figure 1 depicts our conceptual model. This paper describes the results of the initial pilot  
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44 study designed to emulate important elements of the future envisioned full-scale randomized trial.  
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## 50 **Methods**

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### Ethics approval

This study was approved by the institutional review boards at the VA Puget Sound Health Care System (MIRB 01738) and the University of Washington (6951) and registered at Clinicaltrials.gov (NCT03997344). Figure 2 presents an overview of the study, including timing of assessments.

### Patient involvement

Patients were involved in the design and conduct of this study. This study question and design were informed by a Veteran with PTSD who served as a co-investigator. Study design and messaging for this pilot were also informed by a focus group of patients/Veterans who participated in a prior unpublished feasibility study.

### Inclusion/Exclusion Criteria

Inclusion criteria included being a U.S. military Veteran and having PTSD (PTSD-checklist-5 (62) score $\geq$ 33). To ensure safety, we excluded those with a hospitalization in the prior 3 months (self-report); a diagnosis of schizophrenia, bipolar disorder, or other psychotic disorder (self-report); inability to perform unsupervised exercise safely (based on the Physical Activity Readiness Questionnaire (63) and provider approval if any conditions were present), drug abuse in past year (Drug Abuse Screening Test-10 (64) score <3); alcohol disorder/dependence (current/past year; Alcohol Use Disorders Identification Test-10 (65) score >16); and moderate/severe suicidality (past month; MINI Suicidality module (66) score $\geq$ 5). Patients also needed to express an ability/willingness to comply with study procedures (e.g., complete questionnaires, wear and sync an activity monitor, drive to hikes, and walk at least 2 hours at an easy/moderate pace over uneven terrain).

### Recruitment

We used active and passive methods to recruit participants. For active recruitment, we mailed invitation letters to VA enrollees (identified using Department of Veterans Affairs (VA) electronic medical records) with at least one encounter with a diagnosis of PTSD in the prior two years and a zip code in one of three Seattle-Tacoma

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3 area counties (King, Snohomish, and Pierce) (n=1001). We followed the mailing with up to three phone calls until  
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5 we met recruitment targets. For passive recruitment, we placed study recruitment flyers in clinics in the VA  
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7 Puget Sound and mailed flyers to four local organizations and clinics serving Veterans.  
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### 11 12 Screening

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14 Individuals were first screened over the phone. Those who passed initial screening were mailed consent forms  
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16 and given a link to complete a more extensive screening questionnaire online. Via the online screening  
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18 questionnaire, PTSD symptoms, drug use, alcohol misuse, and suicidality were assessed, and a final  
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20 determination of eligibility was made. Those who were eligible based on the two steps and returned signed  
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22 consents were considered enrolled in the study.  
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### 26 27 28 Randomization

29  
30 The random 1:1 allocation sequence was generated using simple randomization in random blocks of 2, 4 and 6.  
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32 Randomization assignments were placed in opaque sequentially numbered envelopes. Once an individual was  
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34 determined to be eligible, the study coordinator selected the next envelope to determine the individual's group  
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36 assignment.  
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### 40 41 Blinding

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43 We did not blind participants, the study coordinator, or the study statistician to group assignment.  
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### 47 48 Interventions, hike leaders, and incentives

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50 The study included two arms: group nature and urban hiking. Both the nature and urban hikes followed the  
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52 same schedule -- 6 hikes, held every other week on Sunday mornings (12 weeks total) from August through  
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54 October 2019. The standard structure for hikes was: 1) "ice breakers" (short, guided conversations), 2) overview  
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3 of the planned hike, including distance, unique features, and planned stops, 3) hike, and 4) post-hike debrief and  
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5 administration of questionnaires.  
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10 Hike durations increased gradually to account for anticipated increases in participants' physical fitness. Initial  
11 hikes were 60-90 minutes (2-3 miles), and later hikes were 2-3 hours (5-6 miles). To ensure safety and inclusion,  
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13 one hike leader was in sight and hearing of the first participant and a second leader accompanied the last  
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15 participant. The group stopped at least every 30 minutes to keep everyone together and offer opportunities to  
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17 rest, regroup, and inquire about and address any issues or concerns arising since the last check-in.  
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23 Two non-clinicians (including at least one woman) co-led each nature and urban hike. Leaders were trained to  
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25 handle physical and mental health emergencies. The same hike leaders led both nature and urban hikes to  
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27 control for hike-leader effects.  
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32 To reduce barriers to attendance, a \$35 incentive was provided to defray parking costs. We provided a rain  
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34 jacket and technical shirt as well as well as an activity monitor (Garmin vivosmart 4) at the participant's first  
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36 hike.  
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#### 41 Selecting hike routes

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43 The criteria used to select the hikes (which applied to both nature and urban hikes) included duration, elevation  
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45 change, availability of facilities (e.g., toilets and water), distance from participants' homes, and access to  
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47 parking. Nature hikes were held in State Parks, National Wildlife Refuges, and Natural Resources Conservation  
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49 areas. Urban hikes were held in primarily built environments, avoiding urban parks or primarily residential  
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51 neighborhoods with substantial greenery or water features. Urban hikes comprised areas that included sports  
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53 stadiums, urban art, and retail establishments and were mainly on sidewalks rather than separated  
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3 bike/pedestrian paths/rail-trails. It was not feasible to match nature and urban hikes on elevation change;  
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5 instead, we aimed to have similar hike durations to match total exertion. Generally, nature hikes were shorter  
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7 and included more elevation gain/loss.  
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### 10 11 12 Baseline and follow-up assessments 13

14 We conducted assessments online using commercial software (QuestionPro) at baseline (before hikes began),  
15  
16 and each week after the first hike for 12 weeks (after the 6<sup>th</sup> hike), and then at week 24; questionnaires  
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18 completed immediately after the hikes were completed on paper. See Figure 2 for an overview and  
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20 Supplemental Table 1 for measures at each time point. Questionnaires at weeks 6, 12, and 24 took  
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22 approximately 30 minutes to complete. Questionnaires administered at weeks 1-5 and 7-11 took 5-10 minutes  
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24 to complete. Participants received gift cards worth \$10 for questionnaires completed in weeks 1-5 and 7-11, \$20  
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26 for the 6-week questionnaire, and \$50 for the 12- and 24-week questionnaires.  
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### 32 Measures 33

#### 34 *Feasibility measures* 35

36 To evaluate feasibility, we assessed recruitment statistics (the proportion of individuals who were contacted,  
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38 eligible, and enrolled, as well as reasons for ineligibility), retention (questionnaire completion), hike attendance,  
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40 and safety (e.g., adverse events). We aimed to recruit 36-45 participants (12-15 people allocated to each of the  
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42 three groups - nature hiking, urban hiking, and a no-hiking control group) and complete enrollment by July (3-4  
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44 months after recruitment initiation) due to concerns about weather for hikes later in the fall. Due to lower-than-  
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46 anticipated recruitment numbers, in late June, we decided to eliminate the no-hiking control group. At this time,  
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48 only one person was randomized to the no-hiking control group and informed of their group assignment; that  
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50 person was re-randomized after this decision was made. The target for retention and attendance was 70%.  
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### *Acceptability measures*

We included questions on acceptability of the hikes (e.g., distance, pace, terrain, and locations) and satisfaction with the study (e.g., communication) in the 6- and 12-week questionnaires. These questionnaires also included open-ended questions for participants to report what they thought went well and what could have been better. Additionally, after the final hike, the lead author conducted semi-structured telephone interviews, with a goal to interview 10-15 participants. To include a range of perspectives, we purposively sampled participants from both arms, aimed to include men and women, and participants who varied in terms of hike attendance. Questions inquired about participants' impressions of the hikes, including difficulty, location, length of time, distance from home, hike leaders, and reasons hikes were missed (if applicable); study communications; enrollment process; assessments; and other thoughts/impressions. All interviews were recorded; the interviewer also took notes during interviews. For both the comments shared via open-ended questions on the questionnaire and comments shared orally during the interviews, we conducted inductive content analysis, which involves open coding of data, organizing codes and data into categories, and comparing data across participants to identify patterns and themes in the data (67).

### *Outcome (efficacy) measures*

Supplemental Table 1 details the measures and instruments that were assessed at each time point. The primary outcome of the future planned study is the PTSD-Checklist-5 (PCL-5), a 20-item instrument that assesses PTSD symptoms in the past month (range 0 to 80). Higher scores indicate greater symptom severity. The primary purpose of the extensive data collection was to evaluate feasibility of data collection rather than to estimate effect sizes because estimating effect sizes from small pilot studies is inherently imprecise (68). Thus, instead of conducting hypothesis tests for which we were underpowered, we present descriptive statistics (e.g., medians and interquartile ranges) for the PCL-5 only.

## Results

### Participants

The mean age of participants was 47 years (range 25-65), 7 (27%) were women, 42% were non-white race/ethnicity, and 14 (54%) were currently married (Table 1). Thirty percent had a college degree or more. Less than half worked full time and 46% had 100% VA service-connected disability, indicating severe impairment in ability to work. Nearly two-thirds of participants had served in combat and 68% had depressive symptoms based on the PHQ-8. Based on self-report nearly 70% met or exceeded PA guidelines of at least 75 minutes per week of vigorous-intensity activity or 150 minutes per week of moderate-intensity activity, or an equivalent combination of the two. At baseline (prior to study initiation), 81% of participants reported hiking at least one time and 27% completed 7 or more hikes in the prior year.

### Feasibility

#### *Recruitment statistics*

Recruitment took place between April and August 2019 (16 weeks total). Of the 1001 patients mailed an invitation letter, we were unable to assess interest or eligibility in 586 (because they did not respond to the mailings and/or answer the phone when called; see Figure 3 for CONSORT diagram). Of the 415 with whom we made contact, 159 were not interested, 102 had health conditions that limited their walking/hiking, 36 had time conflicts (e.g., work or church on Sundays or travel that would prevent participation), and 37 had other reasons that they were unable to participate (e.g., moving out of the area, travel plans, did not have PTSD, etc.). Of the 97 (81 from letters + 16 from passive recruitment) interested who passed the preliminary eligibility review, 48 completed the online screening questionnaire. Twenty individuals were not eligible, 2 decided that they did not wish to participate, and 26 were eligible and randomized. Of the 20 who were not eligible, 13 were ineligible because of a moderate/high risk of suicide or skipping the question on suicidality, and 6 did not meet the threshold for PTSD.

### *Retention (questionnaire completion)*

Mean completion of all questionnaires was 91% in the nature hiking group and 68% in the urban hiking group.

Completion rates were similar for the shorter weekly questionnaires and the longer questionnaires.

### *Hike attendance*

Over the course of the intervention, participants in the nature and urban groups attended an average of 56% and 58%, respectively, of scheduled hikes. In the nature group, one person attended no hikes, four (31%)

attended 1-2 hikes, one attended 3 hikes, and seven (54%) attended 4-6 hikes. In the urban group, one person attended no hikes, 4 (31%) attended 1-2 hikes, no one attended only 3 hikes, and 8 (62%) attended 4-6 hikes.

Attendance was lower among women in the nature group (n=5, mean: 43%) than among women in the urban group (n=2, 67%), whereas among men, hike attendance was similar in the two groups (65% vs. 56%). Common reasons for missing hikes included work, childcare, and prior plans.

### *Safety/Adverse events*

One participant in the urban hiking arm reported increased anxiety/PTSD symptoms in connection with hiking in the urban environment and withdrew from the study.

### *Acceptability*

#### *Quantitative findings*

Acceptability of both the urban and nature hikes was high. Over 70% reported a positive rating (i.e., good or excellent vs. very poor/inadequate, inadequate, or adequate) for the hike locations, distance, and pace.

#### *Qualitative findings*



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3 Overall, qualitative interviews indicated that most participants felt positively about their experience. Veterans  
4 wanted to find more ways of connecting with one another socially during hikes as well as outside of hikes (Table  
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8 2). Hike logistics were noted as potential barriers to attendance.  
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### 10 11 12 Efficacy measures 13

14 Median PCL-5 scores decreased from baseline to week 12 and 24 for those in the nature (baseline=41, 12-weeks  
15 = 32, 24 weeks=31) but not among those in the urban hiking group (baseline=48, 12-weeks = 43, 24 weeks=47)  
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17 (Supplemental Figure 1). We did not test the statistical significance of the changes because this pilot study was  
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19 not designed to answer this question (70).  
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### 25 **Discussion** 26

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30 This study was an important step to establishing feasibility and acceptability and identifying changes to consider  
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32 in the development of a rigorous, fully-powered study to evaluate the impact of nature hiking on PTSD  
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34 symptoms. The results of this pilot study were largely positive. Participants reported high acceptability,  
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36 enjoyment, and value, based on quantitative and qualitative data. Most participants completed most hikes,  
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38 regardless of treatment arm. Feedback about improving the social component supports the hypothesis that  
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40 social connection is an important aspect of these hikes, indicating a need to continue to study group  
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42 interventions like this one. Additionally, the decrease in median scores on the PCL-5 among those in the nature  
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44 group immediately after the 12-week hiking intervention, and 12 weeks later (week 24) is promising. This  
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46 preliminary finding should be investigated more thoroughly in future, larger-scale versions of our study. The  
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48 indication that improvements may persist after the conclusion of the intervention is especially compelling given  
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50 the current unknowns regarding the duration of effects of nature interventions.  
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3 Nevertheless, several issues need to be considered related to feasibility and acceptability for the next iteration  
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5 of this research.  
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### 10 *Feasibility of recruitment*

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12 We fell short of our goal of recruiting at least 36 people over 4 months. Failing to meet recruitment goals in the  
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14 planned timeframe is a common problem in randomized controlled trials (71). Barriers to recruitment included  
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16 unexpected delays, insufficient resources, and an inefficient recruitment process. Regarding delays, we had to  
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18 wait weeks for IRB approval for each proposed modification to recruitment materials/protocol. Our pilot  
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20 experience allowed us to pre-test materials and processes, but modifications will likely be needed, so having a  
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22 plan that can accommodate a slow start or interruptions would be helpful. Regarding resources, we only had 20  
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24 hours per week of paid staff time for recruitment. The addition of two volunteers in the final two months helped  
25  
26 to accelerate enrollment, but more resources earlier in recruitment would have been necessary to meet our  
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28 goal.  
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35 One contributor to inefficiency in recruitment was the broad, population-based approach we employed for  
36  
37 active recruitment. To identify patients for the introductory mailing, the only inclusion criteria were having a  
38  
39 single encounter in VA's electronic medical record with a PTSD diagnosis and living in one of three Puget Sound  
40  
41 counties. The only exclusionary factor was a diagnosis of schizophrenia, bipolar disorder, or other psychotic  
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43 disorder. Likely in part because of this broad approach, approximately a quarter of contacted individuals  
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45 reported a health condition that impaired their walking. Burdensome study procedures may have also impacted  
46  
47 recruitment. About half of interested participants failed to complete the online screening questionnaire and  
48  
49 numerous people had trouble completing the online questionnaire. Restructuring the recruitment process to  
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51 make it faster and easier for potential participants may be necessary.  
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3 Restrictive eligibility criteria and accessibility of the intervention may have also impacted recruitment. In  
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5 addition to being able to walk over uneven ground for at least two hours, participants also had to be available  
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7 during the times selected, have low suicide risk, and be free from physical conditions such as high blood  
8  
9 pressure (or obtain their primary care provider's permission) among several other criteria. Changing inclusion  
10  
11 criteria (e.g., eliminating restrictions related to suicidality) would require tradeoffs related to safety that must be  
12  
13 considered carefully.  
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18 Lastly, about 38% (159/415) of those for whom we were able to assess eligibility and interest declined  
19  
20 participation. While some of these people may have declined because of the additional burdens of a research  
21  
22 study, this statistic indicates that hiking may only appeal to a segment of the population, just as psychotherapy  
23  
24 and pharmacotherapy only appeal to subsets of the population (25). Because of differences in treatment  
25  
26 preferences, offering options is important, and nature hiking merits consideration so that we can rigorously  
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28 assess its efficacy.  
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### 32 33 34 *Retention*

35  
36 Retention varied by group and was poorer for the wrist-worn activity monitor than for the questionnaires. The  
37  
38 activity monitor had a substantial amount of missing data, which is a common problem for activity monitors  
39  
40 (72), and may have been related to the number of technical steps required for setting up the watch and syncing  
41  
42 it, as many participants needed additional help to troubleshoot problems. Providing more support to set up the  
43  
44 watch and incentives to wear and sync it may help to obtain more complete data. While overall questionnaire  
45  
46 completion was high, it was higher in the nature hiking group (91%) than in the urban hiking group (68%).  
47  
48 Though the small sample and our inability to conduct interviews with those who did not complete follow-up  
49  
50 measures makes inference difficult, the retention differences could be a marker of commitment to the study.  
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52 Future studies should pay careful attention to marketing the study to ensure that both interventions are  
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3 perceived as helpful. The difference in incentives provided for questionnaire completion vs. the other aspects of  
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5 the study may also have played a role in retention for different study aspects. However, many participants  
6  
7 shared that they participated to help fellow Veterans, indicating altruistic/intrinsic motivators for participation,  
8  
9 reinforcing the importance of understanding drivers of participation, and reducing barriers and enhancing  
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11 facilitators.  
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### 14 15 16 *Acceptability of the hiking interventions*

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18 Hike attendance (56%) was lower than our target (70%) and women had lower attendance in the nature hiking  
19  
20 group than men. While we were unable to ascertain reasons for missing hikes for each person, some reasons  
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22 reported (e.g., other plans, work) were hard to avoid, while others (driving distance to hikes) could be addressed  
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24 in the future by restricting the geographic area of recruitment and hikes and/or organizing small groups at  
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26 different times to accommodate individuals' schedules. A history of military sexual trauma, which is common  
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28 among women Veterans (73), may have impacted some women participants' comfort and perception of safety  
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30 of hiking in nature with a majority male group. Ensuring a greater proportion of female participants in each  
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32 group or organizing women-only groups could address this concern. These changes, would, however, result in  
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34 additional costs and tradeoffs that would need to be carefully considered.  
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### 41 *Conclusions*

42  
43 This pilot study provided useful information related to feasibility and acceptability, including common factors  
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45 that resulted in exclusion; resources and procedures needed for recruitment; factors to consider for selection of  
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47 nature and urban hikes; and barriers and facilitators to achieving high completion in follow-up assessments and  
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49 the hikes. These insights can be harnessed to increase participation and rigor in future, scaled-up iterations of  
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51 the study, and ensure that environments are safe (i.e., non-triggering). Future studies with larger sample sizes  
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are needed to isolate the ways nature contact, PA, and social support conferred by the group impact outcomes to develop and provide well-tailored interventions.

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### List of abbreviations

|       |  |
|-------|--|
| ART   | Attention Restoration Theory                           |
| HIPAA | Health Insurance Portability and Accountability Act    |
| IRB   | Institutional Review Board                             |
| PA    | Physical activity                                      |
| PCL-5 | PTSD Checklist for Diagnostic and Statistical Manual 5 |
| PTSD  | Posttraumatic stress disorder                          |
| SRT   | Stress Recovery Theory                                 |
| VA    | Department of Veterans Affairs                         |

### Acknowledgements

We thank the Veterans who participated in this study for allowing us to learn from them. This material is the result of work supported by VA Puget Sound Health Care System, Seattle, WA. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs, the United States Government, Recreational Equipment, Inc. (REI), or Outdoor Research.

**Contributors:** AJL, GNB, CCE, JCF, KL, JB, and HF conceptualized the study and contributed to the intervention development and design. AJL and GNB oversaw the conduct of the trial all the authors contributed to the ongoing management of the trial. AJL, GNB, MM, AP, and CK oversaw data collection and data analysis. The manuscript was drafted by AJL. All the authors contributed to the interpretation of the findings and revised and reviewed the paper.

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Figure 1. Conceptual model

Figure 2. Depiction of study design and assessments

Figure 3. CONSORT diagram

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**Table 1. Baseline characteristics of Veterans in the urban and nature hiking groups**

| Characteristic             | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|----------------------------|--------------|------------|---------------|------------|--------------|------------|
|                            | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| <b>Age (years)</b>         |              |            |               |            |              |            |
| <30                        | 2            | 8          | 1             | 8          | 1            | 8          |
| 30-39                      | 5            | 19         | 2             | 15         | 3            | 23         |
| 40-49                      | 6            | 23         | 4             | 31         | 2            | 15         |
| 50-59                      | 11           | 42         | 6             | 46         | 5            | 38         |
| ≥60                        | 2            | 8          | 0             | 0          | 2            | 15         |
| <b>Gender</b>              |              |            |               |            |              |            |
| Male                       | 19           | 73         | 8             | 62         | 11           | 85         |
| Female                     | 7            | 27         | 5             | 38         | 2            | 15         |
| <b>Race/ethnicity</b>      |              |            |               |            |              |            |
| Asian/Pacific Islander, NH | 3            | 12         | 2             | 15         | 1            | 8          |
| Black, NH                  | 2            | 8          | 0             | 0          | 2            | 15         |
| Hispanic                   | 3            | 12         | 1             | 8          | 2            | 15         |
| Native American, NH        | 2            | 8          | 0             | 0          | 2            | 15         |
| Other                      | 1            | 4          | 0             | 0          | 1            | 7.7        |
| White, NH                  | 15           | 58         | 10            | 77         | 5            | 38         |
| <b>Marital status</b>      |              |            |               |            |              |            |
| Single, never married      | 4            | 15         | 3             | 23         | 1            | 8          |
| Married currently          | 14           | 54         | 7             | 54         | 7            | 54         |



| Characteristic  | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|---|--------------|------------|---------------|------------|--------------|------------|
|   | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| Separated/divorced  | 8            | 31         | 3             | 23         | 5            | 38         |
| <b>Education</b>  |              |            |               |            |              |            |
| High school degree or equivalent  | 4            | 15         | 1             | 8          | 3            | 23         |
| Some college, no degree   | 10           | 38         | 7             | 54         | 3            | 23         |
| Associate degree  | 4            | 15         | 1             | 8          | 3            | 23         |
| Bachelor's degree   | 4            | 15         | 2             | 15         | 2            | 15         |
| Masters, doctorate, or professional<br>degree                               | 4            | 15         | 2             | 15         | 2            | 15         |
| <b>Annual household income</b>  |              |            |               |            |              |            |
| \$25,000-\$49,999   | 7            | 27         | 4             | 31         | 3            | 23         |
| \$50,000-\$74,999   | 11           | 42         | 4             | 31         | 7            | 54         |
| \$75,000-\$99,999   | 2            | 8          | 1             | 8          | 1            | 8          |
| \$100,000 or more   | 4            | 15         | 3             | 23         | 1            | 8          |
| Prefer not to answer  | 2            | 8          | 1             | 8          | 1            | 8          |
| <b>Employment status</b>  |              |            |               |            |              |            |
| Full-time   | 12           | 46         | 6             | 46         | 6            | 46         |
| Part-time   | 1            | 4          | 1             | 8          | 0            | 0          |
| Not employed (disabled, retired, not<br>looking for work, homemaker, other) | 13           | 50         | 6             | 46         | 7            | 54         |
| <b>Highest military rank</b>  |              |            |               |            |              |            |

| Characteristic                               | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|--|--------------|------------|---------------|------------|--------------|------------|
|  | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| Enlisted (E1-E4)                             | 9            | 35         | 4             | 31         | 5            | 38         |
| Non-commissioned officer (E5-E9)             | 15           | 58         | 8             | 62         | 7            | 54         |
| Officer (O1-O4)                              | 2            | 8          | 1             | 8          | 1            | 8          |
| <b>VA disability rating*†</b>                |              |            |               |            |              |            |
| No rating                                    | 2            | 8          | 0             | 0          | 2            | 15         |
| 30-60%                                       | 2            | 8          | 2             | 15         | 0            | 0          |
| 70-90%                                       | 8            | 31         | 4             | 31         | 4            | 31         |
| 100%   | 12           | 46         | 6             | 46         | 6            | 46         |
| <b>Self-reported health</b>                  |              |            |               |            |              |            |
| Excellent/very good                          | 9            | 35         | 3             | 23         | 6            | 45         |
| Good   | 11           | 42         | 7             | 54         | 4            | 31         |
| Fair (no one reported poor)                  | 6            | 23         | 3             | 23         | 3            | 23         |
| <b>PCL-5 score‡</b>                          |              |            |               |            |              |            |
| Mean, SD                                     | 47.1         | 10.9       | 46.0          | 11.4       | 48.2         | 10.8       |
| <b>Served in combat [yes]</b>                | 17           | 65         | 8             | 62         | 9            | 69         |
| <b>Combat Exposure Score; mean (SD)* †</b>   | 16.6         | 7.9        | 15.6          | 8.2        | 17.7         | 7.9        |
| <b>Patient Health Questionnaire-8 score*</b> |              |            |               |            |              |            |
| <10 (no depression)                          | 8            | 32         | 4             | 33         | 4            | 31         |
| 10-19 (major depression)                     | 14           | 56         | 7             | 58         | 7            | 54         |
| ≥20 (severe major depression)                | 3            | 12         | 1             | 8          | 2            | 15         |

| Characteristic  | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|---|--------------|------------|---------------|------------|--------------|------------|
|   | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| <b>Physical activity level</b>  |              |            |               |            |              |            |
| Low   | 8            | 31         | 5             | 38         | 3            | 23         |
| Moderate  | 3            | 12         | 1             | 8          | 2            | 15         |
| High  | 15           | 58         | 7             | 54         | 8            | 62         |
| <b>Times gone hiking for 1+ hrs in last year</b>                      |              |            |               |            |              |            |
| Never   | 5            | 19         | 3             | 23         | 2            | 15         |
| 1-3   | 9            | 35         | 4             | 31         | 5            | 38         |
| 4-6   | 5            | 19         | 2             | 15         | 3            | 23         |
| 7+  | 7            | 27         | 4             | 31         | 3            | 23         |
| <b>Outdoor / nature-based activity<br/>experience</b>                 |              |            |               |            |              |            |
| None (no experience in the outdoors)                                  | 0            | 0          | 0             | 0          | 0            | 0          |
| Casual (done some day hiking on<br>maintained trails and car camping) | 10           | 38         | 5             | 38         | 5            | 38         |
| Amateur (have experience with<br>backpacking)                         | 11           | 42         | 6             | 46         | 5            | 38         |
| Expert (substantial backcountry<br>experience)                        | 5            | 19         | 2             | 15         | 3            | 23         |

Abbreviations: NH, Non-Hispanic; PCL-5, Post-traumatic stress disorder checklist for Diagnostic and Statistical Manual 5; PTSD, post-traumatic stress disorder; SD, standard deviation

\* Missing response for 1 nature participant

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3 † Missing response for 1 urban participant  
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6 ‡ One person in the nature hiking group had a PCL-5 of 32 (below the eligibility threshold of 33) due to  
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8 an undetected error in initial scoring.  
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Table 2. Key themes and findings from qualitative data

| Themes                | Findings  |
|-----------------------|---|
| A positive experience | <ul style="list-style-type: none"> <li>Both nature hiking group members (“All expectations were exceeded”) and urban study participants (“LOVE THE GROUP”) provided positive feedback.</li> </ul>   |
| Perceived benefits    | <ul style="list-style-type: none"> <li>Participants reported on how the hikes helped them to be more active, lose weight, reduce stress, and feel more connected to others.</li> </ul>  |
| Hike logistics        | <ul style="list-style-type: none"> <li>Participants suggested that prior to hikes, we ensure parking access, availability of toilets, and locate the hikes closer to participants’ homes.</li> <li>Others suggested that we consider organizing carpools and/or covering gas/mileage costs</li> </ul>   |
| Difficulty of hikes   | <ul style="list-style-type: none"> <li>Most found the difficulty just right.</li> <li>Some felt that the hikes were too short/easy.</li> </ul>  |
| Location of hikes     | <ul style="list-style-type: none"> <li><u>Nature group</u>: One participant wished that there was more of a “reward” (“like a waterfall”, “when you have a view, it seems more profound”), because some were just “walks through the woods.”</li> <li><u>Urban group</u>: One person noted that some neighborhoods were “sketchy” and they were “constantly walking around garbage” for one hike. Others noted that they really enjoyed exploring different neighborhoods, areas around sports stadium, and learning about the history of areas.</li> </ul> |

|   |  |
|---|--|
| Group composition   | <ul style="list-style-type: none"> <li>• A few participants suggested that we enroll more women or organize women-only groups and/or groups for survivors of sexual assault.</li> </ul>  |
| Incentives for completing questionnaires                          | <ul style="list-style-type: none"> <li>• Participants suggested that we offer the option to receive a single gift card that accumulated value instead of separate ones each time a questionnaire was completed.</li> </ul>   |
| Assessments   | <ul style="list-style-type: none"> <li>• Several participants had trouble with the online software (e.g., getting “kicked out” of the survey mid-way through);</li> <li>• Some participants reported that they would have liked text prompts instead of email, since they did not regularly check their email.</li> <li>• Some participants found some questions to be difficult to answer (e.g., the Perceived Cohesion Scale) or they were confused by differences in the time frame for different instruments (e.g., on the weekly questionnaires, some questions asked participants how they felt “right now” while others asked about the prior week).</li> </ul> |
| Activity monitors   | <ul style="list-style-type: none"> <li>• Several participants noted having problems programming and syncing the activity monitor.</li> </ul>   |
| Fostering interaction/connections between participants in a group | <ul style="list-style-type: none"> <li>• Participants suggested facilitating more structured ways to get to know other members of the group, including a social gathering prior to the initial hike, re-introductions before each hike, gathering for lunch or other meal after hikes, and organizing a social media group.</li> </ul>   |

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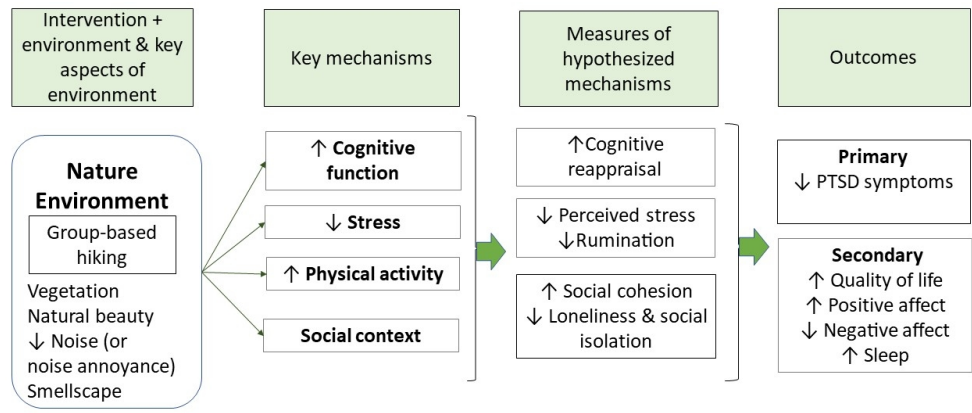


Figure 1. Conceptual model  
338x190mm (96 x 96 DPI)

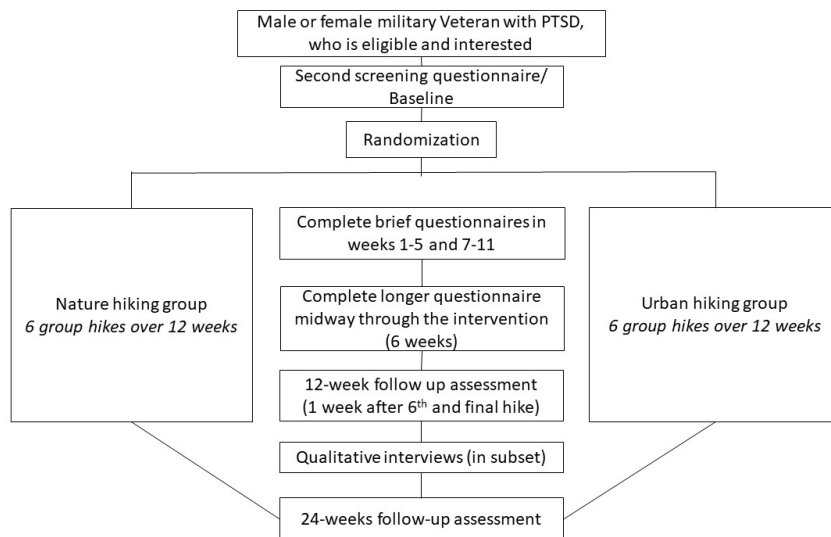
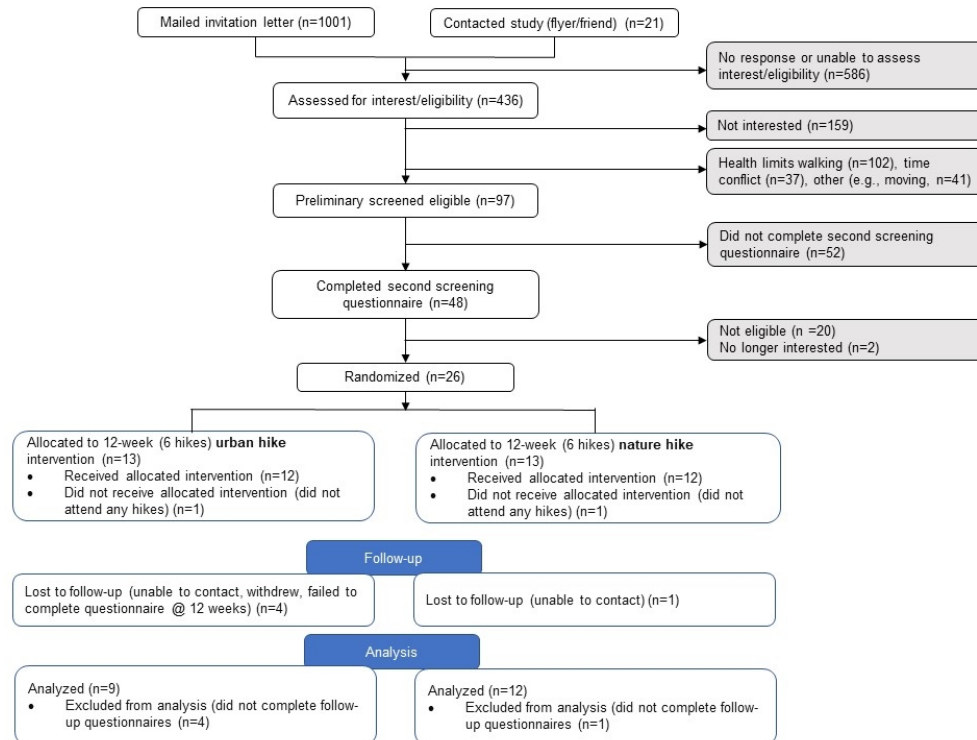


Figure 2. Depiction of study design and assessments

338x190mm (96 x 96 DPI)





**Supplemental Table 1. Constructs, instruments, and timing of assessments**

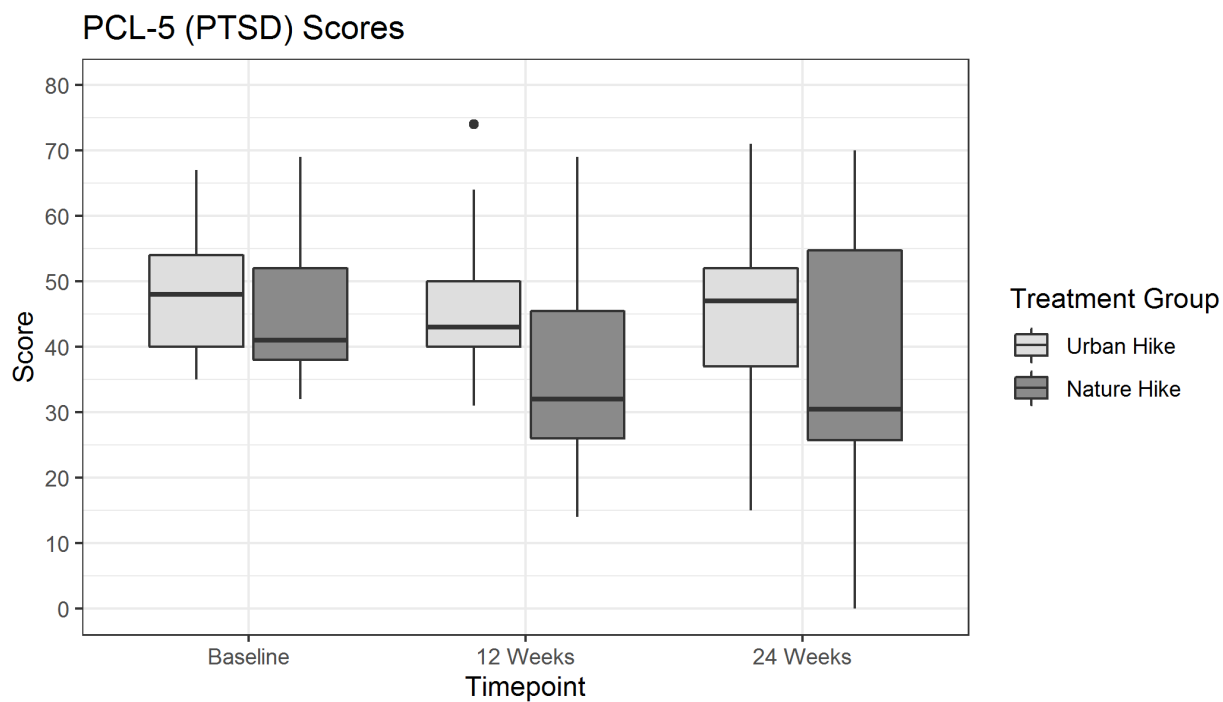
| Constructs   | Instrument   |
|--|--|
| Demographics   | n/a (Age, gender, race/ethnicity, education, service-connected disability, etc.)         |
| Combat exposure  | First two questions of the PTSD Diagnostic Scale-5 (73) and Combat Exposure Scale (74)   |
| Ability to safely perform unsupervised physical activity | Physical Activity Readiness Questionnaire (PAR-Q) (62)                                   |
| Suicidal ideation  | MINI Suicidality module (65)   |
| QoL/well-being   | Satisfaction with Life Scale (75)  |
| Physical health  | 14-item Physical Health Questionnaire (76)   |
| PTSD symptoms  | PTSD Checklist for DSM- 5 (61)   |
| Depression   | Personal Health Questionnaire (PHQ)-8 (77)   |
| Perceived Stress   | 4-item Perceived Stress Scale (PSS) (78,79)  |
| Affect   | 20-item Positive and Negative Affect Schedule (PANAS) (80,81)                            |
|  | 10-item PANAS  |
| Loneliness   | 3-item UCLA loneliness scale (82)  |
| Social connectedness                                     | First four items of the 6-item Perceived Cohesion Scale (83)                             |
| Anxiety  | 20-item Stress and Anxiety Scale (STAI) – state level                                    |
|  | 6-item STAI  |
| Sleep  | Full (19-item) Pittsburgh Sleep Quality Index (PSQI) (84)                                |
|  | Shortened (5-item) PSQI  |
| Nature connection  | Connectedness to Nature Scale (6-items) (85)   |
| Rumination   | Full (12-item) state rumination (brooding subscale of Rumination Reflection Scale [RRS]) |
|  | Shortened (8-item) state rumination (brooding subscale of RRS) (86)                      |
| Cognitive reappraisal                                    | 4-item state emotion regulation questionnaire (ERQ) (87)                                 |
| Physical activity – self report                          | 9-item International Physical Activity Questionnaire (IPAQ) short form (68)              |

| Constructs                                 | Instrument   |
|--|--|
| Physical activity monitor                  | Wrist worn activity monitor (Garmin Vivosmart 4)               |
| Alcohol consumption                        | 10-item Alcohol Use Disorders Identification Test (AUDIT) (64) |
|  | 3-item (AUDIT-C) (88)  |
| Drug-related problems                      | Drug Abuse Screening Test-10 (63)                              |
| PTSD treatments                            | n/a  |
| Preference for treatment, hiking frequency | n/a  |
| and expectation about treatment            | n/a  |
| Acceptability of hikes                     | n/a  |

‡Timing of assessment: S/B: screening/baseline, WK: weekly – weeks 1-5 and 7-11, FU: 6-, 12-, and 24-week follow-ups

†A, acceptability; CO, covariate (including moderators); E, eligibility (to assess inclusion/exclusion criteria); M, mediator P, primary outcome; S, secondary outcome

Figure 1. PTSD Checklist scores at baseline, 12- and to 24-weeks follow-up



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## CONSORT 2010 checklist of information to include when reporting a pilot or feasibility trial\*

| Section/Topic                    | Item No | Checklist item  | Reported on page No |
|----------------------------------|---------|---|---------------------|
| <b>Title and abstract</b>        |         |   |                     |
|                                  | 1a      | Identification as a pilot or feasibility randomised trial in the title  | 1                   |
|                                  | 1b      | Structured summary of pilot trial design, methods, results, and conclusions (for specific guidance see CONSORT abstract extension for pilot trials)   | 2                   |
| <b>Introduction</b>              |         |   |                     |
| Background and objectives        | 2a      | Scientific background and explanation of rationale for future definitive trial, and reasons for randomised pilot trial  | 4-7                 |
|                                  | 2b      | Specific objectives or research questions for pilot trial   | 6-7                 |
| <b>Methods</b>                   |         |   |                     |
| Trial design                     | 3a      | Description of pilot trial design (such as parallel, factorial) including allocation ratio  | 7                   |
|                                  | 3b      | Important changes to methods after pilot trial commencement (such as eligibility criteria), with reasons  | 10-11               |
| Participants                     | 4a      | Eligibility criteria for participants   | 7                   |
|                                  | 4b      | Settings and locations where the data were collected  | 7,9-10              |
|                                  | 4c      | How participants were identified and consented  | 8                   |
| Interventions                    | 5       | The interventions for each group with sufficient details to allow replication, including how and when they were actually administered   | 8-9                 |
| Outcomes                         | 6a      | Completely defined prespecified assessments or measurements to address each pilot trial objective specified in 2b, including how and when they were assessed                                | 10-11               |
|                                  | 6b      | Any changes to pilot trial assessments or measurements after the pilot trial commenced, with reasons  | n/a                 |
|                                  | 6c      | If applicable, prespecified criteria used to judge whether, or how, to proceed with future definitive trial   | n/a                 |
| Sample size                      | 7a      | Rationale for numbers in the pilot trial  | 10-11               |
|                                  | 7b      | When applicable, explanation of any interim analyses and stopping guidelines  | n/a                 |
| Randomisation:                   |         |   |                     |
| Sequence generation              | 8a      | Method used to generate the random allocation sequence  | 8                   |
|                                  | 8b      | Type of randomisation(s); details of any restriction (such as blocking and block size)  | 8                   |
| Allocation concealment mechanism | 9       | Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned | 8                   |

|  |     |   |                       |
|--|-----|---|-----------------------|
| Implementation                                       | 10  | Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions   | 8                     |
| Blinding   | 11a | If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how  | 8                     |
|  | 11b | If relevant, description of the similarity of interventions   | 9-10                  |
| Statistical methods                                  | 12  | Methods used to address each pilot trial objective whether qualitative or quantitative  | 10-11                 |
| <b>Results</b>                                       |     |   |                       |
| Participant flow (a diagram is strongly recommended) | 13a | For each group, the numbers of participants who were approached and/or assessed for eligibility, randomly assigned, received intended treatment, and were assessed for each objective | Figure 3              |
|  | 13b | For each group, losses and exclusions after randomisation, together with reasons  | Figure 3              |
| Recruitment  | 14a | Dates defining the periods of recruitment and follow-up   | Figure 2, page 10-11  |
|  | 14b | Why the pilot trial ended or was stopped  | 11                    |
| Baseline data  | 15  | A table showing baseline demographic and clinical characteristics for each group  | Table 1               |
| Numbers analysed                                     | 16  | For each objective, number of participants (denominator) included in each analysis. If relevant, these numbers should be by randomised group  | Figure 3              |
| Outcomes and estimation                              | 17  | For each objective, results including expressions of uncertainty (such as 95% confidence interval) for any estimates. If relevant, these results should be by randomised group        | Supplemental Figure 1 |
| Ancillary analyses                                   | 18  | Results of any other analyses performed that could be used to inform the future definitive trial  | Table 2               |
| Harms  | 19  | All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)   | 13-14                 |
|  | 19a | If relevant, other important unintended consequences  | n/a                   |
| <b>Discussion</b>                                    |     |   |                       |
| Limitations  | 20  | Pilot trial limitations, addressing sources of potential bias and remaining uncertainty about feasibility   | 15-18                 |
| Generalisability                                     | 21  | Generalisability (applicability) of pilot trial methods and findings to future definitive trial and other studies   | 15-18                 |
| Interpretation                                       | 22  | Interpretation consistent with pilot trial objectives and findings, balancing potential benefits and harms, and considering other relevant evidence                                   | 18                    |
|  | 22a | Implications for progression from pilot to future definitive trial, including any proposed amendments   | 15-18                 |
| <b>Other information</b>                             |     |   |                       |
| Registration   | 23  | Registration number for pilot trial and name of trial registry  | 3                     |
| Protocol   | 24  | Where the pilot trial protocol can be accessed, if available  | n/a                   |
| Funding  | 25  | Sources of funding and other support (such as supply of drugs), role of funders   | 3                     |
|  | 26  | Ethical approval or approval by research review committee, confirmed with reference number  | 7                     |

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Citation: Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L, et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ*. 2016;355.  
\*We strongly recommend reading this statement in conjunction with the CONSORT 2010, extension to randomised pilot and feasibility trials, Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see [www.consort-statement.org](http://www.consort-statement.org).

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# BMJ Open

## Nature vs. urban hiking for Veterans with posttraumatic stress disorder: a pilot randomized trial conducted in the Pacific Northwest United States

|                                 |   |
|---------------------------------|---|
| Journal:                        | <i>BMJ Open</i>   |
| Manuscript ID                   | bmjopen-2021-051885.R1  |
| Article Type:                   | Original research   |
| Date Submitted by the Author:   | 21-Jul-2021   |
| Complete List of Authors:       | Littman, Alyson; VA Puget Sound Health Care System, Seattle Epidemiologic Research and Information System and Seattle-Denver Center of Innovation; University of Washington, Epidemiology<br>Bratman, Gregory N; University of Washington<br>Lehavot, Keren; University of Washington School of Public Health, Department of Veterans Affairs Puget Sound Health Care System<br>Engel, Charles C; University of Washington School of Public Health, Department of Veterans Affairs Puget Sound Health Care System<br>Fortney, John ; University of Washington<br>Peterson, Alexander; VA Puget Sound Health Care System, Seattle Epidemiologic Research and Information Center<br>Jones, Alex; Outdoors for All<br>Klassen, Carolyn; Seattle Epidemiologic Research and Information Center<br>Brandon, Josh; Spirit of America<br>Frumkin, Howard; University of Washington |
| <b>Primary Subject Heading</b>: | Mental health   |
| Secondary Subject Heading:      | Complementary medicine, Epidemiology, Public health, Qualitative research, Sports and exercise medicine   |
| Keywords:                       | Adult psychiatry < PSYCHIATRY, TRAUMA MANAGEMENT, COMPLEMENTARY MEDICINE, PUBLIC HEALTH   |
|                                 |   |

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3 1 **Nature vs. urban hiking for Veterans with posttraumatic stress disorder: a pilot randomized trial conducted in**  
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5 2 **the Pacific Northwest United States**

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7 3 Alyson J Littman<sup>1,2,3\*</sup>, Gregory N Bratman<sup>4,10</sup>, Keren Lehavot<sup>3,6,7</sup>, Charles C Engel<sup>3,6</sup>, John C Fortney<sup>3,5,6</sup>, Alexander  
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3 **25 ABSTRACT**  
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5 **26 Objectives:** To evaluate feasibility and acceptability of a group-based nature recreation intervention (nature  
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7 hiking) and control condition (urban hiking) for military Veterans with post-traumatic stress disorder (PTSD).  
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10 **28 Design and setting:** A pilot randomized controlled trial conducted in the U.S. Pacific Northwest.  
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12 **29 Participants:** Veterans with PTSD due to any cause.  
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14 **30 Interventions:** Twenty-six participants were randomized to a 12-week intervention involving either six nature  
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16 hikes (n=13) or six urban hikes (n=13).  
17 **31**

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19 **32 Primary and secondary outcome measures:** Feasibility was assessed based on recruitment, retention and  
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21 attendance. Questionnaires and post-intervention qualitative interviews were conducted to explore intervention  
22  
23 acceptability. Questionnaires assessing acceptability and outcomes planned for the future trial (e.g., PTSD  
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25 symptoms) were collected at baseline, 6-, 12- (immediately after the final hike) and 24-weeks follow-up.  
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28 **36 Results:** Of 415 people assessed for eligibility/interest, 97 were interested and passed preliminary eligibility  
29  
30 screening, and 26 were randomized. Mean completion of all questionnaires was 91% among those in the nature  
31  
32 hiking group and 68% in those in the urban hiking group. Over the course of the intervention, participants in the  
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34 nature and urban groups attended an average of 56% and 58%, respectively, of scheduled hikes. Acceptability of  
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36 both urban and nature hikes was high; over 70% reported a positive rating (i.e., good/excellent) for the hike  
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38 locations, distance, and pace. Median PTSD symptom scores (PTSD Checklist-5) improved more at 12- and 24-  
39  
40 weeks among those in the nature vs. urban hiking group.  
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42 **42**

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44 **43 Conclusions:** This pilot study largely confirmed the feasibility and acceptability of nature hiking as a potential  
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46 treatment for Veterans with PTSD. Adaptations will be needed to improve recruitment and increase hike  
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48 attendance for a future randomized controlled trial to effectively test and isolate the ways in which nature  
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50 contact, physical activity, and social support conferred by the group impact outcomes.  
51 **46**

52 **47 Trial registration:** Clinicaltrials.gov (NCT03997344)  
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3 49 **Key words:** posttraumatic stress disorder, Veterans, nature, green exercise, pilot randomized controlled trial

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8 51 **Strengths and limitations of the study**

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10 52 • The intervention, nature hiking (green exercise), is attractive because it has the potential to be a low  
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12 53 stigma PTSD treatment option with physical and mental health benefits.  
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14 54 • By using group-based urban hiking as a comparison group to control for the effects of physical activity  
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16  
17 55 and social cohesion (present in both interventions), this study was designed to isolate benefits  
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19 56 specifically due to the environment (which differed between the interventions).  
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21 57 • We used population-based recruitment methods to enroll a representative sample of Veterans with  
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23 58 PTSD.  
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26 59 • Because of its small size and focus on feasibility, the study was not large enough to determine the  
27  
28 60 effectiveness of nature hiking on outcomes.  
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31  
32 62 **Funding:** This work was funded by Recreational Equipment, Inc. (REI; Award/Grant number is not applicable)  
33  
34  
35 63 and supported by equipment and outfitting contributions from Outdoor Research.  
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37 64

38  
39 65 **Competing interests:** The authors have no competing interests to report.  
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41 66 **Data availability statement:** Data are available upon reasonable request. Due to legal and ethical restrictions,  
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44 67 we are unable to share data publicly because the data contain potentially identifying and/or sensitive patient  
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46 68 information. Subject to IRB approval, de-identified data will be released to a local Department of Veterans  
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48 69 Affairs (VA) Puget Sound Health Care System and/or national VA research data repository for release to non-VA  
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50 70 protocols. The VA research data repository administrator will be responsible for reviewing and responding to  
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52 71 requests to release data to non-VA requestors. A data use agreement compliant with Veterans Health  
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55 72 Administration Handbooks 1200.12 and 1605.1 will be required between Veterans Health Administration and  
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73 the requestor. Review and approval by VA privacy officer is required prior to disclosure. Data access requests  
74 will be reviewed by the IRB of the VA Puget Sound Health Care System (contact via Dr. Littman –  
75 alyson.littman@va.gov), via mail address: 1660 S Columbian Way, Building 101 – 5W41, Seattle, WA 98108.

For peer review only

## 76 Introduction

77 Posttraumatic Stress Disorder (PTSD) is a common, chronic mental health condition that affects up to 30% of  
78 military Veterans and is frequently comorbid with anxiety, depression, and substance misuse (1–3). PTSD  
79 increases the risk of suicide as well as obesity, physical inactivity, and cardiovascular and metabolic disorders (1–  
80 12). Clinical practice guidelines recommend treatment with several evidence-based psychotherapies and  
81 medications (13), but many Veterans who need PTSD treatment do not receive it (14). Barriers to obtaining  
82 treatment include concerns about medication side effects, desire for self-management approaches, stigma  
83 about receiving mental health care, and a lack of confidence in mental health treatment in general (14–17).  
84 These and other factors adversely impact engagement, contributing to low initiation of (14,18–22) and high  
85 drop-out rates from treatment (20,23,24). Identifying a wider range of approaches that are acceptable and  
86 effective is key to reducing the burden PTSD places on individuals and their communities.

87  
88 There is growing interest in nature contact as a potential therapy for Veterans with PTSD and robust evidence  
89 that nature contact improves physical and psychological health, among healthy individuals and those with  
90 mental health disorders (25). Nature contact has been shown to increase subjective well-being; decrease stress,  
91 anxiety, depression, and negative affect; and promote adaptive shifts in emotion regulation (25,26). Benefits of  
92 nature contact are generally posited to occur based on two theories: Attention Restoration Theory (ART) and  
93 Stress Recovery Theory (SRT) (27,28). ART theorizes that nature contact improves cognitive function through a  
94 replenishment of “directed attention”, a capacity that is overly taxed in urban environments due to the need to  
95 block out distracting stimuli (e.g., noise) to focus on a specific task or cognitive process. This depleted attention  
96 capacity can be restored in natural environments through the engagement of “soft fascination”, with  
97 implications for both cognitive and emotional well-being. SRT is based on psycho-evolutionary principles, and  
98 posits that many types of nature exposure enhance psychological well-being through a pre-cognitive, positive

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3 99 affective response and activation of the parasympathetic nervous system in ways that reduce stress and  
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5 100 sympathetic nervous system arousal (26,29,30).  
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10 102 Like nature contact, physical activity (PA) is considered to be a promising approach to improve outcomes for  
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12 103 individuals with PTSD. PA reduces anxiety and depression and improves stress regulation, sleep, and cognitive  
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14 104 functioning in the general population (10,11,31), and in people with PTSD, though only eight studies have  
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16 105 involved randomized controlled trial (RCT) designs (4,32–39), and five of the RCTs were pilot studies or included  
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18 106 fewer than 30 people (32,33,35,38,39). Furthermore, we are aware of only one RCT focused on Veterans (39).  
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21 107 Group-based PA interventions may be particularly well-suited for military Veterans, due to 1) proportionally  
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23 108 higher rates of PTSD among Veterans (40), 2) consistency of PA interventions with values cultivated during  
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25 109 military service, and 3) benefits of social interaction with Veteran peers (41). To our knowledge, no PA  
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27 110 interventions in those with PTSD investigated the PA environment as a component of treatment. This is an  
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29 111 important omission, because the environment in which PA takes place may play an important role in its benefits  
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31 112 (42).  
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38 114 Green exercise, defined as activity that takes place in natural environments, is a burgeoning area of research  
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40 115 (43–48). A number of studies have documented benefits from green exercise in Veteran populations and among  
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42 116 individuals with PTSD (45–55). The specific interventions studied (from care farming to river rafting),  
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45 117 dose/duration, and inclusion of additional, explicit therapeutic components vary substantially among studies. A  
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47 118 2019 systematic review that examined evidence for the proposed additive effects of exercise in the presence of  
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49 119 nature observed some benefits (e.g., lower perceived exertion and enjoyment), the authors concluded that  
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51 120 there was a high risk of bias across trials and an overall low quality of evidence (44). Thus, uncertainty about the  
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54 121 duration and impacts of green exercise remains due to methodological issues and because most interventional  
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56 122 studies tested only a single bout of exercise (43,44). Furthermore, in the studies including Veterans, important  
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3 123 limitations include low retention for follow-up, absence of control groups, and insufficient statistical power (52–  
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11 126 In addition to nature contact and PA, a third important component of many green exercise interventions  
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13 127 includes a group component. Some recent research suggests that increased social cohesion and connectedness  
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15 128 may mediate benefits of green exercise (59), but findings are inconsistent (60). Social support forged through  
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18 129 group activity could be particularly relevant for Veterans, as camaraderie and solidarity are critical components  
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20 130 of military culture, and ones that are frequently lost in the return to civilian life (61). Social support is associated  
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22 131 with reduced PTSD symptoms and improved treatment response (62) and may directly impact stress response  
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24 132 by increasing personal resources (63), and/or may indirectly impact PTSD symptom severity and response to  
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27 133 treatment through buffering the potentially harmful impacts of stressful events (64).  
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31 135 Adequately powered studies involving ongoing green exercise that are designed to distinguish between benefits  
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33 136 due to PA and those due to the physical (e.g., nature) and social (e.g., group cohesion) environment are needed.  
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36 137 Thus, our goal was to design and conduct a pilot study to test the feasibility and acceptability of a green exercise  
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38 138 intervention for PTSD symptoms in military Veterans, regardless of PTSD etiology. The intervention (nature  
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40 139 hiking) and the active control (urban hiking) were group-based and involved similar amounts of PA, to ensure  
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42 140 control of the potential benefits of the group-based social support and of PA. Figure 1 depicts our conceptual  
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45 141 model. This paper describes the results of the initial pilot study designed to emulate important elements of the  
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47 142 future envisioned full-scale randomized trial.  
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## 49 143 50 51 144 **Methods**

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### 147 Identification and recruitment of participants

148 We used active and passive methods to identify and recruit Veterans to participate. While receiving care at a  
149 Department of Veterans Affairs (VA) health care facility was not an inclusion criterion, we used VA electronic  
150 medical records as a key source to identify potentially eligible Veterans. We identified VA enrollees (identified  
151 using electronic medical records) with at least one encounter with a diagnosis of PTSD in the prior two years; a  
152 zip code in one of three Seattle-Tacoma area counties (King, Snohomish, and Pierce); no hospitalizations in the  
153 prior 3 months; and no diagnoses of schizophrenia, bipolar disorder, or other psychotic disorder. We randomly  
154 selected 1001 individuals who met these criteria from a total of approximately 7000 and mailed them a letter  
155 informing them about the study and inviting them to participate. We followed the mailing with up to three  
156 phone calls until we met recruitment targets, or the recruitment period ended, whichever happened first. We  
157 also placed study recruitment flyers in clinics in the VA Puget Sound and mailed flyers to four local organizations  
158 and clinics serving Veterans. Individuals who expressed an interest were mailed an invitation letter.

160 We initially screened all Veterans who expressed an interest in participating for eligibility over the phone;  
161 inclusion criteria assessed included a history of PTSD, ability/willingness to comply with study procedures (e.g.,  
162 complete questionnaires, wear and sync an activity monitor, drive to hikes, and walk at least 2 hours at an  
163 easy/moderate pace over uneven terrain). Exclusion criteria assessed included a diagnosis of schizophrenia,  
164 bipolar disorder, or other psychotic disorder; hospital admission in the prior 3 months, and inability to perform  
165 unsupervised physical activity based on the Physical Activity Readiness Questionnaire (65). We invited those  
166 who passed all criteria except for the Physical Activity Readiness Questionnaire to obtain approval to participate  
167 from their primary care provider. Though some of this information was available in VA medical records, because  
168 we also included Veterans who did not have VA medical records, we employed methods that allowed us to  
169 evaluate eligibility without medical record access. Those who passed initial screening were mailed consent forms  
170 and given a link to complete a more extensive screening questionnaire online. Via the online screening

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3 171 questionnaire, PTSD symptoms, drug use, alcohol misuse, and suicidality were assessed. PTSD was determined  
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5 172 based on a PTSD-checklist-5 (66) score  $\geq 33$ . We excluded those with drug abuse in past year (Drug Abuse  
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8 173 Screening Test-10 (67) score  $< 3$ ); alcohol disorder/dependence (current/past year; Alcohol Use Disorders  
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10 174 Identification Test-10 (68) score  $> 16$ ); and moderate/severe suicidality (past month; MINI Suicidality module (69)  
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12 175 score  $\geq 5$ ). Those who were eligible and returned signed consents were considered enrolled in the study.  
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### 14 176 15 16 17 177 Study design

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19 178 We conducted a two-arm randomized controlled feasibility trial. The two interventions were group nature and  
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21 179 group urban hiking. The random 1:1 allocation sequence was generated using simple randomization in random  
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23 180 blocks of 2, 4 and 6. Randomization assignments were placed in opaque sequentially numbered envelopes. Once  
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26 181 an individual was determined to be eligible, the study coordinator selected the next envelope to determine the  
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28 182 individual's group assignment. We did not blind participants, the study coordinator, or the study statistician to  
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30 183 group assignment. This study was registered at Clinicaltrials.gov (NCT03997344). Figure 2 presents an overview  
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32 184 of the study, including timing of assessments.  
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### 34 185 35 36 37 186 Description of hike locations and amenities

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39 187 The criteria used to select the hike locations (which applied to both nature and urban hikes) included duration,  
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41 188 elevation change, availability of facilities (e.g., toilets and water), distance from participants' homes, and access  
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44 189 to parking. Nature hikes were held in State Parks, National Wildlife Refuges, and Natural Resources Conservation  
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46 190 areas in the US Pacific Northwest. The nature hikes were in forest habitat, including old growth forest, saltwater  
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48 191 shoreline, waterfalls, and alpine lakes. Elevations ranged from sea level to 2200 feet above sea level. Urban  
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50 192 hikes were held in primarily built environments, avoiding urban parks or primarily residential neighborhoods  
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52 193 with substantial greenery or water features. Urban hikes comprised areas that included sports stadiums, urban  
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55 194 art, and retail establishments and were mainly on sidewalks rather than separated bike/pedestrian paths/rail-

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3 195 trails. It was not feasible to match nature and urban hikes on elevation change; instead, we aimed to have  
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5 196 similar hike durations to match total exertion. Generally, nature hikes involved somewhat shorter distances but  
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8 197 included more elevation gain/loss.  
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12 199 Hiking intervention  
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14 200 A total of 6 hikes over 12 weeks (one every other week) were offered between August and October 2019. We  
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17 201 chose to offer 6 hikes (vs. more or fewer) because this number was thought to be feasible and would be  
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19 202 sufficient to assess feasibility and acceptability. The standard structure for hikes was: 1) “ice breakers” (short,  
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21 203 guided conversations), 2) overview of the planned hike, including distance, unique features, and planned stops,  
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23 204 3) hike, and 4) post-hike debrief and administration of questionnaires. There were no additional  
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26 205 group/therapeutic activities.  
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30 207 Hike durations increased gradually to account for anticipated increases in participants’ physical fitness. Initial  
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32 208 hikes were 60-90 minutes (2-3 miles), and later hikes were 2-3 hours (5-6 miles). To ensure safety and inclusion,  
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35 209 one hike leader was in sight and hearing of the first participant and a second leader accompanied the last  
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37 210 participant. The group stopped at least every 30 minutes to keep everyone together and offer opportunities to  
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39 211 rest, regroup, and inquire about and address any issues or concerns arising since the last check-in.  
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43 213 The same hike leaders, who were non-clinicians, led both nature and urban hikes to control for hike-leader  
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46 214 effects. On every hike, at least one of the leaders was a woman. Leaders were experienced outdoor educators  
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48 215 who were employed by a Seattle-based outdoor organization that provides outdoor recreation activities for  
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50 216 people with disabilities. While the leaders were not Veterans, the organization received grants from the VA as  
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52 217 part of the Adaptive Sports Program (70) and had previously led programs for Veterans. Leaders were trained to  
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3 218 handle physical and mental health emergencies by the PIs (AJL and GNB) and a co-I who is a licensed clinical  
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5 219 psychologist (KL). AJL and GNB supervised the hike leaders during the study.  
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10 221 To reduce barriers to attendance, a \$35 incentive was provided to defray parking costs. We provided a rain  
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12 222 jacket and technical shirt as well as well as an activity monitor (Garmin vivosmart 4) at the participant's first  
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14 223 hike.  
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### 18 Outcomes

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21 226 The primary outcomes of interest were feasibility and acceptability. **Feasibility** was assessed based on  
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23 227 recruitment statistics (the proportion of individuals who were contacted, eligible, and enrolled, as well as  
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25 228 reasons for ineligibility), retention (questionnaire completion), hike attendance, and safety (e.g., adverse  
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27 229 events). We aimed to recruit 36-45 participants (12-15 people allocated to each of the three groups - nature  
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29 230 hiking, urban hiking, and a no-hiking control group) and complete enrollment by July 2019 (approximately 3  
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31 231 months after recruitment began) due to concerns about weather for hikes later in the fall. Because of lower-  
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33 232 than-anticipated recruitment numbers, in late June, we decided to eliminate the no-hiking control group. At this  
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35 233 time, only one person was randomized to the no-hiking control group and informed of their group assignment;  
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37 234 that person was re-randomized after this decision was made. The target for retention and attendance was 70%.  
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41 236 To assess **acceptability**, in the 6- and 12-week questionnaires, we included questions about distance, pace,  
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43 237 terrain, and locations of hikes and pre-hike and trailhead information and communication. These questions were  
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45 238 created for the study and asked participants to rate their perceptions on a 5- or 6-point Likert scale (e.g., from  
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47 239 very poor to excellent). We also included open-ended questions for participants to report what they thought  
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49 240 went well and what could have been better. Additionally, after the final hike, the lead author (AJL) conducted  
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51 241 semi-structured telephone interviews, with a goal to interview 10-15 participants. To include a range of  
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3 242 perspectives, we purposively sampled participants from both arms, aimed to include men and women, and  
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5 243 participants who varied in terms of hike attendance. Questions inquired about participants' impressions of the  
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8 244 hikes, including difficulty, location, length of time, distance from home, hike leaders, and reasons hikes were  
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10 245 missed (if applicable); study communications; enrollment process; assessments; and other  
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12 246 thoughts/impressions.

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17 248 Determination of **efficacy** was not a goal of this pilot RCT. The primary outcome of the future planned study is  
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19 249 PTSD symptoms, assessed by the PTSD-Checklist-5 (PCL-5), a 20-item instrument that assesses PTSD symptoms  
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21 250 in the past month (range 0 to 80, with higher scores indicating greater symptom severity). Other outcome  
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23 251 measures of interest for the future planned study, which are detailed in Supplemental Table 1, include quality of  
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26 252 life (71), positive and negative affect (72,73), sleep (74), rumination (75), and cognitive reappraisal (76).

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30 254 Baseline and follow-up assessments

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32 255 We conducted assessments online using commercial software (QuestionPro) at baseline (before hikes began),  
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35 256 each week after the first hike for 12 weeks (after the 6<sup>th</sup> hike), and then at week 24; questionnaires completed  
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37 257 immediately after the hikes were completed on paper. See Figure 2 for an overview and Supplemental Table 1  
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39 258 for measures at each time point. Questionnaires at weeks 6, 12, and 24 took approximately 30 minutes to  
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41 259 complete. Questionnaires administered at weeks 1-5 and 7-11 included fewer measures and/or shortened  
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44 260 versions and took 5-10 minutes to complete. Participants received gift cards worth \$10 for completing  
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46 261 questionnaires in weeks 1-5 and 7-11, \$20 for the 6-week questionnaire, and \$50 for the 12- and 24-week  
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48 262 questionnaires. In addition to questionnaires, to obtain objective information about PA (a potential mechanism  
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50 263 of benefit, which we would want to measure precisely in a future study), we asked participants to wear a wrist  
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52 264 worn-activity monitor (Garmin vivosmart 4) every day, for at least 10 hours per day, for the first 12 weeks of the  
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55 265 study. No incentives were provided for wearing or synching the watch.

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5 267 Data analysis

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8 268 *Quantitative analysis*

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10 269 The primary purpose of the extensive data collection was to evaluate feasibility of data collection rather than to  
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12 270 estimate effect sizes because estimating effect sizes from small pilot studies is inherently imprecise (77). Thus,  
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14 271 instead of conducting hypothesis tests for which we were underpowered, we present descriptive statistics (e.g.,  
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17 272 medians and interquartile ranges) for the primary outcome (PCL-5) only.  
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21 274 *Qualitative analysis*

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23 275 All interviews were recorded, and the interviewer took notes during interviews. For both the comments shared  
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26 276 via open-ended questions on the questionnaire and comments shared orally during the interviews, we  
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28 277 conducted inductive content analysis, which involves open coding of data, organizing codes and data into  
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30 278 categories, and comparing data across participants to identify patterns and themes in the data (78).  
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35 280 Patient and public involvement

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37 281 Patients were involved in the design and conduct of this study. The study question and design were informed by  
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39 282 a Veteran with PTSD who served as a co-investigator. The design and messaging for this pilot study were also  
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41 283 informed by a focus group of patients/Veterans who participated in a prior unpublished feasibility study.  
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46 285 Ethics approval

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48 286 This study was approved by the institutional review boards at the VA Puget Sound Health Care System (MIRB  
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50 287 01738) and the University of Washington (6951).  
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55 289 **Results**

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60290 *Feasibility*291 *Recruitment statistics*

Recruitment took place between April and August 2019 (16 weeks total). Of the 1001 patients mailed an invitation letter, we were unable to assess interest or eligibility in 586 (because they did not respond to the mailings and/or answer the phone when called; see Figure 3 for CONSORT diagram). Of the 415 with whom we made contact, 159 were not interested, 102 had health conditions that limited their walking/hiking, 36 had time conflicts (e.g., work or church on Sundays or travel that would prevent participation), and 37 had other reasons that they were unable to participate (e.g., moving out of the area, did not have PTSD, etc.). Of the 97 (81 from letters + 16 from passive recruitment) interested who passed initial screening, 48 completed the online screening questionnaire. Twenty individuals were not eligible, 2 decided that they did not wish to participate, and 26 were eligible and randomized. Of the 20 who were not eligible, 13 were ineligible because of a moderate/high risk of suicide or skipping the question on suicidality, and 6 did not meet the threshold for PTSD. Compared to those contacted and not randomized, a greater proportion of those randomized were women (27% randomized vs. 15% of those contacted), white (73% vs. 63%), and Hispanic (8% vs. 6%). Additionally, those who were randomized were younger (mean age = 47, range 25-65) than those not randomized (mean age = 52, range: 21-95).

Table 1 presents characteristics of Veterans who were randomized and includes self-reported race/ethnicity, which differed from race/ethnicity in the electronic medical record (reported above). Specifically, 42% of those randomized self-reported being white, whereas the electronic medical record data indicated that 73% were white. Thirty percent had a college degree or more. Less than half worked full time and 46% had 100% VA service-connected disability, indicating severe impairment in ability to work. Nearly two-thirds of participants had served in combat and 68% had depressive symptoms based on the PHQ-8. Based on self-report, nearly 70% met or exceeded PA guidelines of at least 75 minutes per week of vigorous-intensity activity or 150 minutes per

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3 314 week of moderate-intensity activity, or an equivalent combination of the two. At baseline (prior to study  
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5 315 initiation), 81% of participants reported hiking at least one time and 27% completed 7 or more hikes in the prior  
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8 316 year.

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12 318 *Retention (questionnaire completion)*

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14 319 Mean completion of all questionnaires was 91% in the nature hiking group and 68% in the urban hiking group.  
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17 320 Completion rates were similar for the shorter weekly questionnaires and the longer questionnaires.

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21 322 *Hike attendance*

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23 323 Over the course of the intervention, participants in the nature and urban groups attended an average of 56%  
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25 324 and 58%, respectively, of scheduled hikes. In the nature group, one person attended no hikes, four (31%)  
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28 325 attended 1-2 hikes, one attended 3 hikes, and seven (54%) attended 4-6 hikes. In the urban group, one person  
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30 326 attended no hikes, four (31%) attended 1-2 hikes, no one attended only 3 hikes, and eight (62%) attended 4-6  
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32 327 hikes. Attendance was lower among women in the nature group (n=5, mean: 43%) than among women in the  
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34 328 urban group (n=2, 67%), whereas among men, hike attendance was similar in the two groups (65% vs. 56%).  
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37 329 Common reasons for missing hikes included work, childcare, and prior plans.

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41 331 *Safety/Adverse events*

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43 332 One participant in the urban hiking arm reported increased anxiety/PTSD symptoms in connection with hiking in  
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46 333 the urban environment and withdrew from the study.

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50 335 *Acceptability*

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52 336 *Quantitative findings*



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3 337 Acceptability of both the urban and nature hikes was high. Over 70% reported a positive rating (i.e., good or  
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5 338 excellent vs. very poor/inadequate, inadequate, or adequate) for the hike locations, distance, and pace.  
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8 339 Additionally, on average, pre-hike information, pre-hike communication, and trailhead communication were  
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10 340 rated as good to excellent. Scores (minimum=1, maximum=5) were similar in the urban and nature hike groups  
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12 341 at 6 weeks, but were lower in the urban hiking arm at 12 weeks (pre-hike information, mean scores: nature=4.4,  
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14 342 urban=3.6; pre-hike communication: nature=4.6, urban=3.8; trailhead communication: nature=4.6, urban=4.1)  
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### 18 19 344 *Qualitative findings*

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21 345 In response to the open-ended question on the questionnaire (“What went well so far?”), participants shared  
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23 346 positive comments such as “This group seems to mesh really well”, “all expectations were exceeded”, and “good  
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25 347 planning, leadership, and execution.” In response to the question, “What do you think we can do better?”,  
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28 348 suggestions included having regional groups, closer hikes or paying for gas; weekly (instead of every other week)  
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30 349 hikes; more team building and opportunities to socialize with others; and including more women and/or  
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32 350 women-only groups. Key themes from the qualitative interviews, which are presented in Table 2, echoed, and  
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34  
35 351 elaborated on themes shared in the questionnaire. Most participants felt positively about their experience in the  
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37 352 study. As noted above, they liked getting to know other Veterans and having a “mission.” Veterans wanted to  
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39 353 find more ways of connecting with one another socially during hikes as well as outside of hikes. Hike logistics  
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41 354 (e.g., distance from home) were noted as potential barriers to attendance.  
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### 45 46 356 *Efficacy measures*

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48 357 Median PCL-5 scores decreased from baseline to week 12 and remained at the 12-week level at week 24 for  
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50 358 those in the nature hiking group (baseline=41, 12-weeks = 32, 24 weeks=31). Among those in the urban hiking  
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52 359 group, PCL-5 scores decreased from baseline to 12 weeks but increased nearly back to baseline levels at 24  
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3 360 weeks (baseline=48, 12-weeks = 43, 24 weeks=47) (Supplemental Figure 1). We did not test the statistical  
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5 361 significance of the changes because this pilot study was not designed to answer this question (79).  
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## 10 363 **Discussion**

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14 365 This study was an important step in establishing feasibility and acceptability and identifying changes to consider  
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17 366 in the development of a rigorous, fully-powered study to evaluate the impact of nature hiking on PTSD  
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19 367 symptoms. The results of this pilot study generally supported feasibility and acceptability. Participants reported  
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21 368 high acceptability, enjoyment, and value, based on quantitative and qualitative data. In both arms, more than half  
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23 369 of participants completed most hikes. Qualitative feedback about improving the social component supports the  
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26 370 hypothesis that social connection is an important aspect of hikes, indicating a need to further develop the social  
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28 371 component and continue to study group interventions like this one. Additionally, the decrease in median scores  
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30 372 on the PCL-5 among those in the nature group after the 12-week hiking intervention, and 12 weeks later (week  
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32 373 24) is promising. This preliminary finding should be investigated more thoroughly in future, larger-scale versions  
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35 374 of our study. The indication that improvements may persist after the conclusion of the intervention is especially  
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37 375 compelling given the current unknowns regarding the duration of effects of nature interventions.  
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41 377 Nevertheless, several issues need to be considered related to feasibility and acceptability for the next iteration  
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43 378 of this research.  
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### 48 380 *Feasibility of recruitment*

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50 381 We fell short of our goal of recruiting at least 36 people over 4 months. Failing to meet recruitment goals in the  
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52 382 planned timeframe is a common problem in randomized controlled trials (80). Barriers to recruitment included  
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55 383 unexpected delays, insufficient resources, and an inefficient recruitment process. Regarding delays, we had to  
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3 384 wait weeks for IRB approval for each proposed modification to recruitment materials/protocol. Regarding  
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5 385 resources, we only had 20 hours per week of paid staff time for recruitment. The addition of two volunteers in  
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8 386 the final two months helped to accelerate enrollment, but more resources earlier in recruitment would have  
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10 387 been necessary to meet our goal.

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14 389 One contributor to inefficiency in recruitment was the broad, population-based approach we employed for  
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17 390 active recruitment. To identify patients for the introductory mailing, the only inclusion criteria were having a  
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19 391 single encounter in VA's electronic medical record with a PTSD diagnosis and living in one of three Puget Sound  
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21 392 counties. The only exclusion criteria were a diagnosis of schizophrenia, bipolar disorder, or other psychotic  
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23 393 disorder. Likely in part because of this broad approach, which did not include upper age limits, approximately  
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26 394 one quarter of contacted individuals reported a health condition that impaired their walking. Burdensome study  
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28 395 procedures may have also impacted recruitment. About half of interested participants failed to complete the  
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30 396 online screening questionnaire and others informed us that they had trouble completing the online  
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32 397 questionnaire. Imposing an upper age limit (e.g., 65 years) and restructuring the recruitment process to make it  
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35 398 faster and easier for potential participants may be necessary.

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39 400 Accessibility of the intervention and restrictive eligibility criteria may have also impacted recruitment. In  
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41 401 addition to being able to walk over uneven ground for at least two hours, participants also had to be available  
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44 402 during the times selected, have low suicide risk, and be free from physical conditions such as high blood  
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46 403 pressure (or obtain their primary care provider's permission) among several other criteria. Changing inclusion  
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48 404 criteria (e.g., eliminating restrictions related to suicidality) would require tradeoffs related to safety that must be  
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50 405 considered carefully.

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3 407 Lastly, about 38% (159/415) of those for whom we were able to assess eligibility and interest declined  
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5 408 participation. While some of these people may have declined because of the additional burdens of a research  
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8 409 study, this statistic indicates that hiking may only appeal to a segment of the population, just as psychotherapy  
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10 410 and pharmacotherapy only appeal to subsets of the population (81). Because of differences in treatment  
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12 411 preferences, offering options is important, and nature hiking merits consideration so that we can rigorously  
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14 412 assess its efficacy.  
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#### 18 19 414 *Retention*

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21 415 Retention varied by group and was poorer for the wrist-worn activity monitor than for the questionnaires. The  
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23 416 activity monitor had a substantial amount of missing data, which is a common problem for activity monitors  
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25 417 (82), and may have been related to the number of technical steps required for setting up the watch and syncing  
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28 418 it, as many participants needed additional help to troubleshoot problems. Providing more support to set up the  
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30 419 watch and incentives to wear and sync it may help to obtain more complete data. While overall questionnaire  
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32 420 completion was high, it was higher in the nature hiking group (91%) than in the urban hiking group (68%).  
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35 421 Though the small sample and our inability to conduct interviews with those who did not complete follow-up  
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37 422 measures makes inference difficult, the retention differences could be a marker of commitment to the study.  
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39 423 Future studies should pay careful attention to marketing the study to ensure that both interventions are  
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41 424 perceived as helpful. Enhancing the social aspects of the interventions may help achieve that goal. The  
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43 425 difference in incentives provided for questionnaire completion vs. the other aspects of the study may also have  
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46 426 played a role in retention for different study aspects. However, many participants shared that they participated  
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48 427 to help fellow Veterans, indicating altruistic/intrinsic motivators for participation, reinforcing the importance of  
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50 428 understanding drivers of participation, and reducing barriers and enhancing facilitators.  
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#### 53 54 55 430 *Acceptability of the hiking interventions*

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3 431 Hike attendance (56%) was lower than our target (70%) and women had lower attendance in the nature hiking  
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5 432 group than men. While we were unable to ascertain reasons for missing hikes for each person, some reasons  
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7 reported (e.g., other plans, work) were hard to avoid, while others (driving distance to hikes) could be addressed  
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10 434 in the future by restricting the geographic area of recruitment and hikes and/or organizing small groups at  
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12 435 different times to accommodate individuals' schedules. Our study, unfortunately, does not shed light on the  
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14 436 optimal hike "dose." We suspect that 8-12 hikes (similar to a standard psychotherapy course) may be optimal  
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17 437 for achieving clinically meaningful results. Additional research will be necessary to examine this important  
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19 438 question. There were also an indication of lower acceptability/ratings for information sharing in the urban hiking  
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21 439 vs. the nature hiking groups. While we aimed to share information about the urban area, we did not provide an  
22  
23 440 exact route, which may have made it more difficult for participants to research urban vs. nature hikes, where we  
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25 listed a trail. Providing a map of the route might help participants feel prepared. Regarding differences in  
26 441  
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28 442 attendance by gender, a history of military sexual trauma, which is common among women Veterans (83), may  
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30 443 have impacted some women participants' comfort and perception of safety of hiking in nature with a majority  
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32 444 male group. Ensuring a greater proportion of women in each group or organizing women-only groups (as was  
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34 suggested by some participants) could address this concern. These changes, would, however, result in additional  
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37 446 costs and tradeoffs that would need to be carefully considered.  
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#### 41 448 *Conclusions*

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43 449 This pilot study provided useful information related to feasibility and acceptability, including common factors  
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45 that resulted in exclusion; resources and procedures needed for recruitment; factors to consider for selection of  
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48 451 nature and urban hikes; and barriers and facilitators to achieving high completion in follow-up assessments and  
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50 452 the hikes. These insights can be harnessed to increase participation and rigor in future, scaled-up iterations of  
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52 453 the study, and ensure that environments are safe (i.e., non-triggering). Future studies with larger sample sizes  
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3 454 are needed to isolate the ways nature contact, PA, and social support conferred by the group impact outcomes  
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6 455 to develop and provide well-tailored interventions.  
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For peer review only

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3 458 **List of abbreviations**

4  
5 459 ART Attention Restoration Theory  
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8 460 HIPAA Health Insurance Portability and Accountability Act  
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10 461 IRB Institutional Review Board  
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12 462 PA Physical activity  
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14 463 PCL-5 PTSD Checklist for Diagnostic and Statistical Manual 5  
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17 464 PTSD Posttraumatic stress disorder  
18  
19 465 SRT Stress Recovery Theory  
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21 466 VA Department of Veterans Affairs  
22

23 467  
24  
25 468 **Acknowledgements**

26  
27  
28 469 We thank the Veterans who participated in this study for allowing us to learn from them, including the Veterans  
29  
30 470 who participated in a prior unpublished feasibility study. We also thank Morgan Meadows and Gabrielle Fong  
31  
32 471 for their help with recruitment. This material is the result of work supported by VA Puget Sound Health Care  
33  
34 472 System, Seattle, WA. The views expressed in this article are those of the authors and do not necessarily reflect  
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36  
37 473 the position or policy of the Department of Veterans Affairs, the United States Government, Recreational  
38  
39 474 Equipment, Inc. (REI), or Outdoor Research.  
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45 476 **Contributors:** AJL, GNB, CCE, JCF, KL, JB, and HF conceptualized the study and contributed to the intervention  
46  
47 477 development and design. AJL and GNB oversaw the conduct of the trial all the authors contributed to the  
48  
49 478 ongoing management of the trial. AJL, GNB, MM, AP, and CK oversaw data collection and data analysis. The  
50  
51 479 manuscript was drafted by AJL. All the authors contributed to the interpretation of the findings and revised and  
52  
53  
54 480 reviewed the paper.  
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Figure 1. Conceptual model

Figure 2. Depiction of study design and assessments

Figure 3. CONSORT diagram

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**Table 1. Baseline characteristics of Veterans in the urban and nature hiking groups**

| Characteristic             | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|----------------------------|--------------|------------|---------------|------------|--------------|------------|
|                            | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| <b>Age (years)</b>         |              |            |               |            |              |            |
| <30                        | 2            | 8          | 1             | 8          | 1            | 8          |
| 30-39                      | 5            | 19         | 2             | 15         | 3            | 23         |
| 40-49                      | 6            | 23         | 4             | 31         | 2            | 15         |
| 50-59                      | 11           | 42         | 6             | 46         | 5            | 38         |
| ≥60                        | 2            | 8          | 0             | 0          | 2            | 15         |
| <b>Gender</b>              |              |            |               |            |              |            |
| Male                       | 19           | 73         | 8             | 62         | 11           | 85         |
| Female                     | 7            | 27         | 5             | 38         | 2            | 15         |
| <b>Race/ethnicity</b>      |              |            |               |            |              |            |
| Asian/Pacific Islander, NH | 3            | 12         | 2             | 15         | 1            | 8          |
| Black, NH                  | 2            | 8          | 0             | 0          | 2            | 15         |
| Hispanic                   | 3            | 12         | 1             | 8          | 2            | 15         |
| Native American, NH        | 2            | 8          | 0             | 0          | 2            | 15         |
| Other                      | 1            | 4          | 0             | 0          | 1            | 7.7        |
| White, NH                  | 15           | 58         | 10            | 77         | 5            | 38         |
| <b>Marital status</b>      |              |            |               |            |              |            |
| Single, never married      | 4            | 15         | 3             | 23         | 1            | 8          |
| Married currently          | 14           | 54         | 7             | 54         | 7            | 54         |

| Characteristic  | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|---|--------------|------------|---------------|------------|--------------|------------|
|   | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| Separated/divorced  | 8            | 31         | 3             | 23         | 5            | 38         |
| <b>Education</b>  |              |            |               |            |              |            |
| High school degree or equivalent  | 4            | 15         | 1             | 8          | 3            | 23         |
| Some college, no degree   | 10           | 38         | 7             | 54         | 3            | 23         |
| Associate degree  | 4            | 15         | 1             | 8          | 3            | 23         |
| Bachelor's degree   | 4            | 15         | 2             | 15         | 2            | 15         |
| Masters, doctorate, or professional<br>degree                               | 4            | 15         | 2             | 15         | 2            | 15         |
| <b>Annual household income</b>  |              |            |               |            |              |            |
| \$25,000-\$49,999   | 7            | 27         | 4             | 31         | 3            | 23         |
| \$50,000-\$74,999   | 11           | 42         | 4             | 31         | 7            | 54         |
| \$75,000-\$99,999   | 2            | 8          | 1             | 8          | 1            | 8          |
| \$100,000 or more   | 4            | 15         | 3             | 23         | 1            | 8          |
| Prefer not to answer  | 2            | 8          | 1             | 8          | 1            | 8          |
| <b>Employment status</b>  |              |            |               |            |              |            |
| Full-time   | 12           | 46         | 6             | 46         | 6            | 46         |
| Part-time   | 1            | 4          | 1             | 8          | 0            | 0          |
| Not employed (disabled, retired, not<br>looking for work, homemaker, other) | 13           | 50         | 6             | 46         | 7            | 54         |
| <b>Highest military rank</b>  |              |            |               |            |              |            |

| Characteristic                               | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|--|--------------|------------|---------------|------------|--------------|------------|
|  | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| Enlisted (E1-E4)                             | 9            | 35         | 4             | 31         | 5            | 38         |
| Non-commissioned officer (E5-E9)             | 15           | 58         | 8             | 62         | 7            | 54         |
| Officer (O1-O4)                              | 2            | 8          | 1             | 8          | 1            | 8          |
| <b>VA disability rating*†</b>                |              |            |               |            |              |            |
| No rating                                    | 2            | 8          | 0             | 0          | 2            | 15         |
| 30-60%                                       | 2            | 8          | 2             | 15         | 0            | 0          |
| 70-90%                                       | 8            | 31         | 4             | 31         | 4            | 31         |
| 100%   | 12           | 46         | 6             | 46         | 6            | 46         |
| <b>Self-reported health</b>                  |              |            |               |            |              |            |
| Excellent/very good                          | 9            | 35         | 3             | 23         | 6            | 45         |
| Good   | 11           | 42         | 7             | 54         | 4            | 31         |
| Fair (no one reported poor)                  | 6            | 23         | 3             | 23         | 3            | 23         |
| <b>PCL-5 score‡</b>                          |              |            |               |            |              |            |
| Mean, SD                                     | 47.1         | 10.9       | 46.0          | 11.4       | 48.2         | 10.8       |
| <b>Served in combat [yes]</b>                | 17           | 65         | 8             | 62         | 9            | 69         |
| <b>Combat Exposure Score; mean (SD)* †</b>   | 16.6         | 7.9        | 15.6          | 8.2        | 17.7         | 7.9        |
| <b>Patient Health Questionnaire-8 score*</b> |              |            |               |            |              |            |
| <10 (no depression)                          | 8            | 32         | 4             | 33         | 4            | 31         |
| 10-19 (major depression)                     | 14           | 56         | 7             | 58         | 7            | 54         |
| ≥20 (severe major depression)                | 3            | 12         | 1             | 8          | 2            | 15         |

| Characteristic  | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|---|--------------|------------|---------------|------------|--------------|------------|
|   | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| <b>Physical activity level</b>  |              |            |               |            |              |            |
| Low   | 8            | 31         | 5             | 38         | 3            | 23         |
| Moderate  | 3            | 12         | 1             | 8          | 2            | 15         |
| High  | 15           | 58         | 7             | 54         | 8            | 62         |
| <b>Times gone hiking for 1+ hrs in last year</b>                      |              |            |               |            |              |            |
| Never   | 5            | 19         | 3             | 23         | 2            | 15         |
| 1-3   | 9            | 35         | 4             | 31         | 5            | 38         |
| 4-6   | 5            | 19         | 2             | 15         | 3            | 23         |
| 7+  | 7            | 27         | 4             | 31         | 3            | 23         |
| <b>Outdoor / nature-based activity<br/>experience</b>                 |              |            |               |            |              |            |
| None (no experience in the outdoors)                                  | 0            | 0          | 0             | 0          | 0            | 0          |
| Casual (done some day hiking on<br>maintained trails and car camping) | 10           | 38         | 5             | 38         | 5            | 38         |
| Amateur (have experience with<br>backpacking)                         | 11           | 42         | 6             | 46         | 5            | 38         |
| Expert (substantial backcountry<br>experience)                        | 5            | 19         | 2             | 15         | 3            | 23         |

Abbreviations: NH, Non-Hispanic; PCL-5, Post-traumatic stress disorder checklist for Diagnostic and  
Statistical Manual 5; PTSD, post-traumatic stress disorder; SD, standard deviation

\* Missing response for 1 nature participant

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3 † Missing response for 1 urban participant  
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6 ‡ One person in the nature hiking group had a PCL-5 of 32 (below the eligibility threshold of 33) due to  
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8 an undetected error in initial scoring.  
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**Table 2. Key themes and findings from qualitative data**

| Themes                | Findings  |
|-----------------------|---|
| A positive experience | <ul style="list-style-type: none"> <li>Both nature (“All expectations were exceeded”) and urban study participants (“LOVE THE GROUP”) provided positive feedback.</li> </ul>  |
| Perceived benefits    | <ul style="list-style-type: none"> <li>Participants reported on how the hikes helped them to be more active, lose weight, reduce stress, and feel more connected to others.</li> </ul>  |
| Hike logistics        | <ul style="list-style-type: none"> <li>Participants suggested that prior to hikes, we ensure parking access, availability of toilets, and locate the hikes closer to participants’ homes.</li> <li>Others suggested that we consider organizing carpools and/or covering gas/mileage costs</li> </ul>   |
| Difficulty of hikes   | <ul style="list-style-type: none"> <li>Most found the difficulty just right.</li> <li>Some felt that the hikes were too short/easy.</li> </ul>  |
| Location of hikes     | <ul style="list-style-type: none"> <li><u>Nature group</u>: One participant wished that there was more of a “reward” (“like a waterfall”, “when you have a view, it seems more profound”), because some were just “walks through the woods.”</li> <li><u>Urban group</u>: One person noted that some neighborhoods were “sketchy” and they were “constantly walking around garbage” for one hike. Others noted that they really enjoyed exploring different neighborhoods, areas around sports stadium, and learning about the history of areas.</li> </ul> |

|   |  |
|---|--|
| Group composition   | <ul style="list-style-type: none"> <li>• A few participants suggested that we enroll more women or organize women-only groups and/or groups for survivors of sexual assault.</li> </ul>  |
| Incentives for completing questionnaires                          | <ul style="list-style-type: none"> <li>• Participants suggested that we offer the option to receive a single gift card that accumulated value instead of separate ones each time a questionnaire was completed.</li> </ul>   |
| Assessments   | <ul style="list-style-type: none"> <li>• Several participants had trouble with the online software (e.g., getting “kicked out” of the survey mid-way through);</li> <li>• Some participants reported that they would have liked text prompts instead of email, since they did not regularly check their email.</li> <li>• Some participants found some questions to be difficult to answer (e.g., the Perceived Cohesion Scale) or they were confused by differences in the time frame for different instruments (e.g., on the weekly questionnaires, some questions asked participants how they felt “right now” while others asked about the prior week).</li> </ul> |
| Activity monitors   | <ul style="list-style-type: none"> <li>• Several participants noted having problems programming and syncing the activity monitor.</li> </ul>   |
| Fostering interaction/connections between participants in a group | <ul style="list-style-type: none"> <li>• Participants suggested facilitating more structured ways to get to know other members of the group, including a social gathering prior to the initial hike, re-introductions before each hike, gathering for lunch or other meal after hikes, and organizing a social media group.</li> </ul>   |



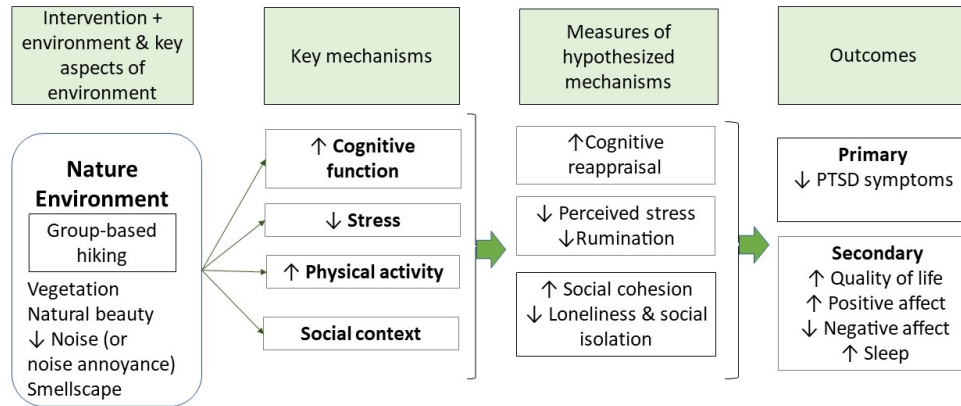


Figure 1. Conceptual model

338x190mm (96 x 96 DPI)

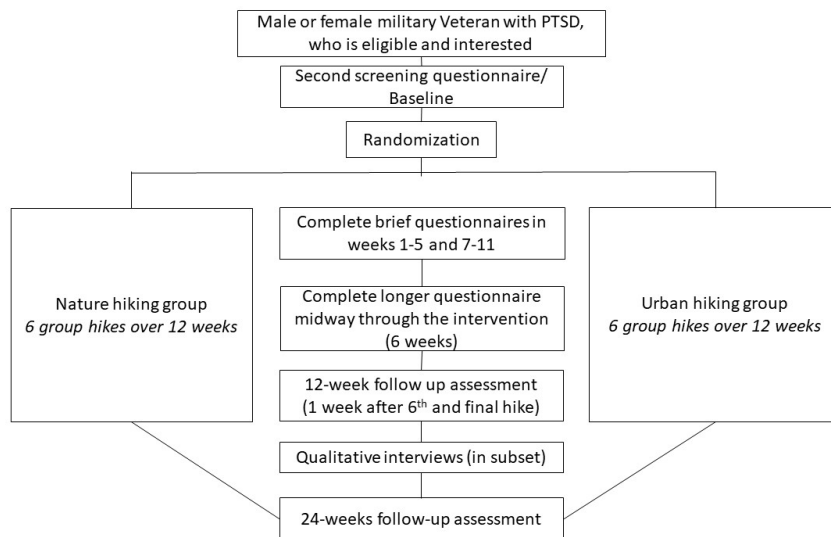


Figure 2. Depiction of study design and assessments

338x190mm (96 x 96 DPI)

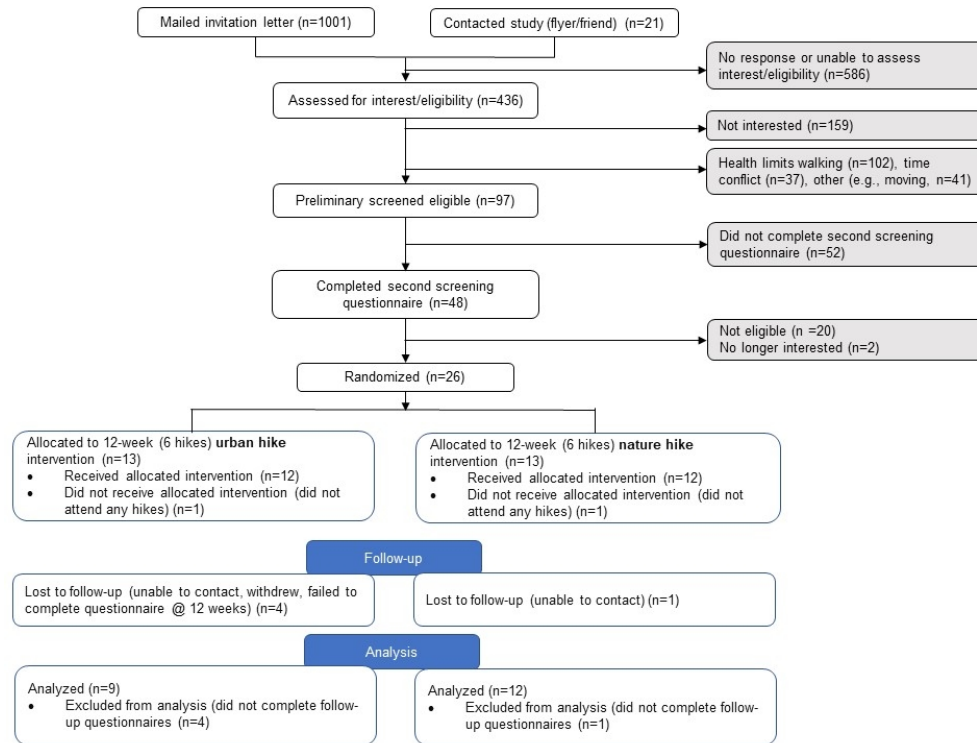


Figure 3. CONSORT diagram

254x190mm (96 x 96 DPI)

**Supplemental Table 1. Constructs, instruments, and timing of assessments**

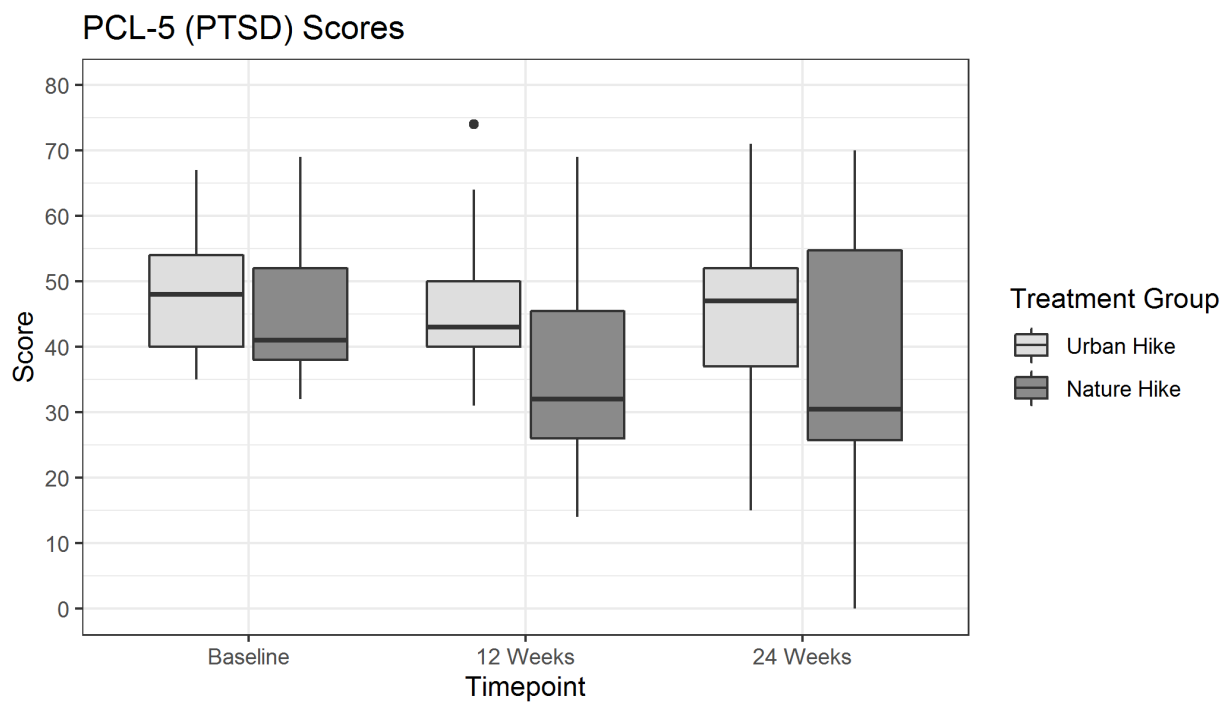
| Constructs   | Instrument   |
|--|--|
| Demographics   | n/a (Age, gender, race/ethnicity, education, service-connected disability, etc.)         |
| Combat exposure  | First two questions of the PTSD Diagnostic Scale-5 (73) and Combat Exposure Scale (74)   |
| Ability to safely perform unsupervised physical activity | Physical Activity Readiness Questionnaire (PAR-Q) (62)                                   |
| Suicidal ideation  | MINI Suicidality module (65)   |
| QoL/well-being   | Satisfaction with Life Scale (75)  |
| Physical health  | 14-item Physical Health Questionnaire (76)   |
| PTSD symptoms  | PTSD Checklist for DSM- 5 (61)   |
| Depression   | Personal Health Questionnaire (PHQ)-8 (77)   |
| Perceived Stress   | 4-item Perceived Stress Scale (PSS) (78,79)  |
| Affect   | 20-item Positive and Negative Affect Schedule (PANAS) (80,81)                            |
|  | 10-item PANAS  |
| Loneliness   | 3-item UCLA loneliness scale (82)  |
| Social connectedness                                     | First four items of the 6-item Perceived Cohesion Scale (83)                             |
| Anxiety  | 20-item Stress and Anxiety Scale (STAI) – state level                                    |
|  | 6-item STAI  |
| Sleep  | Full (19-item) Pittsburgh Sleep Quality Index (PSQI) (84)                                |
|  | Shortened (5-item) PSQI  |
| Nature connection  | Connectedness to Nature Scale (6-items) (85)   |
| Rumination   | Full (12-item) state rumination (brooding subscale of Rumination Reflection Scale [RRS]) |
|  | Shortened (8-item) state rumination (brooding subscale of RRS) (86)                      |
| Cognitive reappraisal                                    | 4-item state emotion regulation questionnaire (ERQ) (87)                                 |
| Physical activity – self report                          | 9-item International Physical Activity Questionnaire (IPAQ) short form (68)              |

| Constructs                                 | Instrument   |
|--|--|
| Physical activity monitor                  | Wrist worn activity monitor (Garmin Vivosmart 4)               |
| Alcohol consumption                        | 10-item Alcohol Use Disorders Identification Test (AUDIT) (64) |
|  | 3-item (AUDIT-C) (88)  |
| Drug-related problems                      | Drug Abuse Screening Test-10 (63)                              |
| PTSD treatments                            | n/a  |
| Preference for treatment, hiking frequency | n/a  |
| and expectation about treatment            | n/a  |
| Acceptability of hikes                     | n/a  |

‡Timing of assessment: S/B: screening/baseline, WK: weekly – weeks 1-5 and 7-11, FU: 6-, 12-, and 24-week follow-ups

†A, acceptability; CO, covariate (including moderators); E, eligibility (to assess inclusion/exclusion criteria); M, mediator P, primary outcome; S, secondary outcome

**Figure 1. PTSD Checklist scores at baseline, 12- and to 24-weeks follow-up**



review only



## CONSORT 2010 checklist of information to include when reporting a pilot or feasibility trial\*

| Section/Topic                    | Item No | Checklist item  | Reported on page No |
|----------------------------------|---------|---|---------------------|
| <b>Title and abstract</b>        |         |   |                     |
|                                  | 1a      | Identification as a pilot or feasibility randomised trial in the title  | 1                   |
|                                  | 1b      | Structured summary of pilot trial design, methods, results, and conclusions (for specific guidance see CONSORT abstract extension for pilot trials)   | 2                   |
| <b>Introduction</b>              |         |   |                     |
| Background and objectives        | 2a      | Scientific background and explanation of rationale for future definitive trial, and reasons for randomised pilot trial  | 5-7                 |
|                                  | 2b      | Specific objectives or research questions for pilot trial   | 7                   |
| <b>Methods</b>                   |         |   |                     |
| Trial design                     | 3a      | Description of pilot trial design (such as parallel, factorial) including allocation ratio  | 9                   |
|                                  | 3b      | Important changes to methods after pilot trial commencement (such as eligibility criteria), with reasons  | 11                  |
| Participants                     | 4a      | Eligibility criteria for participants   | 8                   |
|                                  | 4b      | Settings and locations where the data were collected  | 8-10                |
|                                  | 4c      | How participants were identified and consented  | 8                   |
| Interventions                    | 5       | The interventions for each group with sufficient details to allow replication, including how and when they were actually administered   | 9-11                |
| Outcomes                         | 6a      | Completely defined prespecified assessments or measurements to address each pilot trial objective specified in 2b, including how and when they were assessed                                | 8, 11-12            |
|                                  | 6b      | Any changes to pilot trial assessments or measurements after the pilot trial commenced, with reasons  | n/a                 |
|                                  | 6c      | If applicable, prespecified criteria used to judge whether, or how, to proceed with future definitive trial   | n/a                 |
| Sample size                      | 7a      | Rationale for numbers in the pilot trial  | 11                  |
|                                  | 7b      | When applicable, explanation of any interim analyses and stopping guidelines  | n/a                 |
| Randomisation:                   |         |   |                     |
| Sequence generation              | 8a      | Method used to generate the random allocation sequence  | 9                   |
|                                  | 8b      | Type of randomisation(s); details of any restriction (such as blocking and block size)  | 9                   |
| Allocation concealment mechanism | 9       | Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned | 9                   |

|  |     |   |                       |
|--|-----|---|-----------------------|
| Implementation                                       | 10  | Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions   | 8                     |
| Blinding   | 11a | If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how  | 8                     |
|  | 11b | If relevant, description of the similarity of interventions   | 9-10                  |
| Statistical methods                                  | 12  | Methods used to address each pilot trial objective whether qualitative or quantitative  | 9-11                  |
| <b>Results</b>                                       |     |   |                       |
| Participant flow (a diagram is strongly recommended) | 13a | For each group, the numbers of participants who were approached and/or assessed for eligibility, randomly assigned, received intended treatment, and were assessed for each objective | Figure 3              |
|  | 13b | For each group, losses and exclusions after randomisation, together with reasons  | Figure 3              |
| Recruitment  | 14a | Dates defining the periods of recruitment and follow-up   | Figure 2, page 11-12  |
|  | 14b | Why the pilot trial ended or was stopped  | 12                    |
| Baseline data  | 15  | A table showing baseline demographic and clinical characteristics for each group  | Table 1               |
| Numbers analysed                                     | 16  | For each objective, number of participants (denominator) included in each analysis. If relevant, these numbers should be by randomised group  | Figure 3              |
| Outcomes and estimation                              | 17  | For each objective, results including expressions of uncertainty (such as 95% confidence interval) for any estimates. If relevant, these results should be by randomised group        | Supplemental Figure 1 |
| Ancillary analyses                                   | 18  | Results of any other analyses performed that could be used to inform the future definitive trial  | Table 2               |
| Harms  | 19  | All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)   | 15                    |
|  | 19a | If relevant, other important unintended consequences  | n/a                   |
| <b>Discussion</b>                                    |     |   |                       |
| Limitations  | 20  | Pilot trial limitations, addressing sources of potential bias and remaining uncertainty about feasibility   | 17-21                 |
| Generalisability                                     | 21  | Generalisability (applicability) of pilot trial methods and findings to future definitive trial and other studies   | 17-21                 |
| Interpretation                                       | 22  | Interpretation consistent with pilot trial objectives and findings, balancing potential benefits and harms, and considering other relevant evidence                                   | 17-21                 |
|  | 22a | Implications for progression from pilot to future definitive trial, including any proposed amendments   | 17-21                 |
| <b>Other information</b>                             |     |   |                       |
| Registration   | 23  | Registration number for pilot trial and name of trial registry  | 3                     |
| Protocol   | 24  | Where the pilot trial protocol can be accessed, if available  | n/a                   |
| Funding  | 25  | Sources of funding and other support (such as supply of drugs), role of funders   | 2, 9                  |
|  | 26  | Ethical approval or approval by research review committee, confirmed with reference number  | 13                    |



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Citation: Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L, et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ*. 2016;355.  
\*We strongly recommend reading this statement in conjunction with the CONSORT 2010, extension to randomised pilot and feasibility trials, Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see [www.consort-statement.org](http://www.consort-statement.org).

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# BMJ Open

## Nature versus urban hiking for Veterans with posttraumatic stress disorder: a pilot randomized trial conducted in the Pacific Northwest United States

|                                 |   |
|---------------------------------|---|
| Journal:                        | <i>BMJ Open</i>   |
| Manuscript ID                   | bmjopen-2021-051885.R2  |
| Article Type:                   | Original research   |
| Date Submitted by the Author:   | 31-Aug-2021   |
| Complete List of Authors:       | Littman, Alyson; VA Puget Sound Health Care System, Seattle Epidemiologic Research and Information System and Seattle-Denver Center of Innovation; University of Washington, Epidemiology<br>Bratman, Gregory N; University of Washington<br>Lehavot, Keren; University of Washington School of Public Health, Department of Veterans Affairs Puget Sound Health Care System<br>Engel, Charles C; University of Washington School of Public Health, Department of Veterans Affairs Puget Sound Health Care System<br>Fortney, John ; University of Washington<br>Peterson, Alexander; VA Puget Sound Health Care System, Seattle Epidemiologic Research and Information Center<br>Jones, Alex; Outdoors for All<br>Klassen, Carolyn; Seattle Epidemiologic Research and Information Center<br>Brandon, Josh; Spirit of America<br>Frumkin, Howard; University of Washington |
| <b>Primary Subject Heading</b>: | Mental health   |
| Secondary Subject Heading:      | Complementary medicine, Epidemiology, Public health, Qualitative research, Sports and exercise medicine   |
| Keywords:                       | Adult psychiatry < PSYCHIATRY, TRAUMA MANAGEMENT, COMPLEMENTARY MEDICINE, PUBLIC HEALTH   |
|                                 |   |

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3 1 **Nature versus urban hiking for Veterans with posttraumatic stress disorder: a pilot randomized trial**  
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5 2 **conducted in the Pacific Northwest United States**  
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7 3 Alyson J Littman<sup>1,2,3\*</sup>, Gregory N Bratman<sup>4,10</sup>, Keren Lehavot<sup>3,6,7</sup>, Charles C Engel<sup>3,6</sup>, John C Fortney<sup>3,5,6</sup>, Alexander  
8 4 Peterson<sup>2</sup>, Alex Jones<sup>8</sup>, Carolyn Klassen<sup>2</sup>, Josh Brandon<sup>9</sup>, Howard Frumkin<sup>10</sup>  
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3 **25 ABSTRACT**  
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5 **26 Objectives:** To evaluate feasibility and acceptability of a group-based nature recreation intervention (nature  
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7 hiking) and control condition (urban hiking) for military Veterans with post-traumatic stress disorder (PTSD).  
8

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10 **28 Design and setting:** A pilot randomized controlled trial conducted in the U.S. Pacific Northwest.  
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12 **29 Participants:** Veterans with PTSD due to any cause.  
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14 **30 Interventions:** Twenty-six participants were randomized to a 12-week intervention involving either six nature  
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16 hikes (n=13) or six urban hikes (n=13).  
17

18  
19 **32 Primary and secondary outcome measures:** Feasibility was assessed based on recruitment, retention and  
20  
21 attendance. Questionnaires and post-intervention qualitative interviews were conducted to explore intervention  
22  
23 acceptability. Questionnaires assessing acceptability and outcomes planned for the future trial (e.g., PTSD  
24  
25 symptoms) were collected at baseline, 6-, 12- (immediately after the final hike) and 24-weeks follow-up.  
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28 **36 Results:** Of 415 people assessed for eligibility/interest, 97 were interested and passed preliminary eligibility  
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30 screening, and 26 were randomized. Mean completion of all questionnaires was 91% among those in the nature  
31  
32 hiking group and 68% in those in the urban hiking group. Over the course of the intervention, participants in the  
33  
34 nature and urban groups attended an average of 56% and 58%, respectively, of scheduled hikes. Acceptability of  
35  
36 both urban and nature hikes was high; over 70% reported a positive rating (i.e., good/excellent) for the hike  
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38 locations, distance, and pace. Median PTSD symptom scores (PTSD Checklist-5) improved more at 12- and 24-  
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40 weeks among those in the nature versus urban hiking group.  
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44 **43 Conclusions:** This pilot study largely confirmed the feasibility and acceptability of nature hiking as a potential  
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46 treatment for Veterans with PTSD. Adaptations will be needed to improve recruitment and increase hike  
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48 attendance for a future randomized controlled trial to effectively test and isolate the ways in which nature  
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50 contact, physical activity, and social support conferred by the group impact outcomes.  
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52 **47 Trial registration:** Clinicaltrials.gov (NCT03997344)  
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55 **48**  
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3 49 **Key words:** posttraumatic stress disorder, Veterans, nature, green exercise, pilot randomized controlled trial  
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8 51 **Strengths and limitations of the study**  
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- 10 52 • By using group-based urban hiking as a comparison group to control for the effects of physical activity  
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12 53 and social cohesion (present in both interventions), this study was designed to isolate benefits  
13  
14 54 specifically due to the environment (which differed between the interventions).  
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16  
17 55 • We used population-based recruitment methods to enroll a representative sample of Veterans with  
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19 56 PTSD.  
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21 57 • Because of its small size and focus on feasibility, the study was not large enough to determine the  
22  
23 58 effectiveness of nature hiking on outcomes.  
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28 60 **Funding:** This work was funded by Recreational Equipment, Inc. (REI; Award/Grant number is not applicable)  
29  
30 61 and supported by equipment and outfitting contributions from Outdoor Research.  
31  
32 62

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35 63 **Competing interests:** The authors have no competing interests to report.  
36

37 64 **Data availability statement:** Data are available upon reasonable request. Due to legal and ethical restrictions,  
38  
39 65 we are unable to share data publicly because the data contain potentially identifying and/or sensitive patient  
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41 66 information. Subject to IRB approval, de-identified data will be released to a local Department of Veterans  
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43 67 Affairs (VA) Puget Sound Health Care System and/or national VA research data repository for release to non-VA  
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45 68 protocols. The VA research data repository administrator will be responsible for reviewing and responding to  
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47 69 requests to release data to non-VA requestors. A data use agreement compliant with Veterans Health  
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50 70 Administration Handbooks 1200.12 and 1605.1 will be required between Veterans Health Administration and  
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52 71 the requestor. Review and approval by VA privacy officer is required prior to disclosure. Data access requests  
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72 will be reviewed by the IRB of the VA Puget Sound Health Care System (contact via Dr. Littman –  
73 alyson.littman@va.gov), via mail address: 1660 S Columbian Way, Building 101 – 5W41, Seattle, WA 98108.

For peer review only

## 74 Introduction

75 Posttraumatic Stress Disorder (PTSD) is a common, chronic mental health condition that affects up to 30% of  
76 military Veterans and is frequently comorbid with anxiety, depression, and substance misuse (1–3). PTSD  
77 increases the risk of suicide as well as obesity, physical inactivity, and cardiovascular and metabolic disorders (1–  
78 12). Clinical practice guidelines recommend treatment with several evidence-based psychotherapies and  
79 medications (13), but many Veterans who need PTSD treatment do not receive it (14). Barriers to obtaining  
80 treatment include concerns about medication side effects, desire for self-management approaches, stigma  
81 about receiving mental health care, and a lack of confidence in mental health treatment in general (14–17).  
82 These and other factors adversely impact engagement, contributing to low initiation of (14,18–22) and high  
83 drop-out rates from treatment (20,23,24). Identifying a wider range of approaches that are acceptable and  
84 effective is key to reducing the burden PTSD places on individuals and their communities.

85  
86 There is growing interest in nature contact as a potential therapy for Veterans with PTSD and robust evidence  
87 that nature contact improves physical and psychological health, among healthy individuals and those with  
88 mental health disorders (25). Nature contact has been shown to increase subjective well-being; decrease stress,  
89 anxiety, depression, and negative affect; and promote adaptive shifts in emotion regulation (25,26). Benefits of  
90 nature contact are generally posited to occur based on two theories: Attention Restoration Theory (ART) and  
91 Stress Recovery Theory (SRT) (27,28). ART theorizes that nature contact improves cognitive function through a  
92 replenishment of “directed attention”, a capacity that is overly taxed in urban environments due to the need to  
93 block out distracting stimuli (e.g., noise) to focus on a specific task or cognitive process. This depleted attention  
94 capacity can be restored in natural environments through the engagement of “soft fascination”, with  
95 implications for both cognitive and emotional well-being. SRT is based on psycho-evolutionary principles, and  
96 posits that many types of nature exposure enhance psychological well-being through a pre-cognitive, positive



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3 97 affective response and activation of the parasympathetic nervous system in ways that reduce stress and  
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5 98 sympathetic nervous system arousal (26,29,30).  
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10 100 Like nature contact, physical activity (PA) is considered to be a promising approach to improve outcomes for  
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12 101 individuals with PTSD. PA reduces anxiety and depression and improves stress regulation, sleep, and cognitive  
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14 102 functioning in the general population (10,11,31), and in people with PTSD, though only eight studies have  
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16 103 involved randomized controlled trial (RCT) designs (4,32–39), and five of the RCTs were pilot studies or included  
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18 104 fewer than 30 people (32,33,35,38,39). Furthermore, we are aware of only one RCT focused on Veterans (39).  
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21 105 Group-based PA interventions may be particularly well-suited for military Veterans, due to 1) proportionally  
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23 106 higher rates of PTSD among Veterans (40), 2) consistency of PA interventions with values cultivated during  
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25 107 military service, and 3) benefits of social interaction with Veteran peers (41). To our knowledge, no PA  
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27 108 interventions in those with PTSD investigated the PA environment as a component of treatment. This is an  
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29 109 important omission, because the environment in which PA takes place may play an important role in its benefits  
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31 110 (42).  
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38 112 Green exercise, defined as activity that takes place in natural environments, is a burgeoning area of research  
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40 113 (43–48). A number of studies have documented benefits from green exercise in Veteran populations and among  
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42 114 individuals with PTSD (45–55). The specific interventions studied (from care farming to river rafting),  
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44 115 dose/duration, and inclusion of additional, explicit therapeutic components vary substantially among studies. A  
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46 116 2019 systematic review that examined evidence for the proposed additive effects of exercise in the presence of  
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48 117 nature observed some benefits (e.g., lower perceived exertion and enjoyment), the authors concluded that  
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50 118 there was a high risk of bias across trials and an overall low quality of evidence (44). Thus, uncertainty about the  
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52 119 duration and impacts of green exercise remains due to methodological issues and because most interventional  
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54 120 studies tested only a single bout of exercise (43,44). Furthermore, in the studies including Veterans, important  
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3 121 limitations include low retention for follow-up, absence of control groups, and insufficient statistical power (52–  
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5 122 58).

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11 124 In addition to nature contact and PA, a third important component of many green exercise interventions  
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13 125 includes a group component. Some recent research suggests that increased social cohesion and connectedness  
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15 126 may mediate benefits of green exercise (59), but findings are inconsistent (60). Social support forged through  
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18 127 group activity could be particularly relevant for Veterans, as camaraderie and solidarity are critical components  
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20 128 of military culture, and ones that are frequently lost in the return to civilian life (61). Social support is associated  
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22 129 with reduced PTSD symptoms and improved treatment response (62) and may directly impact stress response  
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25 130 by increasing personal resources (63), and/or may indirectly impact PTSD symptom severity and response to  
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27 131 treatment through buffering the potentially harmful impacts of stressful events (64).

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31 133 Adequately powered studies involving ongoing green exercise that are designed to distinguish between benefits  
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33 134 due to PA and those due to the physical (e.g., nature) and social (e.g., group cohesion) environment are needed.  
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36 135 Thus, our goal was to design and conduct a pilot study to test the feasibility and acceptability of a green exercise  
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38 136 intervention for PTSD symptoms in military Veterans, regardless of PTSD etiology. The intervention (nature  
39  
40 137 hiking) and the active control (urban hiking) were group-based and involved similar amounts of PA, to ensure  
41  
42 138 control of the potential benefits of the group-based social support and of PA. Figure 1 depicts our conceptual  
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44  
45 139 model. This paper describes the results of the initial pilot study designed to emulate important elements of the  
46  
47 140 future envisioned full-scale randomized trial.

## 48 49 141 50 51 142 **Methods**

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### 145 Identification and recruitment of participants

146 We used active and passive methods to identify and recruit Veterans to participate. While receiving care at a  
147 Department of Veterans Affairs (VA) health care facility was not an inclusion criterion, we used VA electronic  
148 medical records as a key source to identify potentially eligible Veterans. We identified VA enrollees (identified  
149 using electronic medical records) with at least one encounter with a diagnosis of PTSD in the prior two years; a  
150 zip code in one of three Seattle-Tacoma area counties (King, Snohomish, and Pierce); no hospitalizations in the  
151 prior 3 months; and no diagnoses of schizophrenia, bipolar disorder, or other psychotic disorder. We randomly  
152 selected 1001 individuals who met these criteria from a total of approximately 7000 and mailed them a letter  
153 informing them about the study and inviting them to participate. We followed the mailing with up to three  
154 phone calls until the recruitment period ended. We also placed study recruitment flyers in clinics in the VA Puget  
155 Sound and mailed flyers to four local organizations and clinics serving Veterans. Individuals who expressed an  
156 interest were mailed an invitation letter.

157  
158 We initially screened all Veterans who expressed an interest in participating for eligibility over the phone;  
159 inclusion criteria assessed included a history of PTSD, ability/willingness to comply with study procedures (e.g.,  
160 complete questionnaires, wear and sync an activity monitor, drive to hikes, and walk at least 2 hours at an  
161 easy/moderate pace over uneven terrain). Exclusion criteria assessed included a diagnosis of schizophrenia,  
162 bipolar disorder, or other psychotic disorder; hospital admission in the prior 3 months, and inability to perform  
163 unsupervised physical activity based on the Physical Activity Readiness Questionnaire (65). We invited those  
164 who passed all criteria except for the Physical Activity Readiness Questionnaire to obtain approval to participate  
165 from their primary care provider. Though some of this information was available in VA medical records, because  
166 we also included Veterans who did not have VA medical records, we employed methods that allowed us to  
167 evaluate eligibility without medical record access. Those who passed initial screening were mailed consent forms  
168 and given a link to complete a more extensive screening questionnaire online. Via the online screening

1  
2  
3 169 questionnaire, PTSD symptoms, drug use, alcohol misuse, and suicidality were assessed. PTSD was determined  
4  
5 170 based on a PTSD-checklist-5 (66) score  $\geq 33$ . We excluded those with drug abuse in past year (Drug Abuse  
6  
7  
8 171 Screening Test-10 (67) score  $< 3$ ); alcohol disorder/dependence (current/past year; Alcohol Use Disorders  
9  
10 172 Identification Test-10 (68) score  $> 16$ ); and moderate/severe suicidality (past month; MINI Suicidality module (69)  
11  
12 173 score  $\geq 5$ ). Those who were eligible and returned signed consents were considered enrolled in the study.  
13

#### 14 174 15 16 17 175 Study design

18  
19 176 We conducted a two-arm randomized controlled pilot trial. The two interventions were group nature and group  
20  
21 177 urban hiking. The random 1:1 allocation sequence was generated using simple randomization in random blocks  
22  
23 178 of 2, 4 and 6. Randomization assignments were placed in opaque sequentially numbered envelopes. Once an  
24  
25  
26 179 individual was determined to be eligible, the study coordinator selected the next envelope to determine the  
27  
28 180 individual's group assignment. We did not blind participants, the study coordinator, or the study statistician to  
29  
30 181 group assignment. This study was registered at Clinicaltrials.gov (NCT03997344). Figure 2 presents an overview  
31  
32 182 of the study, including timing of assessments.  
33

#### 34 183 35 36 37 184 Description of hike locations and amenities

38  
39 185 The criteria used to select the hike locations (which applied to both nature and urban hikes) included duration,  
40  
41 186 elevation change, availability of facilities (e.g., toilets and water), distance from participants' homes, and access  
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43  
44 187 to parking. Nature hikes were held in State Parks, National Wildlife Refuges, and Natural Resources Conservation  
45  
46 188 areas in the US Pacific Northwest. The nature hikes were in forest habitat, including old growth forest, saltwater  
47  
48 189 shoreline, waterfalls, and alpine lakes. Elevations ranged from sea level to 2200 feet above sea level. Urban  
49  
50 190 hikes were held in primarily built environments, avoiding urban parks or primarily residential neighborhoods  
51  
52 191 with substantial greenery or water features. Urban hikes comprised areas that included sports stadiums, urban  
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55 192 art, and retail establishments and were mainly on sidewalks rather than separated bike/pedestrian paths/rail-

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3 193 trails. It was not feasible to match nature and urban hikes on elevation change; instead, we aimed to have  
4  
5 194 similar hike durations to match total exertion. Generally, nature hikes involved somewhat shorter distances but  
6  
7  
8 195 included more elevation gain/loss.  
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10 196

11  
12 197 Hiking intervention  
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14 198 A total of 6 hikes over 12 weeks (one every other week) were offered between August and October 2019. We  
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16  
17 199 chose to offer 6 hikes (versus more or fewer) because this number was thought to be feasible and would be  
18  
19 200 sufficient to assess feasibility and acceptability. The standard structure for hikes was: 1) “ice breakers” (short,  
20  
21 201 guided conversations), 2) overview of the planned hike, including distance, unique features, and planned stops,  
22  
23 202 3) hike, and 4) post-hike debrief and administration of questionnaires. There were no additional  
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26 203 group/therapeutic activities.  
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28 204

29  
30 205 Hike durations increased gradually to account for anticipated increases in participants’ physical fitness. Initial  
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32 206 hikes were 60-90 minutes (2-3 miles), and later hikes were 2-3 hours (5-6 miles). To ensure safety and inclusion,  
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34  
35 207 one hike leader was in sight and hearing of the first participant and a second leader accompanied the last  
36  
37 208 participant. The group stopped at least every 30 minutes to keep everyone together and offer opportunities to  
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39 209 rest, regroup, and inquire about and address any issues or concerns arising since the last check-in.  
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43  
44 211 The same hike leaders, who were non-clinicians, led both nature and urban hikes to control for hike-leader  
45  
46 212 effects. On every hike, at least one of the leaders was a woman. Leaders were experienced outdoor educators  
47  
48 213 who were employed by a Seattle-based outdoor organization that provides outdoor recreation activities for  
49  
50 214 people with disabilities. While the leaders were not Veterans, the organization received grants from the VA as  
51  
52 215 part of the Adaptive Sports Program (70) and had previously led programs for Veterans. Leaders were trained to  
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3 216 handle physical and mental health emergencies by the PIs (AJL and GNB) and a co-I who is a licensed clinical  
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5 217 psychologist (KL). AJL and GNB supervised the hike leaders during the study.  
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10 219 To reduce barriers to attendance, a \$35 incentive was provided to defray parking costs. We provided a rain  
11  
12 220 jacket and technical shirt as well as well as an activity monitor (Garmin vivosmart 4) at the participant's first  
13  
14 221 hike.  
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### 18 19 223 Outcomes

20  
21 224 The primary outcomes of interest were feasibility and acceptability. **Feasibility** was assessed based on  
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23 225 recruitment statistics (the proportion of individuals who were contacted, eligible, and enrolled, as well as  
24  
25 226 reasons for ineligibility), retention (questionnaire completion), hike attendance, and safety (e.g., adverse  
26  
27 227 events). We aimed to recruit 36-45 participants (12-15 people allocated to each of the three groups - nature  
28  
29 228 hiking, urban hiking, and a no-hiking control group) and complete enrollment by July 2019 (approximately 3  
30  
31 229 months after recruitment began) due to concerns about weather for hikes later in the fall. Because of lower-  
32  
33 230 than-anticipated recruitment numbers, in late June, we decided to eliminate the no-hiking control group. At this  
34  
35 231 time, only one person was randomized to the no-hiking control group and informed of their group assignment;  
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37 232 that person was re-randomized after this decision was made. The target for retention and attendance was 70%,  
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39 233 a commonly cited standard for trials (71,72).  
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46 235 To assess **acceptability**, in the 6- and 12-week questionnaires, we included questions created for the study  
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48 236 about the difficulty of the hikes' distance, pace, and the terrain (rated on a 5-point scale from extremely difficult  
49  
50 237 to effortless), and satisfaction with the locations of hikes (rated on a 5-point scale from extremely unsatisfied to  
51  
52 238 very satisfied). Lastly, pre-hike and trailhead information and communication were assessed on a 5-point scale  
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54 239 (e.g., from very poor (1) to excellent (5)). We also included open-ended questions for participants to report what  
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3 240 they thought went well and what could have been better. Additionally, after the final hike, the lead author (AJL)  
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5 241 conducted semi-structured telephone interviews, with a goal to interview 10-15 participants. To include a range  
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8 242 of perspectives, we purposively sampled participants from both arms, aimed to include men and women, and  
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10 243 participants who varied in terms of hike attendance. Questions inquired about participants' impressions of the  
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12 244 hikes, including difficulty, location, length of time, distance from home, hike leaders, and reasons hikes were  
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14 245 missed (if applicable); study communications; enrollment process; assessments; and other  
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17 246 thoughts/impressions.

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21 248 Determination of **efficacy** was not a goal of this pilot RCT. The primary outcome of the future planned study is  
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23 249 PTSD symptoms, assessed by the PTSD-Checklist-5 (PCL-5), a 20-item instrument that assesses PTSD symptoms  
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26 250 in the past month (range 0 to 80, with higher scores indicating greater symptom severity). Other outcome  
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28 251 measures of interest for the future planned study, which are detailed in Supplemental Table 1, include quality of  
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30 252 life (73), positive and negative affect (74,75), sleep (76), rumination (77), and cognitive reappraisal (78).

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32 253  
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35 254 *Baseline and follow-up assessments*

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37 255 We conducted assessments online using commercial software (QuestionPro) at baseline (before hikes began),  
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39 256 and then weekly for 12 weeks, starting with the week of the first hike and ending the week after the 6<sup>th</sup> hike,  
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41 257 and finally at week 24; questionnaires completed immediately after the hikes were completed on paper. See  
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44 258 Figure 2 for an overview and Supplemental Table 1 for measures at each time point. Questionnaires at weeks 6,  
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46 259 12, and 24 took approximately 30 minutes to complete. Questionnaires administered at weeks 1-5 and 7-11  
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48 260 included fewer measures and/or shortened versions and took 5-10 minutes to complete. Participants received  
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50 261 gift cards worth \$10 for completing questionnaires in weeks 1-5 and 7-11, \$20 for the 6-week questionnaire, and  
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52 262 \$50 for the 12- and 24-week questionnaires. In addition to questionnaires, to obtain objective information about  
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55 263 PA (a potential mechanism of benefit, which we would want to measure precisely in a future study), we asked

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3 264 participants to wear a wrist worn-activity monitor (Garmin vivosmart 4) every day, for at least 10 hours per day,  
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5 265 for the first 12 weeks of the study. No incentives were provided for wearing or synching the watch.  
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### 8 266 9 10 267 Data analysis

#### 11 12 268 *Quantitative analysis*

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14 269 The primary purpose of the extensive data collection was to evaluate feasibility of data collection rather than to  
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17 270 estimate effect sizes because estimating effect sizes from small pilot studies is inherently imprecise (79). Thus,  
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19 271 instead of conducting hypothesis tests for effectiveness outcomes for which we were underpowered, we  
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21 272 present descriptive statistics (e.g., medians and interquartile ranges) for the primary outcome (PCL-5) only. For  
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23 273 acceptability measures related to communication, we categorized responses as positive if respondents chose  
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25 274 one of the two most favorable response options (e.g., satisfied/very satisfied; good/excellent) and not positive if  
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27 they chose one of the other response options (extremely unsatisfied/unsatisfied/ neither satisfied or unsatisfied;  
28 275 inadequate/very poor/adequate). We then calculated the proportion of urban and nature participants with  
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30 276 favorable responses for each question. In addition to proportions, we also calculated the mean scores for hike  
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32 277 locations, distance, pace, pre-hike information, pre-hike communication, and trailhead communication by  
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34 278 group.  
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#### 41 281 *Qualitative analysis*

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43 282 All interviews were recorded, and the interviewer took notes during interviews. For both the comments shared  
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46 283 via open-ended questions on the questionnaire and comments shared orally during the interviews, we  
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48 284 conducted inductive content analysis, which involves open coding of data, organizing codes and data into  
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50 285 categories, and comparing data across participants to identify patterns and themes in the data (80).  
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#### 53 54 55 287 Patient and public involvement



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3 288 Patients were involved in the design and conduct of this study. The study question and design were informed by  
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5 289 a Veteran with PTSD who served as a co-investigator. The design and messaging for this pilot study were also  
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8 290 informed by a focus group of patients/Veterans who participated in a prior unpublished feasibility study.  
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12 292 Ethics approval

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14 293 This study was approved by the institutional review boards at the VA Puget Sound Health Care System (MIRB  
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17 294 01738) and the University of Washington (6951).  
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## 22 **Results**

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### 24 297 Feasibility

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#### 26 298 *Recruitment statistics*

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28 299 Recruitment took place between April and August 2019 (16 weeks total). Of the 1001 patients mailed an  
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30 300 invitation letter, we were unable to assess interest or eligibility in 586 (because they did not respond to the  
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32 301 mailings and/or answer the phone when called; see Figure 3 for CONSORT diagram). Of the 415 with whom we  
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35 302 made contact, 159 were not interested, 102 had health conditions that limited their walking/hiking, 36 had time  
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37 303 conflicts (e.g., work or church on Sundays or travel that would prevent participation), and 37 had other reasons  
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39 304 that they were unable to participate (e.g., moving out of the area, did not have PTSD, etc.). Of the 97 (81 from  
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41 305 letters + 16 from passive recruitment) interested who passed initial screening, 48 completed the online  
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44 306 screening questionnaire. Twenty individuals were not eligible, 2 decided that they did not wish to participate,  
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46 307 and 26 were eligible and randomized. Of the 20 who were not eligible, 13 were ineligible because of a  
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48 308 moderate/high risk of suicide or skipping the question on suicidality, and 6 did not meet the threshold for PTSD.  
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50 309 Compared to those contacted and not randomized, a greater proportion of those randomized were women  
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52 310 (27% randomized versus 15% of those contacted), white (73% versus 63%), and Hispanic (8% versus 6%).  
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3 311 Additionally, those who were randomized were younger (mean age = 47, range 25-65) than those not  
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5 312 randomized (mean age = 52, range: 21-95).  
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10 314 Table 1 presents characteristics of Veterans who were randomized and includes self-reported race/ethnicity,  
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12 315 which differed from race/ethnicity in the electronic medical record (reported above). Specifically, 42% of those  
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14 316 randomized self-reported being white, whereas the electronic medical record data indicated that 73% were  
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17 317 white. Thirty percent had a college degree or more. Less than half worked full time and 46% had 100% VA  
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19 318 service-connected disability, indicating severe impairment in ability to work. Nearly two-thirds of participants  
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21 319 had served in combat and 68% had depressive symptoms based on the PHQ-8. Based on self-report, nearly 70%  
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23 320 met or exceeded PA guidelines of at least 75 minutes per week of vigorous-intensity activity or 150 minutes per  
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26 321 week of moderate-intensity activity, or an equivalent combination of the two. At baseline (prior to study  
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28 322 initiation), 81% of participants reported hiking at least one time and 27% completed 7 or more hikes in the prior  
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30 323 year.  
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### 32 324 33 34 35 325 *Retention (questionnaire completion)*

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37 326 Mean completion of all questionnaires was 91% in the nature hiking group and 68% in the urban hiking group.  
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39 327 Completion rates were similar for the shorter weekly questionnaires and the longer questionnaires.  
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### 41 328 42 43 44 329 *Hike attendance*

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46 330 Over the course of the intervention, participants in the nature and urban groups attended an average of 56%  
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48 331 and 58%, respectively, of scheduled hikes. In the nature group, one person attended no hikes, four (31%)  
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50 332 attended 1-2 hikes, one attended 3 hikes, and seven (54%) attended 4-6 hikes. In the urban group, one person  
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52 333 attended no hikes, four (31%) attended 1-2 hikes, no one attended only 3 hikes, and eight (62%) attended 4-6  
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55 334 hikes. Attendance was lower among women in the nature group (n=5, mean: 43%) than among women in the  
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3 335 urban group (n=2, 67%), whereas among men, hike attendance was similar in the two groups (65% versus 56%).  
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5 336 Common reasons for missing hikes included work, childcare, and prior plans.  
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10 338 *Safety/Adverse events*

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12 339 One participant in the urban hiking arm reported increased anxiety/PTSD symptoms in connection with hiking in  
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14 340 the urban environment and withdrew from the study.  
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19 342 *Acceptability*

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21 343 *Quantitative findings*

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23 344 Acceptability of both the urban and nature hikes was high. Over 70% reported a positive rating for the hike  
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25 345 locations, distance, and pace; ratings were similar in the urban and nature hiking groups. Additionally, on  
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27 346 average, pre-hike information, pre-hike communication, and trailhead communication were rated as good to  
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29 347 excellent. Scores related to communication were similar in the urban and nature hike groups at 6 weeks, but  
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31 348 were lower in the urban hiking arm at 12 weeks (pre-hike information, mean scores: nature=4.4, urban=3.6; pre-  
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33 349 hike communication: nature=4.6, urban=3.8; trailhead communication: nature=4.6, urban=4.1)  
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39 351 *Qualitative findings*

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41 352 In response to the open-ended question on the questionnaire (“What went well so far?”), participants shared  
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43 353 positive comments such as “This group seems to mesh really well”, “all expectations were exceeded”, and “good  
44  
45 354 planning, leadership, and execution.” In response to the question, “What do you think we can do better?”,  
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47 355 suggestions included having regional groups, closer hikes or paying for gas; weekly (instead of every other week)  
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49 356 hikes; more team building and opportunities to socialize with others; and including more women and/or  
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51 357 women-only groups. Key themes from the qualitative interviews, which are presented in Table 2, echoed, and  
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53 358 elaborated on themes shared in the questionnaire. Most participants felt positively about their experience in the  
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3 359 study. As noted above, they liked getting to know other Veterans and having a “mission.” Veterans wanted to  
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5 360 find more ways of connecting with one another socially during hikes as well as outside of hikes. Hike logistics  
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8 361 (e.g., distance from home) were noted as potential barriers to attendance.  
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### 10 362 11 12 363 Efficacy measures 13

14 364 Median PCL-5 scores decreased from baseline to week 12 and remained at the 12-week level at week 24 for  
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16  
17 365 those in the nature hiking group (baseline=41, 12-weeks = 32, 24 weeks=31). Among those in the urban hiking  
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19 366 group, PCL-5 scores decreased from baseline to 12 weeks but increased nearly back to baseline levels at 24  
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21 367 weeks (baseline=48, 12-weeks = 43, 24 weeks=47) (Supplemental Figure 1). We did not test the statistical  
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23 368 significance of the changes because this pilot study was not designed to answer this question (81).  
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### 26 369 27 28 370 **Discussion** 29

30 371  
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32 372 This study was an important step in establishing feasibility and acceptability and identifying changes to consider  
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35 373 in the development of a rigorous, fully-powered study to evaluate the impact of nature hiking on PTSD  
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37 374 symptoms. The results of this pilot study generally supported feasibility and acceptability. Participants reported  
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39 375 high acceptability, enjoyment, and value, based on quantitative and qualitative data. In both arms, more than half  
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41 376 of participants completed most hikes. Qualitative feedback about improving the social component supports the  
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43  
44 377 hypothesis that social connection is an important aspect of hikes, indicating a need to further develop the social  
45  
46 378 component and continue to study group interventions like this one. Additionally, the decrease in median scores  
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48 379 on the PCL-5 among those in the nature group after the 12-week hiking intervention, and 12 weeks later (week  
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50 380 24) is promising. This preliminary finding should be investigated more thoroughly in future, larger-scale versions  
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52 381 of our study. The indication that improvements may persist after the conclusion of the intervention is especially  
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55 382 compelling given the current unknowns regarding the duration of effects of nature interventions.  
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5 384 Nevertheless, several issues need to be considered related to feasibility and acceptability for the next iteration  
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8 385 of this research.

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12 387 *Feasibility of recruitment*

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14 388 We fell short of our goal of recruiting at least 36 people over 4 months. Failing to meet recruitment goals in the  
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17 389 planned timeframe is a common problem in randomized controlled trials (82). Barriers to recruitment included  
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19 390 unexpected delays, insufficient resources, and an inefficient recruitment process. Regarding delays, we had to  
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21 391 wait weeks for IRB approval for each proposed modification to recruitment materials/protocol. Regarding  
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23 392 resources, we only had 20 hours per week of paid staff time for recruitment. The addition of two volunteers in  
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26 393 the final two months helped to accelerate enrollment, but more resources earlier in recruitment would have  
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28 394 been necessary to meet our goal.

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32 396 One contributor to inefficiency in recruitment was the broad, population-based approach we employed for  
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35 397 active recruitment. To identify patients for the introductory mailing, the only inclusion criteria were having a  
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37 398 single encounter in VA's electronic medical record with a PTSD diagnosis and living in one of three Puget Sound  
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39 399 counties. The only exclusion criteria were a diagnosis of schizophrenia, bipolar disorder, or other psychotic  
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41 400 disorder. Likely in part because of this broad approach, which did not include upper age limits, approximately  
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44 401 one quarter of contacted individuals reported a health condition that impaired their walking. Burdensome study  
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46 402 procedures may have also impacted recruitment. About half of interested participants failed to complete the  
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48 403 online screening questionnaire and others informed us that they had trouble completing the online  
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50 404 questionnaire. Imposing an upper age limit (e.g., 65 years) and restructuring the recruitment process to make it  
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52 405 faster and easier for potential participants may be necessary.

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3 407 Accessibility of the intervention and restrictive eligibility criteria may have also impacted recruitment. In  
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5 408 addition to being able to walk over uneven ground for at least two hours, participants also had to be available  
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7 409 during the times selected, have low suicide risk, and be free from physical conditions such as high blood  
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10 410 pressure (or obtain their primary care provider's permission) among several other criteria. Changing inclusion  
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12 411 criteria (e.g., eliminating restrictions related to suicidality) might improve recruitment and generalizability, but  
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14 412 would require tradeoffs related to safety and retention that must be considered carefully.  
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18  
19 414 Lastly, about 38% (159/415) of those for whom we were able to assess eligibility and interest declined  
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21 415 participation. While some of these people may have declined because of the additional burdens of a research  
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23 416 study, this statistic indicates that hiking may only appeal to a segment of the population, just as psychotherapy  
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25 417 and pharmacotherapy only appeal to subsets of the population (83). Because of differences in treatment  
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28 418 preferences, offering options is important, and nature hiking merits consideration so that we can rigorously  
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30 419 assess its efficacy.  
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### 32 420 33 34 35 421 *Retention*

36  
37 422 Retention varied by group and was poorer for the wrist-worn activity monitor than for the questionnaires. The  
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39 423 activity monitor had a substantial amount of missing data, which is a common problem for activity monitors  
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41 424 (84), and may have been related to the number of technical steps required for setting up the watch and syncing  
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43 425 it, as many participants needed additional help to troubleshoot problems. Providing more support to set up the  
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46 426 watch and incentives to wear and sync it may help to obtain more complete data. While overall questionnaire  
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48 427 completion was high, it was higher in the nature hiking group (91%) than in the urban hiking group (68%).  
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50 428 Though the small sample and our inability to conduct interviews with those who did not complete follow-up  
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52 429 measures makes inference difficult, the retention differences could be a marker of commitment to the study.  
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55 430 Future studies should pay careful attention to marketing the study to ensure that both interventions are  
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3 431 perceived as helpful. Enhancing the social aspects of the interventions may help achieve that goal. The  
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5 432 difference in incentives provided for questionnaire completion versus the other aspects of the study may also  
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8 433 have played a role in retention for different study aspects. However, many participants shared that they  
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10 434 participated to help fellow Veterans, indicating altruistic/intrinsic motivators for participation, reinforcing the  
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12 435 importance of understanding drivers of participation, and reducing barriers and enhancing facilitators.

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17 437 *Acceptability of the hiking interventions*

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19 438 Hike attendance (56%) was lower than our target (70%) and women had lower attendance in the nature hiking  
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21 439 group than men. While we were unable to ascertain reasons for missing hikes for each person, some reasons  
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23 440 reported (e.g., other plans, work) were hard to avoid, while others (driving distance to hikes) could be addressed  
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25  
26 441 in the future by restricting the geographic area of recruitment and hikes and/or organizing small groups at  
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28 442 different times to accommodate individuals' schedules. Our study, unfortunately, does not shed light on the  
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30 443 optimal hike "dose." We suspect that 8-12 hikes (similar to a standard psychotherapy course) may be optimal  
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32 444 for achieving clinically meaningful results. Additional research will be necessary to examine this important  
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34  
35 445 question. There were also an indication of lower acceptability/ratings for information sharing in the urban hiking  
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37 446 versus the nature hiking groups. While we aimed to share information about the urban area, we did not provide  
38  
39 447 an exact route, which may have made it more difficult for participants to research urban versus nature hikes,  
40  
41 448 where we listed a trail. Providing a map of the route might help participants feel prepared. Regarding  
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43  
44 449 differences in attendance by gender, a history of military sexual trauma, which is common among women  
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46 450 Veterans (85), may have impacted some women participants' comfort and perception of safety of hiking in  
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48 451 nature with a majority male group. Ensuring a greater proportion of women in each group or organizing women-  
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50 452 only groups (as was suggested by some participants) could address this concern. These changes, would,  
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52 453 however, result in additional costs and tradeoffs that would need to be carefully considered.  
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3 455 *Conclusions*  
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5 456 This pilot study provided useful information related to feasibility and acceptability, including common factors  
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8 457 that resulted in exclusion; resources and procedures needed for recruitment; factors to consider for selection of  
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10 458 nature and urban hikes; and barriers and facilitators to achieving high completion in follow-up assessments and  
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12 459 the hikes. These insights can be harnessed to increase participation and rigor in future, scaled-up iterations of  
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14 460 the study, and ensure that environments are safe (i.e., non-triggering). Future studies with larger sample sizes  
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16  
17 461 are needed to isolate the ways nature contact, PA, and social support conferred by the group impact outcomes  
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19 462 to develop and provide well-tailored interventions.  
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3 465 **List of abbreviations**  
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|          |       |  |
|----------|-------|--|
| 5 466    | ART   | Attention Restoration Theory                           |
| 6        |       |  |
| 7 467    | HIPAA | Health Insurance Portability and Accountability Act    |
| 8        |       |  |
| 9 10468  | IRB   | Institutional Review Board                             |
| 10       |       |  |
| 11 12469 | PA    | Physical activity                                      |
| 12       |       |  |
| 13 14470 | PCL-5 | PTSD Checklist for Diagnostic and Statistical Manual 5 |
| 14       |       |  |
| 15 16471 | PTSD  | Posttraumatic stress disorder                          |
| 16       |       |  |
| 17 19472 | SRT   | Stress Recovery Theory                                 |
| 18       |       |  |
| 19 21473 | VA    | Department of Veterans Affairs                         |
| 20       |       |  |
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| 25 26475 |       |  |

25 26475 **Acknowledgements**  
27

28476 We thank the Veterans who participated in this study for allowing us to learn from them, including the Veterans  
29  
30477 who participated in a prior unpublished feasibility study. We also thank Morgan Meadows and Gabrielle Fong  
31  
32478 for their help with recruitment. This material is the result of work supported by VA Puget Sound Health Care  
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34479 System, Seattle, WA. The views expressed in this article are those of the authors and do not necessarily reflect  
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37480 the position or policy of the Department of Veterans Affairs, the United States Government, Recreational  
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39481 Equipment, Inc. (REI), or Outdoor Research.  
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45483 **Contributors:** AJL, GNB, CCE, JCF, KL, JB, and HF conceptualized the study and contributed to the intervention  
46  
47484 development and design. AJL and GNB oversaw the conduct of the trial all the authors contributed to the  
48  
49485 ongoing management of the trial. AJL, GNB, MM, AP, and CK oversaw data collection and data analysis. The  
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51486 manuscript was drafted by AJL. All the authors contributed to the interpretation of the findings and revised and  
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54487 reviewed the paper.  
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Figure 1. Conceptual model

Figure 2. Depiction of study design and assessments

Figure 3. CONSORT diagram

For peer review only

**Table 1. Baseline characteristics of Veterans in the urban and nature hiking groups**

| Characteristic             | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|----------------------------|--------------|------------|---------------|------------|--------------|------------|
|                            | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| <b>Age (years)</b>         |              |            |               |            |              |            |
| <30                        | 2            | 8          | 1             | 8          | 1            | 8          |
| 30-39                      | 5            | 19         | 2             | 15         | 3            | 23         |
| 40-49                      | 6            | 23         | 4             | 31         | 2            | 15         |
| 50-59                      | 11           | 42         | 6             | 46         | 5            | 38         |
| ≥60                        | 2            | 8          | 0             | 0          | 2            | 15         |
| <b>Gender</b>              |              |            |               |            |              |            |
| Male                       | 19           | 73         | 8             | 62         | 11           | 85         |
| Female                     | 7            | 27         | 5             | 38         | 2            | 15         |
| <b>Race/ethnicity</b>      |              |            |               |            |              |            |
| Asian/Pacific Islander, NH | 3            | 12         | 2             | 15         | 1            | 8          |
| Black, NH                  | 2            | 8          | 0             | 0          | 2            | 15         |
| Hispanic                   | 3            | 12         | 1             | 8          | 2            | 15         |
| Native American, NH        | 2            | 8          | 0             | 0          | 2            | 15         |
| Other                      | 1            | 4          | 0             | 0          | 1            | 7.7        |
| White, NH                  | 15           | 58         | 10            | 77         | 5            | 38         |
| <b>Marital status</b>      |              |            |               |            |              |            |
| Single, never married      | 4            | 15         | 3             | 23         | 1            | 8          |
| Married currently          | 14           | 54         | 7             | 54         | 7            | 54         |

| Characteristic  | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|---|--------------|------------|---------------|------------|--------------|------------|
|   | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| Separated/divorced  | 8            | 31         | 3             | 23         | 5            | 38         |
| <b>Education</b>  |              |            |               |            |              |            |
| High school degree or equivalent  | 4            | 15         | 1             | 8          | 3            | 23         |
| Some college, no degree   | 10           | 38         | 7             | 54         | 3            | 23         |
| Associate degree  | 4            | 15         | 1             | 8          | 3            | 23         |
| Bachelor's degree   | 4            | 15         | 2             | 15         | 2            | 15         |
| Masters, doctorate, or professional<br>degree                               | 4            | 15         | 2             | 15         | 2            | 15         |
| <b>Annual household income</b>  |              |            |               |            |              |            |
| \$25,000-\$49,999   | 7            | 27         | 4             | 31         | 3            | 23         |
| \$50,000-\$74,999   | 11           | 42         | 4             | 31         | 7            | 54         |
| \$75,000-\$99,999   | 2            | 8          | 1             | 8          | 1            | 8          |
| \$100,000 or more   | 4            | 15         | 3             | 23         | 1            | 8          |
| Prefer not to answer  | 2            | 8          | 1             | 8          | 1            | 8          |
| <b>Employment status</b>  |              |            |               |            |              |            |
| Full-time   | 12           | 46         | 6             | 46         | 6            | 46         |
| Part-time   | 1            | 4          | 1             | 8          | 0            | 0          |
| Not employed (disabled, retired, not<br>looking for work, homemaker, other) | 13           | 50         | 6             | 46         | 7            | 54         |
| <b>Highest military rank</b>  |              |            |               |            |              |            |

| Characteristic                               | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|--|--------------|------------|---------------|------------|--------------|------------|
|  | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| Enlisted (E1-E4)                             | 9            | 35         | 4             | 31         | 5            | 38         |
| Non-commissioned officer (E5-E9)             | 15           | 58         | 8             | 62         | 7            | 54         |
| Officer (O1-O4)                              | 2            | 8          | 1             | 8          | 1            | 8          |
| <b>VA disability rating*†</b>                |              |            |               |            |              |            |
| No rating                                    | 2            | 8          | 0             | 0          | 2            | 15         |
| 30-60%                                       | 2            | 8          | 2             | 15         | 0            | 0          |
| 70-90%                                       | 8            | 31         | 4             | 31         | 4            | 31         |
| 100%   | 12           | 46         | 6             | 46         | 6            | 46         |
| <b>Self-reported health</b>                  |              |            |               |            |              |            |
| Excellent/very good                          | 9            | 35         | 3             | 23         | 6            | 45         |
| Good   | 11           | 42         | 7             | 54         | 4            | 31         |
| Fair (no one reported poor)                  | 6            | 23         | 3             | 23         | 3            | 23         |
| <b>PCL-5 score‡</b>                          |              |            |               |            |              |            |
| Mean, SD                                     | 47.1         | 10.9       | 46.0          | 11.4       | 48.2         | 10.8       |
| <b>Served in combat [yes]</b>                | 17           | 65         | 8             | 62         | 9            | 69         |
| <b>Combat Exposure Score; mean (SD)* †</b>   | 16.6         | 7.9        | 15.6          | 8.2        | 17.7         | 7.9        |
| <b>Patient Health Questionnaire-8 score*</b> |              |            |               |            |              |            |
| <10 (no depression)                          | 8            | 32         | 4             | 33         | 4            | 31         |
| 10-19 (major depression)                     | 14           | 56         | 7             | 58         | 7            | 54         |
| ≥20 (severe major depression)                | 3            | 12         | 1             | 8          | 2            | 15         |

| Characteristic  | Total (n=26) |            | Nature (n=13) |            | Urban (n=13) |            |
|---|--------------|------------|---------------|------------|--------------|------------|
|   | N or<br>mean | % or<br>SD | N or<br>Mean  | % or<br>SD | N or<br>Mean | % or<br>SD |
| <b>Physical activity level</b>  |              |            |               |            |              |            |
| Low   | 8            | 31         | 5             | 38         | 3            | 23         |
| Moderate  | 3            | 12         | 1             | 8          | 2            | 15         |
| High  | 15           | 58         | 7             | 54         | 8            | 62         |
| <b>Times gone hiking for 1+ hrs in last year</b>                      |              |            |               |            |              |            |
| Never   | 5            | 19         | 3             | 23         | 2            | 15         |
| 1-3   | 9            | 35         | 4             | 31         | 5            | 38         |
| 4-6   | 5            | 19         | 2             | 15         | 3            | 23         |
| 7+  | 7            | 27         | 4             | 31         | 3            | 23         |
| <b>Outdoor / nature-based activity<br/>experience</b>                 |              |            |               |            |              |            |
| None (no experience in the outdoors)                                  | 0            | 0          | 0             | 0          | 0            | 0          |
| Casual (done some day hiking on<br>maintained trails and car camping) | 10           | 38         | 5             | 38         | 5            | 38         |
| Amateur (have experience with<br>backpacking)                         | 11           | 42         | 6             | 46         | 5            | 38         |
| Expert (substantial backcountry<br>experience)                        | 5            | 19         | 2             | 15         | 3            | 23         |

Abbreviations: NH, Non-Hispanic; PCL-5, Post-traumatic stress disorder checklist for Diagnostic and Statistical Manual 5; PTSD, post-traumatic stress disorder; SD, standard deviation

\* Missing response for 1 nature participant

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3 † Missing response for 1 urban participant  
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6 ‡ One person in the nature hiking group had a PCL-5 of 32 (below the eligibility threshold of 33) due to  
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8 an undetected error in initial scoring.  
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**Table 2. Key themes and findings from qualitative data**

| Themes                | Findings  |
|-----------------------|---|
| A positive experience | <ul style="list-style-type: none"> <li>Both nature (“All expectations were exceeded”) and urban study participants (“LOVE THE GROUP”) provided positive feedback.</li> </ul>  |
| Perceived benefits    | <ul style="list-style-type: none"> <li>Participants reported on how the hikes helped them to be more active, lose weight, reduce stress, and feel more connected to others.</li> </ul>  |
| Hike logistics        | <ul style="list-style-type: none"> <li>Participants suggested that prior to hikes, we ensure parking access, availability of toilets, and locate the hikes closer to participants’ homes.</li> <li>Others suggested that we consider organizing carpools and/or covering gas/mileage costs</li> </ul>   |
| Difficulty of hikes   | <ul style="list-style-type: none"> <li>Most found the difficulty just right.</li> <li>Some felt that the hikes were too short/easy.</li> </ul>  |
| Location of hikes     | <ul style="list-style-type: none"> <li><u>Nature group</u>: One participant wished that there was more of a “reward” (“like a waterfall”, “when you have a view, it seems more profound”), because some were just “walks through the woods.”</li> <li><u>Urban group</u>: One person noted that some neighborhoods were “sketchy” and they were “constantly walking around garbage” for one hike. Others noted that they really enjoyed exploring different neighborhoods, areas around sports stadium, and learning about the history of areas.</li> </ul> |

|   |  |
|---|--|
| Group composition   | <ul style="list-style-type: none"> <li>• A few participants suggested that we enroll more women or organize women-only groups and/or groups for survivors of sexual assault.</li> </ul>  |
| Incentives for completing questionnaires                          | <ul style="list-style-type: none"> <li>• Participants suggested that we offer the option to receive a single gift card that accumulated value instead of separate ones each time a questionnaire was completed.</li> </ul>   |
| Assessments   | <ul style="list-style-type: none"> <li>• Several participants had trouble with the online software (e.g., getting “kicked out” of the survey mid-way through);</li> <li>• Some participants reported that they would have liked text prompts instead of email, since they did not regularly check their email.</li> <li>• Some participants found some questions to be difficult to answer (e.g., the Perceived Cohesion Scale) or they were confused by differences in the time frame for different instruments (e.g., on the weekly questionnaires, some questions asked participants how they felt “right now” while others asked about the prior week).</li> </ul> |
| Activity monitors   | <ul style="list-style-type: none"> <li>• Several participants noted having problems programming and syncing the activity monitor.</li> </ul>   |
| Fostering interaction/connections between participants in a group | <ul style="list-style-type: none"> <li>• Participants suggested facilitating more structured ways to get to know other members of the group, including a social gathering prior to the initial hike, re-introductions before each hike, gathering for lunch or other meal after hikes, and organizing a social media group.</li> </ul>   |

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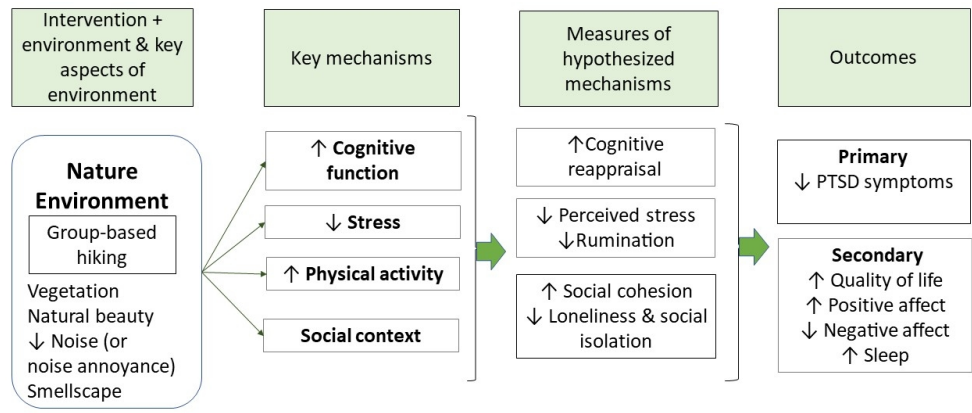


Figure 1. Conceptual model

338x190mm (96 x 96 DPI)

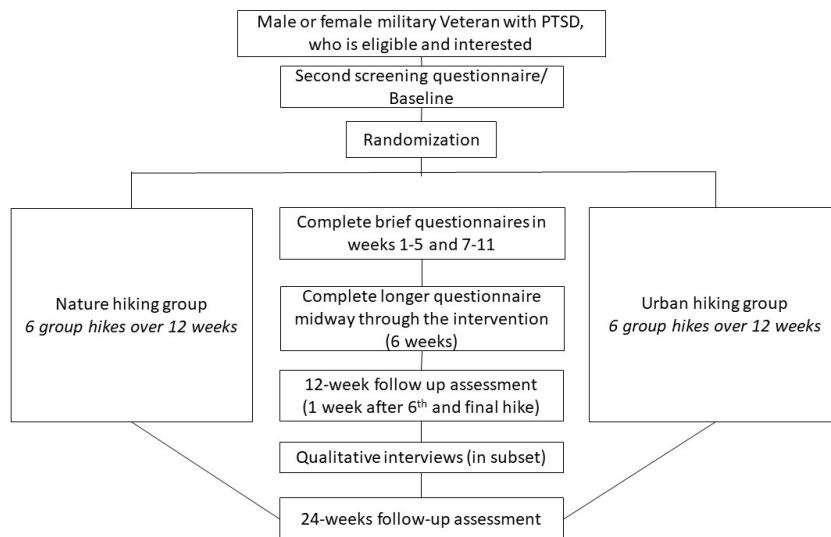


Figure 2. Depiction of study design and assessments

338x190mm (96 x 96 DPI)

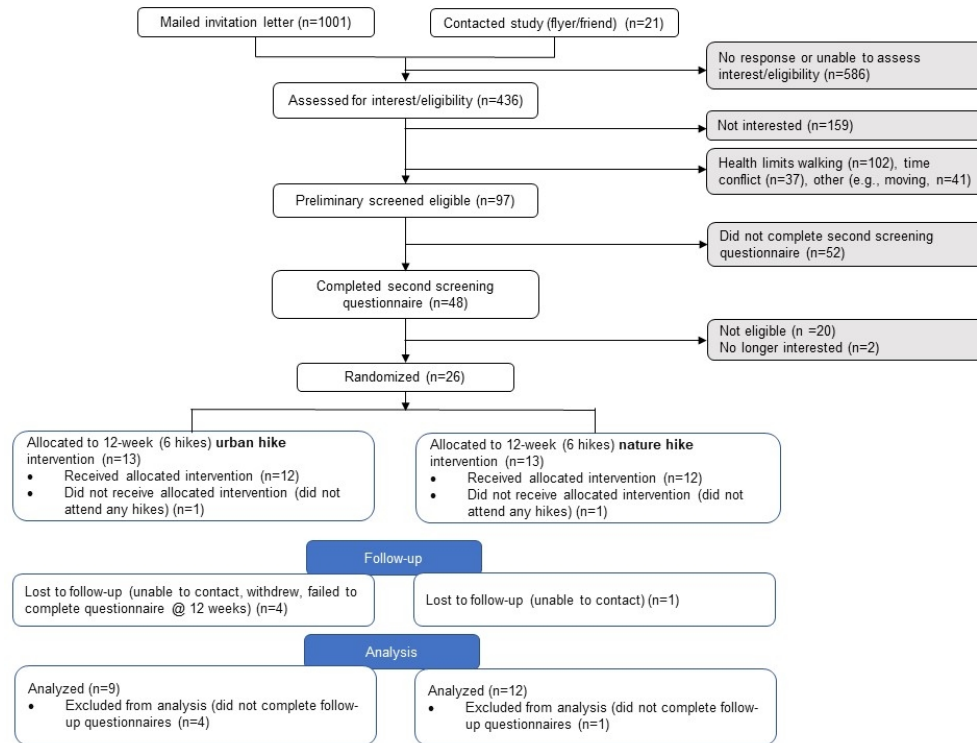


Figure 3. CONSORT diagram

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**Supplemental Table 1. Constructs, instruments, and timing of assessments**

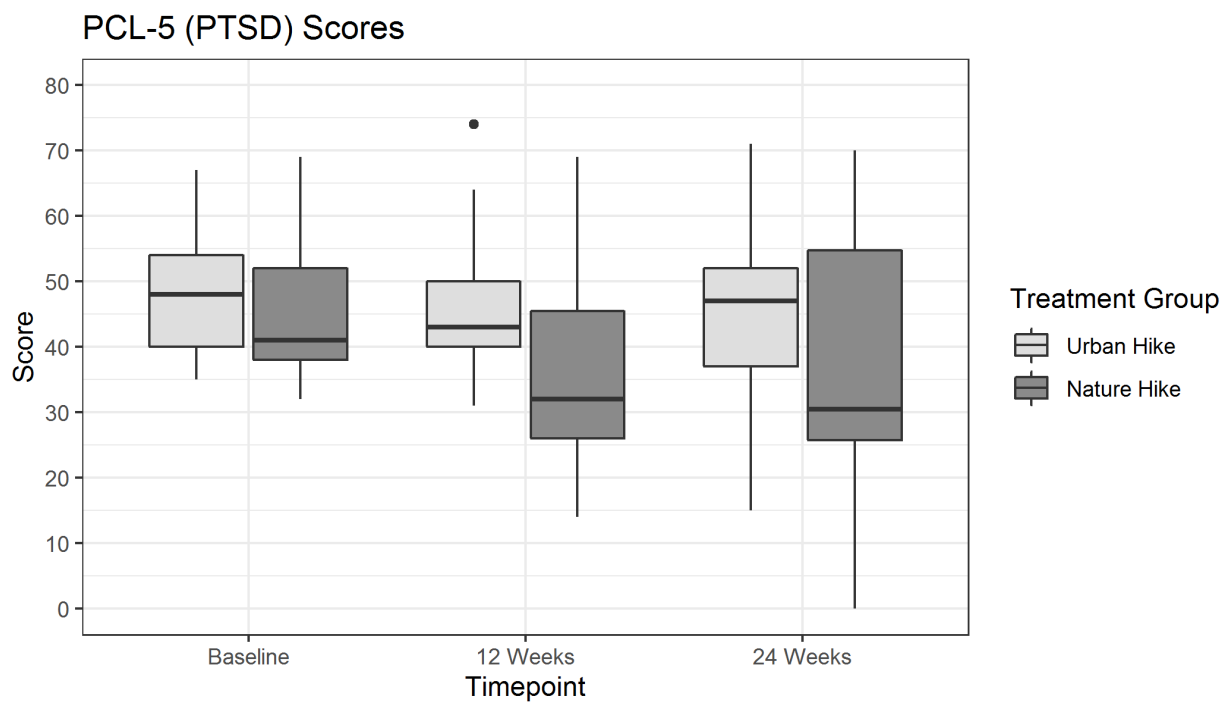
| Constructs   | Instrument   |
|--|--|
| Demographics   | n/a (Age, gender, race/ethnicity, education, service-connected disability, etc.)         |
| Combat exposure  | First two questions of the PTSD Diagnostic Scale-5 (73) and Combat Exposure Scale (74)   |
| Ability to safely perform unsupervised physical activity | Physical Activity Readiness Questionnaire (PAR-Q) (62)                                   |
| Suicidal ideation  | MINI Suicidality module (65)   |
| QoL/well-being   | Satisfaction with Life Scale (75)  |
| Physical health  | 14-item Physical Health Questionnaire (76)   |
| PTSD symptoms  | PTSD Checklist for DSM- 5 (61)   |
| Depression   | Personal Health Questionnaire (PHQ)-8 (77)   |
| Perceived Stress   | 4-item Perceived Stress Scale (PSS) (78,79)  |
| Affect   | 20-item Positive and Negative Affect Schedule (PANAS) (80,81)                            |
|  | 10-item PANAS  |
| Loneliness   | 3-item UCLA loneliness scale (82)  |
| Social connectedness                                     | First four items of the 6-item Perceived Cohesion Scale (83)                             |
| Anxiety  | 20-item Stress and Anxiety Scale (STAI) – state level                                    |
|  | 6-item STAI  |
| Sleep  | Full (19-item) Pittsburgh Sleep Quality Index (PSQI) (84)                                |
|  | Shortened (5-item) PSQI  |
| Nature connection  | Connectedness to Nature Scale (6-items) (85)   |
| Rumination   | Full (12-item) state rumination (brooding subscale of Rumination Reflection Scale [RRS]) |
|  | Shortened (8-item) state rumination (brooding subscale of RRS) (86)                      |
| Cognitive reappraisal                                    | 4-item state emotion regulation questionnaire (ERQ) (87)                                 |
| Physical activity – self report                          | 9-item International Physical Activity Questionnaire (IPAQ) short form (68)              |

| Constructs                                 | Instrument   |
|--|--|
| Physical activity monitor                  | Wrist worn activity monitor (Garmin Vivosmart 4)               |
| Alcohol consumption                        | 10-item Alcohol Use Disorders Identification Test (AUDIT) (64) |
|  | 3-item (AUDIT-C) (88)  |
| Drug-related problems                      | Drug Abuse Screening Test-10 (63)                              |
| PTSD treatments                            | n/a  |
| Preference for treatment, hiking frequency | n/a  |
| and expectation about treatment            |  |
| Acceptability of hikes                     | n/a  |

‡Timing of assessment: S/B: screening/baseline, WK: weekly – weeks 1-5 and 7-11, FU: 6-, 12-, and 24-week follow-ups

†A, acceptability; CO, covariate (including moderators); E, eligibility (to assess inclusion/exclusion criteria); M, mediator P, primary outcome; S, secondary outcome

**Figure 1. PTSD Checklist scores at baseline, 12- and to 24-weeks follow-up**



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## CONSORT 2010 checklist of information to include when reporting a pilot or feasibility trial\*

| Section/Topic                    | Item No | Checklist item  | Reported on page No |
|----------------------------------|---------|---|---------------------|
| <b>Title and abstract</b>        |         |   |                     |
|                                  | 1a      | Identification as a pilot or feasibility randomised trial in the title  | 1                   |
|                                  | 1b      | Structured summary of pilot trial design, methods, results, and conclusions (for specific guidance see CONSORT abstract extension for pilot trials)   | 2                   |
| <b>Introduction</b>              |         |   |                     |
| Background and objectives        | 2a      | Scientific background and explanation of rationale for future definitive trial, and reasons for randomised pilot trial  | 5-7                 |
|                                  | 2b      | Specific objectives or research questions for pilot trial   | 7                   |
| <b>Methods</b>                   |         |   |                     |
| Trial design                     | 3a      | Description of pilot trial design (such as parallel, factorial) including allocation ratio  | 9                   |
|                                  | 3b      | Important changes to methods after pilot trial commencement (such as eligibility criteria), with reasons  | 11                  |
| Participants                     | 4a      | Eligibility criteria for participants   | 8                   |
|                                  | 4b      | Settings and locations where the data were collected  | 8-10                |
|                                  | 4c      | How participants were identified and consented  | 8                   |
| Interventions                    | 5       | The interventions for each group with sufficient details to allow replication, including how and when they were actually administered   | 9-11                |
| Outcomes                         | 6a      | Completely defined prespecified assessments or measurements to address each pilot trial objective specified in 2b, including how and when they were assessed                                | 8, 11-12            |
|                                  | 6b      | Any changes to pilot trial assessments or measurements after the pilot trial commenced, with reasons  | n/a                 |
|                                  | 6c      | If applicable, prespecified criteria used to judge whether, or how, to proceed with future definitive trial   | n/a                 |
| Sample size                      | 7a      | Rationale for numbers in the pilot trial  | 11                  |
|                                  | 7b      | When applicable, explanation of any interim analyses and stopping guidelines  | n/a                 |
| Randomisation:                   |         |   |                     |
| Sequence generation              | 8a      | Method used to generate the random allocation sequence  | 9                   |
|                                  | 8b      | Type of randomisation(s); details of any restriction (such as blocking and block size)  | 9                   |
| Allocation concealment mechanism | 9       | Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned | 9                   |

|  |     |   |                       |
|--|-----|---|-----------------------|
| Implementation                                       | 10  | Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions   | 8                     |
| Blinding   | 11a | If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how  | 8                     |
|  | 11b | If relevant, description of the similarity of interventions   | 9-10                  |
| Statistical methods                                  | 12  | Methods used to address each pilot trial objective whether qualitative or quantitative  | 9-11                  |
| <b>Results</b>                                       |     |   |                       |
| Participant flow (a diagram is strongly recommended) | 13a | For each group, the numbers of participants who were approached and/or assessed for eligibility, randomly assigned, received intended treatment, and were assessed for each objective | Figure 3              |
|  | 13b | For each group, losses and exclusions after randomisation, together with reasons  | Figure 3              |
| Recruitment  | 14a | Dates defining the periods of recruitment and follow-up   | Figure 2, page 11-12  |
|  | 14b | Why the pilot trial ended or was stopped  | 12                    |
| Baseline data  | 15  | A table showing baseline demographic and clinical characteristics for each group  | Table 1               |
| Numbers analysed                                     | 16  | For each objective, number of participants (denominator) included in each analysis. If relevant, these numbers should be by randomised group  | Figure 3              |
| Outcomes and estimation                              | 17  | For each objective, results including expressions of uncertainty (such as 95% confidence interval) for any estimates. If relevant, these results should be by randomised group        | Supplemental Figure 1 |
| Ancillary analyses                                   | 18  | Results of any other analyses performed that could be used to inform the future definitive trial  | Table 2               |
| Harms  | 19  | All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)   | 15                    |
|  | 19a | If relevant, other important unintended consequences  | n/a                   |
| <b>Discussion</b>                                    |     |   |                       |
| Limitations  | 20  | Pilot trial limitations, addressing sources of potential bias and remaining uncertainty about feasibility   | 17-21                 |
| Generalisability                                     | 21  | Generalisability (applicability) of pilot trial methods and findings to future definitive trial and other studies   | 17-21                 |
| Interpretation                                       | 22  | Interpretation consistent with pilot trial objectives and findings, balancing potential benefits and harms, and considering other relevant evidence                                   | 17-21                 |
|  | 22a | Implications for progression from pilot to future definitive trial, including any proposed amendments   | 17-21                 |
| <b>Other information</b>                             |     |   |                       |
| Registration   | 23  | Registration number for pilot trial and name of trial registry  | 3                     |
| Protocol   | 24  | Where the pilot trial protocol can be accessed, if available  | n/a                   |
| Funding  | 25  | Sources of funding and other support (such as supply of drugs), role of funders   | 2, 9                  |
|  | 26  | Ethical approval or approval by research review committee, confirmed with reference number  | 13                    |

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Citation: Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L, et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ*. 2016;355.  
\*We strongly recommend reading this statement in conjunction with the CONSORT 2010, extension to randomised pilot and feasibility trials, Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see [www.consort-statement.org](http://www.consort-statement.org).

For peer review only