Pilot and Feasibility Studies

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Determining the feasibility and acceptability of a randomized telehealth pilot study for veterans with chronic multisymptom illness

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Abstract

Background The shift toward a patient-centered and whole health care model offers a promising approach for the management of symptoms among veterans with chronic multisymptom illness (CMI). A behavioral intervention aimed at reducing cognitive control dysregulation which is a component of impairments common among veterans with CMI may be helpful. Therefore, a pilot study was conducted to explore the feasibility, safety, and acceptability of a telehealth mental and physical (MAP) training intervention among veterans with CMI.

Methods Utilizing a two-arm randomized trial, participants were either randomized to 8 weeks of a directed MAP training protocol (dMAP) that received weekly guidance via text messaging or 8 weeks of self-guided MAP training (sgMAP) which did not receive guidance aside from the intervention goals. The MAP intervention was the same for both groups except for the delivery and consisted of two MAP training sessions and one telephone health coaching session per week. The primary aim of the study was to evaluate the feasibility (e.g., recruitment, retention, and adherence rates; amount of missing data), safety (e.g., adverse events), and acceptability (e.g., satisfaction) of a telehealth MAP intervention.

Results Out of 44 potentially eligible veterans, 26 were randomized to either the dMAP group ($n=13$) or the sgMAP group ($n=13$), resulting in a recruitment rate of 59% (26/44 patients). Two participants withdrew after randomization, resulting in 24 participants used for analyses. The retention rates at endpoint and 3-month follow-up were 79.2% (19/24; dMAP:sgMAP = 9:10) and 62.5% (15/24; dMAP:sgMAP = 7:8), respectively. Participants completed an average of 48.2% of the MAP sessions (7.7/16 sessions; dMAP:sgMAP = 7.9:7.5 sessions) and 82.8% of the health coaching sessions (6.6/8 sessions; dMAP:sgMAP = 7.2:6.2 sessions). Missing data was minimal, and no adverse events related to the study were reported. Acceptability was high as veterans were satisfied with the wearables and valued the health coaching support.

Conclusions This pilot study provides insights into the feasibility of a large-scale randomized control trial that promotes meditation and physical activity to augment cognitive control to facilitate self-regulation. Future efforts should expand recruitment strategies and add internal data quality monitoring.

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Keywords Telehealth, Veterans, Exercise, Meditation, Health coaching

Key messages regarding feasibility

- What uncertainties existed regarding the feasibility?

  The traditional method for administering mental and physical (MAP) training has predominantly been in person within a group setting. Recent efforts have explored the feasibility of a virtual MAP training intervention during the COVID-19 pandemic; however, adherence rates were lower than expected and the remote delivery of MAP training has not been studied among veterans. Therefore, a pilot study was designed to examine the feasibility of delivering a telehealth MAP training intervention that combined distance-based technology with health coaching among veterans with chronic multisymptom illness.
- What are the key feasibility findings?
  The key feasibility findings from this pilot study included poor recruitment potential (due to the conservative eligibility criteria applied to a chronically ill veteran population), a high retention rate, adherence rates just below the progression threshold, a minimal amount of missing data, and no adverse events related to the study were reported. Participants provided positive feedback regarding the monitoring capabilities of wearables and satisfaction with health coaching because of the increased support and accountability.
- What are the implications of the feasibility findings for the design of the main study?
  This pilot study demonstrated that the combination of distance-based technology (e.g., apps and a wearable device) and health coaching for delivering a telehealth MAP intervention is feasible and safe among veterans with CMI; however, some slight modifications to the methods are warranted. Future efforts will need to expand recruitment strategies and add internal monitoring for data quality issues.

Background

Chronic multisymptom illness (CMI) is a complex condition that encompasses a wide array of persistent, medically unexplainable symptoms that impact quality of life, particularly for veterans. The estimated prevalence of CMI in veterans is approximately between 25 and 50%, thus representing a significant challenge for healthcare providers [1]. Although typically associated with veterans who served during the 1990/1991 Gulf War (commonly referred to as Gulf War illness [2]), 50% of surveyed veterans who deployed in Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF), or Operation New Dawn (OND) also suffered from CMI [3], with a recent study reporting over twice as many cases of CMI among female OEF/OIF/OND veterans compared to women Veterans Health Administration (VHA) users of the same period [4].

The Department of Veterans Affairs (VA) and Department of Defense recently published an update to their evidence-based clinical practice guidelines for military populations with CMI, which emphasized the importance of developing an individualized management plan that monitors "progress toward personal goals" [1]. These clinical recommendations align with the broader VA Whole Health patient-driven health care model as well as principles of health coaching-related behavioral change. A pivotal factor needed for engaging in this level of self-care is cognitive control which enables individuals to plan and develop personal goals [5]. However, cognitive control dysregulation is a central component of impairments that are common in veterans with CMI. Therefore, they may encounter obstacles to recovery, adherence to self-regulation practices, and achievement of individual goals (e.g., health, professional, personal).

The application of neuroscience methods focused on promoting neurogenesis and learning may offer a brain health-facilitating intervention that benefits cognitive function [6] and enhances cognitive control capacity. The combination of mental and physical (MAP) training, based on the notion that increases in neuron numbers (from physical activity) and activity-dependent survival of neurons (from the cognitive challenge of meditation), offers a unique approach intended to benefit both cognition and brain health [7]. These practices have been extensively studied separately [8–15]; however, recent evidence indicates an advantage in combining both mental and physical training together to effectively augment cognitive control and reduce symptoms of anxiety, depression, and trauma [16–19] as well as improve overall well-being [20]. Moreover, MAP interventions have demonstrated increased oxygen consumption associated with aerobic fitness [18], neural responsivity of cognitive control event-related potentials [19], and hippocampal-mediated learning discrimination [21].

The traditional method for administering MAP training has predominantly been in person within a group setting, which has limited accessibility. Recent efforts have explored the feasibility of a virtual MAP training intervention during the COVID-19 pandemic that combined live-streamed sessions with unsupervised pre-recorded sessions and demonstrated favorable mental health and wellbeing outcomes [20]. However, adherence rates were lower than expected, and the remote delivery of MAP training has not been studied among veterans [20]. This emphasizes the need for additional research demonstrating the feasibility of distance-bridging approaches for delivering health interventions among veterans.

The VA has been offering telehealth services for 20 years and continues to expand services to accommodate the increased demand that continues following the COVID-19 pandemic [22]. Previous research has demonstrated the effectiveness of VA delivered telehealth services in reducing psychiatric hospitalizations, emergency department visits, and suicidal ideation [23–25] as well as improving continuity of care and patient satisfaction [26, 27]. Leveraging the technology used to deliver telehealth services may be a viable option for remotely engaging veterans in a health intervention; however, compliance continues to be a limiting factor for interventions delivered remotely [28]. One meta-analysis observed higher compliance among digital (remote) interventions that were augmented by human support (via email or the telephone) as compared to unsupported interventions [28], thus indicating that additional human support may be needed to promote compliance, especially among veterans. Health coaching is one form of human support that is emerging as a potent means of offering distance-based care through a collaborative, patient-centered approach to promoting health behavior change in those who suffer from chronic illness [29]. There is preliminary evidence demonstrating the feasibility and acceptability of combining an Internet-based (remote) intervention with telephone health coaching among veterans with post-traumatic stress disorder [30], suggesting the applicability of this approach for administering health interventions remotely to veterans.

There is a critical need for evaluating the feasibility of remote interventions aimed at promoting health behaviors (e.g., meditation and physical activity) in veterans endorsing complex deployment-related health symptoms. The implementation of a MAP training program delivered using telehealth distance-based approaches, including web-based applications, remote devices, and patient-centered health coaching may be an effective adjuvant for whole healthcare delivery. Therefore, this pilot study examined the feasibility, safety, and acceptability of a telehealth MAP training intervention that combined distance-based technology with health coaching designed to support overall brain function while benefiting neurocognitive and emotional functioning among veterans with CMI.

Methods

Design

This study was a two-arm randomized pilot trial in which participants were randomized to either 8 weeks of directed MAP (dMAP) training or 8 weeks of self-guided MAP (sgMAP) training. The protocol was approved by the Institutional Review Board (IRB no. 1574770) at the Washington, DC Veterans Affairs Medical Center (DC VAMC), and all participants provided written or verbal consent prior to participating in the study.

Setting

The War-Related Illness and Injury Study Center (WRIISC) is a national post-deployment health program whose mandate includes evaluating veterans with post-deployment health concerns and medically unexplained symptoms that are attributable to their deployment experience, thus representing a population with probable CMI. As part of the comprehensive clinical evaluation, an individually tailored recommendation plan is given to the veteran and referring primary care provider. This pilot study was thus integrated into the WRIISC clinical processes to support investigation of the feasibility of a telehealth approach for these complex cases with the idea that this has direct implications for delivery of clinical care to those seen at the WRIISC.

Participants

Between October 2018 and May 2021, all veterans undergoing a comprehensive clinical evaluation at the WRIISC located at the DC VAMC were provided with a study brochure and invited to participate in the study. It was clearly stated to all veterans that a decision to decline or accept participation in research would have no effect on their clinical evaluation. Any veteran expressing interest was screened further to determine eligibility during the week of their comprehensive evaluation.

Participants were screened in person or telephonically to ensure they were (a) > 18 years of age (self-report); (b) previously deployed US veterans; (c) experiencing chronic multisymptom illness according to the Fukuda case definition [31] (one or more chronic symptoms ≥ 6 months in duration from two or more symptom domains: fatigue, mood/cognition, and musculoskeletal); (d) had a smart phone; and (e) able to engage in physical activity. Potential participants were excluded if they had (a) current or within the past 90 days drug use, abuse, or dependence; (b) excessive alcohol consumption (men: Alcohol Use

Disorders Identification Test-Consumption [AUDIT-C] score ≥ 4; women: AUDIT-C score ≥ 3); (c) current prominent suicidal or homicidal ideation; (d) recent exposure to trauma within the past month; (e) acute or unstable chronic illness; and (f) dementia or other significant cognitive impairment. Given the physical activity component of the study, acute or unstable chronic illness was identified during the medical record review conducted as part of the comprehensive evaluation and from the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) [32]. In cases where self-reported measures and clinical interviews did not align (e.g., veterans who underreport on symptom questions), licensed nurses reviewed these gathered screening data and used clinical judgement to determine final eligibility.

Due to the initially low recruitment rates through the WRIISC, recruitment was expanded to include local veterans receiving care at WRIISC (e.g., through the exposure health education classes or were prior national referral patients in the DC area). The inclusion and exclusion criteria remained the same; however, veterans who did not undergo a comprehensive clinical evaluation at the WRIISC were asked to complete additional questionnaires that aligned with the standard procedures of the clinical evaluation. These questionnaires included the Calibrated Neuropsychological Normative System Mental Status Examination — Telephone Version [33], a history and physical, Columbia Suicide Severity Rating Scale [34], a trauma exposure measure, Modified Brief Addiction Monitor, and AUDIT-C [35].

Procedures

All consenting and baseline study procedures were originally in person at the DC VAMC. However, these procedures were modified to be entirely distance based during the COVID-19 pandemic by using video-conferencing technology (VA Virtual Care Manager). For those completing distance-based enrollment, all study-related materials were shipped to the participant after obtaining electronic informed consent so that participants could complete their baseline procedures via the study devices/apps. The baseline procedures were the same for all participants (onsite and remote enrollment) and included randomization, instruction on how to use the study devices and apps, introductory meeting with their assigned health coach, and completion of baseline assessment consisting of several questionnaires.

The random allocation sequence was generated using a simple randomization process (computer-generated random numbers) and concealed in sequentially numbered opaque envelopes by a research assistant. After obtaining informed consent, a different research assistant would open the opaque envelopes in sequential order to randomly assign participants to either the dMAP group or the sgMAP group in a 1:1 allocation ratio. Blinding was not practical for this pilot study given the small number of staff dedicated to the project, but self-report measures were administered via a custom-developed web-based application (called the Brain Health app — see next section for a description), thus minimizing risk of implementation bias.

Study devices and apps

All participants received a Fitbit Charge 2 (Fitbit, LLC, San Francisco, CA, USA) and a Samsung Galaxy Tab A tablet (Samsung Electronics America, Inc., Ridgefield Park, NJ, USA). The Fitbit was used for logging each exercise session and for determining exercise adherence using the data collected (e.g., heart rate and duration). Every tablet was preinstalled with three web-based applications for mobile devices: (1) Brain Health app (custom developed), (2) Daily Workouts Fitness Trainer app (Daily Workout Apps, LLC), and (3) Fitbit: Health & Fitness app (Fitbit, LLC, San Francisco, CA, USA). The Brain Health app was custom designed by Georgetown University as a secure, web-based application to serve as a portal for collecting self-report measures at each timepoint (baseline, endpoint, and 3-month follow-up) and for administering the pre-recorded guided meditations. Participant use of the Brain Health app was tracked by the app developers who would provide research staff with a report containing the following data elements: timestamp of each meditation session (date and start/end time), duration (defined as the length of time the meditation portal was viewed), and the title of the guided iRest® meditation script selected. The Daily Workouts Fitness Trainer app provided participants with a collection of workout routines; however, participants were allowed to use their preferred method of exercise if it met the intervention goals (e.g., target heart rate, duration). The Fitbit: Health & Fitness app served as a portal for transferring data collected by each participant's Charge 2 device to their Fitbit dashboard, so that research staff could download the data to determine adherence.

Intervention

Participants in both groups completed an 8-week telehealth MAP intervention that included two sessions of MAP training and one session of health coaching per week. Participants randomized to the dMAP group received weekly text messages using the VA's Annie mobile application [36] for veterans that specified which meditation and workout sessions to complete using the mobile apps preinstalled on their tablet. Since both meditation and exercise have well-documented benefits and given that there are ethical concerns about withholding

active treatment from volunteer participants, an active control group (sgMAP) was used instead of a no-treatment condition. The sgMAP received instruction on the intervention goals (e.g., target heart rate, duration) during the baseline procedures and were given the same study devices and apps as the dMAP group; however, no additional guidance was given during the intervention.

Each MAP training session consisted of two components: 30 min of guided meditation and 30 min of aerobic exercise at moderate-to-vigorous intensity. For the guided meditation component, iRest® Yoga Nidra [37] was used. This meditation practice is designed to induce deep relaxation and restoration, to help manage negative emotions and thought patterns, and to increase moment-to-moment awareness of kinesthetic, emotional, energetic, and cognitive experiences. The iRest® protocol consists of 10 sequential stages that include a body scan, breath awareness, and observation of feelings, emotions, and beliefs. Each iRest® guided meditation was pre-recorded and lasted approximately 30–35 min. Participants listened to these recordings via the Brain Health app. The dMAP group was prompted via texts as to which meditation script to listen to while the sgMAP group was free to choose. For the aerobic exercise component, participants exercised aerobically for 30 min at moderate-to-vigorous intensity, which is equivalent to 50–85% of their age-predicted maximal heart rate (calculated as 220 minus age). Participants utilized their Fitbit Charge 2 for logging their exercise sessions and for monitoring their heart rate within the prescribed intensity level.

Each participant regardless of group assignment received one 30-min telephone health coaching session each week with a registered nurse for a total of eight sessions during the intervention. Two licensed registered nurses, with training in VA Whole Health coaching and over 15 years of nursing experience, served as the health coaches during the intervention. In contrast to traditional Whole Health coaching that is focused on complete patient centeredness and patient-determined goals, WRIISC provides clinically guided health coaching that offers continuity with the clinical services. The pilot study applied a similar expert-informed technique and utilized elements of Whole Health coaching methods, such as action plans and self-discovery to allow the participant to control how the MAP intervention was integrated into their lifestyle, thus applying a more prescriptive, yet still veteran-centric, health coaching approach. Therefore, the goal of the health coaching sessions was to maximize study adherence and promote positive health outcomes by reviewing with the participant their app usage for the meditation component and the number of exercise sessions logged with their Fitbit. Health coaches completed a weekly coaching checklist form that prompted discussion with participants on how they were doing, what progress was made since their last session, what barriers were encountered with completing the intervention, and what were their committed actions for the upcoming week. The weekly check-ins where these data were acquired enabled the coaches to develop contingency plans and work within those barriers to create accountability and maximize the likelihood that participants will engage in these practices. Health coaches also completed an adverse event monitoring form during each health coaching session which asked participants to self-report doctor/hospital visits, physical complaints and/or medical procedures, changes in mood, and accidents or near misses since their last encounter.

Feasibility, safety, and acceptability outcomes

The primary outcomes of this study were to evaluate the feasibility, safety, and acceptability of a telehealth MAP intervention. The assessment of feasibility included examining recruitment, retention, adherence, and completeness of data in which progression criteria were predefined using thresholds found in the literature with comparable populations and/or interventions to determine whether modifications are warranted before proceeding forward with a definitive trial. Additionally, the safety, acceptability, and practicability of the study intervention were also evaluated in conjunction with the predefined progression criteria for feasibility.

Recruitment

Recruitment rate was calculated by dividing the number of eligible participants who consented into the study by the number of eligible WRIISC patients approached during study enrollment. Recruitment goal was set at enrolling 30 participants (15 per group).

Retention

Retention rate was defined as the percentage of participants completing each assessment and was calculated separately for endpoint and 3-month follow-up. A meta-analysis of remote digital health studies reported an average retention rate of 48% for study durations lasting less than 12 weeks (interquartile range: 38 to 73%); with most of the included studies targeting clinical populations which aligns with our sample characteristics [38]. Therefore, 48% was selected as the progression threshold for retention rate.

Adherence

Adherence rates were calculated separately for each MAP component as well as overall for the combined MAP training. Participants were asked to complete two 30-min meditation sessions per week and were assumed

to be meditating during the time the meditation script was playing using the Brain Health app. Therefore, duration of meditation was quantified by the length of time the meditation portal was viewed in the app. Adherence to the meditation component was calculated as the number of 30-min sessions completed divided by the total number of possible sessions (no. of participants who received their allocated intervention × 16 sessions). For the aerobic exercise component, both the average heart rate and the duration of each logged exercise session were collected from the Fitbit online dashboard to determine whether participants exercised for at least 30 min at moderate-to-vigorous intensity. To assess adherence to the exercise prescription, the number of logged sessions meeting the exercise prescription criteria was divided by the total number of possible sessions (no. of participants who received their allocated intervention × 16 sessions). Overall adherence to the MAP intervention was defined as the number of sessions completed that successfully met the criteria for both components (in that each session contained 30 min of meditation AND 30 min of moderate-to-vigorous intensity exercise) divided by the total number of possible sessions (no. of participants who received their allocated intervention × 16 sessions). For participants who completed additional sessions beyond the 16 total required sessions, individual adherence was capped at 100% (16 sessions). A recently published study examining the feasibility of a virtual MAP training intervention, which combined live-streamed sessions with unsupervised pre-recorded sessions, observed lower adherence rates for the pre-recorded sessions compared to the live-streamed (50% versus 66.7%) [20]. Given that our intervention did not include live-streamed sessions, we selected 50% as the progression threshold for adherence to the MAP training protocol (each session contained 30 min of meditation AND 30 min of moderate-to-vigorous intensity exercise). The percentage of sessions attempted were also calculated for each component. Attempts included meditation sessions that were less than 30 min and exercise sessions in which duration and/or intensity did not meet the exercise prescription. Exercise sessions were also marked as attempts when there was missing data for duration and/or heart rate. Adherence was calculated for the health coaching sessions as the number of sessions completed out of the total number of possible sessions (no. of participants who received their allocated intervention × 8 sessions).

Missing data

Data were examined for missingness and reported as counts and percentages. The progression threshold for missing data was set at ≤ 10%.

Safety

Safety of administering the MAP intervention remotely was quantified by reviewing the notes documented on the weekly coaching checklist forms as well as the adverse event monitoring forms completed during each study encounter. Participants were asked to self-report doctor/hospital visits, physical complaints and/or medical procedures, mood changes, and any accidents or near misses since their last contact with study staff. Safety was based on any unintended effect or adverse event reported during the intervention.

Acceptability and practicability

Acceptability was evaluated through qualitative feedback obtained from participants during health coaching sessions which included their experiences and satisfaction with the study protocol, devices, and apps. Health coaches were instructed to monitor for barriers to achieving adherence with study procedures in addition to any constraints mentioned by participants that may impact the delivery of the intervention (practicability). These data were documented by health coaches on the weekly coaching checklist form that was completed during each session.

The practicability of the intervention was assessed separately for each individual component of the MAP training to identify any constraints that may impact the delivery of a telehealth intervention. For the meditation component, practicability was defined as the number of the meditation sessions in which participants self-reported issues using the Brain Health app (e.g., login errors). Practicability for the exercise component was defined as the number of exercise sessions in which participants self-reported logging errors using their Fitbit.

Sample size justification A sample size calculation was not formally conducted given that the goal of this pilot study was to examine the feasibility of delivering a telehealth MAP training intervention that combined distance-based technology with health coaching among veterans with CMI. Instead, a recruitment goal of 15 participants per group (n = 30) was set based on the sample size recommendation of at least 12 per group [39]. With a sample size of 30, we can estimate a retention rate of 48% to within ± 18% with 95% confidence.

Data analysis

Descriptive statistics were reported for the baseline characteristics as frequencies (%) for categorical variables and means (standard deviations) for continuous variables. Some of the baseline data was missing for one of the dMAP participants, and therefore was not included

in the descriptive statistics. Feasibility (recruitment, retention, and adherence rates), missing data, safety, and practicability outcomes were reported as numbers and/or percentages. The acceptability of the intervention was quantified using content analysis in which the frequency of reoccurring words or subjects appearing within the written health coaching notes was counted and reported narratively at the participant level. All participants were included in the feasibility results regardless of compliance/completion (intention to treat).

Results

Participant demographics

Table 1 describes the demographic characteristics of the participants by intervention group. Overall, the mean age of the participants was 49 (*SD* = 8.9) years. Most of the participants were male (92%), white (96%), and married (80%), had more than a high school education (76%), and were employed at least part-time (64%). The majority owned their smartphones for more than 4 years (95.8%) and used their smartphone apps everyday (83.3%).

Table 1 Demographic characteristics by intervention group

Characteristic	Total (*n* = 25)[a]	dMAP (*n* = 12)	sgMAP (*n* = 13)
Age, mean ± SD	49.2 ± 8.9	48.2 ± 11.5	50.2 ± 6.0
Gender, no. (%)			
Male	23 (92.0)	12 (100.0)	11 (84.6)
Female	2 (8.0)	0 (0.0)	2 (15.4)
Race, no. (%)			
White	24 (96.0)	12 (100.0)	12 (92.3)
Non-white	1 (4.0)	0 (0.0)	1 (7.7)
Marital status, no. (%)			
Married	20 (80.0)	9 (75.0)	11 (84.6)
Separated/divorced	4 (16.0)	2 (16.7)	2 (15.4)
Living with a partner	1 (4.0)	1 (8.3)	0 (0.0)
Education, no. (%)			
HS/GED	6 (24.0)	2 (16.7)	4 (30.8)
> HS/GED	19 (76.0)	10 (83.3)	9 (69.2)
Employment status, no. (%)			
Unemployed	1 (4.0)	0 (0.0)	1 (7.7)
Student	1 (4.0)	1 (8.3)	0 (0.0)
Employed at least part-time	16 (64.0)	9 (75.0)	7 (53.8)
Retired	7 (28.0)	2 (16.7)	5 (38.5)
Length of time owning a smartphone, no. (%)[b]			
2–4 years	1 (4.2)	0.0 (0.0)	1 (7.7)
4 + years	23 (95.8)	11 (100.0)	12 (92.3)
Utilization frequency of smartphone apps, no. (%)[b]			
A few times a week	4 (16.7)	2 (18.2)	2 (15.4)
Everyday	20 (83.3)	9 (81.8)	11 (84.6)

Note: No significant differences were observed between the two intervention arms. *dMAP*, directed mental and physical training; *GED*, General Education Development; *HS*, high school; *SD*, standard deviation; *sgMAP*, self-guided mental and physical training

[a] Data were missing for the last enrolled participant due to the study app being discontinued after enrollment

[b] Data for smartphone ownership and web-based app utilization were missing for two participants (one of which was due to the discontinuation of the study app)

Feasibility

Recruitment

There were 44 potentially eligible patients who were screened between October 2018 and May 2021 (Fig. 1), which included a 5-month period when enrollment stopped during the COVID-19 pandemic. Of these, 26 met the inclusion criteria and were randomized to either the dMAP group ($n = 13$) or the sgMAP group ($n = 13$), resulting in a recruitment rate of 59% (26/44 patients) and a recruitment potential of at least one participant per month. There were two participants randomized to the dMAP group that did not receive the allocated treatment because they withdrew from the study directly after randomization, resulting in a total of 24 participants used for analyses. Reasons for early withdrawal included military redeployment ($n = 1$) and discontinuation of the customized study app which prevented data collection and administering the intervention to the last enrolled participant ($n = 1$).

Retention

Nineteen of the 24 randomized participants, who received a portion of their allocated intervention, completed the endpoint assessment (dMAP:sgMAP = 9:10; 79.2% retention rate). Of the five participants who discontinued the study, two were due to lack of time (dMAP:sgMAP = 1:1), two had medical complications unrelated to the study (dMAP:sgMAP = 1:1), and one discontinued because of frustration with the study devices and apps (dMAP:sgMAP = 0:1). Fifteen participants completed the 3-month follow-up assessment (dMAP:sgMAP = 7:8; 62.5% retention rate) as 4 participants, 2 from each group, were lost to follow-up. Participants who dropped out of the intervention or were lost to follow-up were slightly younger than those who completed all of the assessments. No other differences were observed for baseline demographic characteristics.

Adherence

Table 2 describes the level of adherence for each component of the telehealth MAP intervention. Overall, participants successfully completed 263 meditation sessions out of 384 total sessions (24 participants × 16 sessions), resulting in an adherence rate of 68.5% (95% confidence interval [CI]: 63.6–73.1). The average (SD) number of

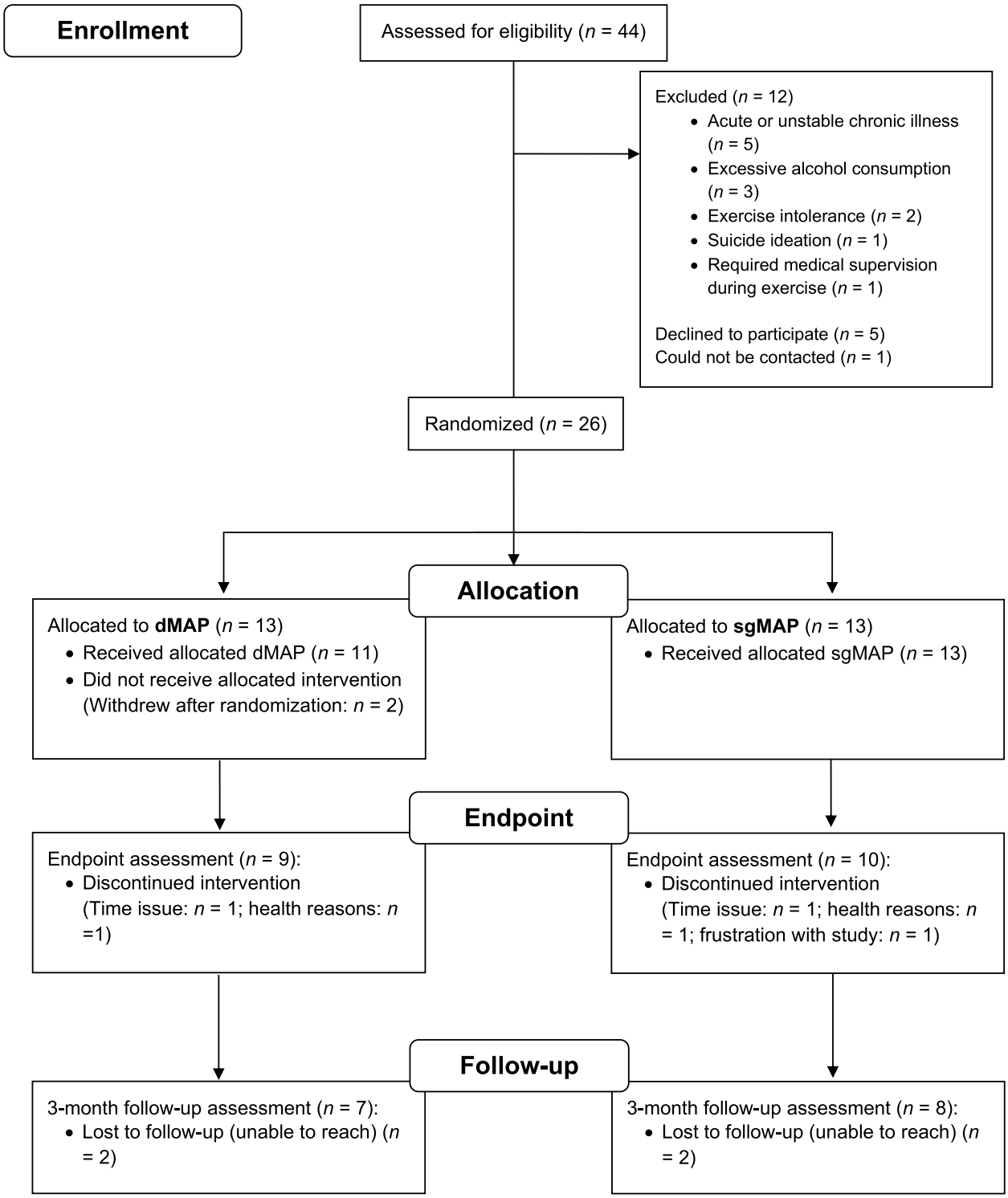

Fig. 1 Flow diagram of study participation. dMAP, directed mental and physical training group; sgMAP, self-guided MAP training group

sessions completed was 11.0 (5.4) out of 16 total sessions (range: 0–16 sessions). There were two participants, one from each group, who dropped out of the study during the first week without completing a single meditation session, resulting in 0% adherence to the meditation component. The dMAP group completed approximately

Table 2 Adherence to the components of the telehealth MAP intervention

	Overall ($n=24$)		dMAP ($n=11$)		sgMAP ($n=13$)	
	Completed	**Attempts[a] + completed**	**Completed**	**Attempts[a] + completed**	**Completed**	**Attempts[a] + completed**
% of MAP training sessions (out of 384 sessions)						
Mean (95% CI)[b]	48.2 (43.1–53.3)	63.5 (58.5–68.4)	49.4 (41.8–57.1)	63.6 (56.1–70.7)	47.1 (40.2–54.1)	63.5 (56.5–70.0)
% of guided meditation sessions (out of 384 sessions)						
Mean (95% CI)	68.5 (63.6–73.1)	74.7 (70.1–79.0)	74.4 (67.3–80.7)	80.1 (73.4–85.7)	63.5 (56.5–70.0)	70.2 (63.5–76.3)
% of aerobic exercise sessions (out of 384 sessions)						
Mean (95% CI)	64.1 (59.0–68.9)	78.9 (74.5–82.9)	71.0 (63.7–77.6)	85.2 (79.1–90.1)	58.2 (51.2–65.0)	73.6 (67.0–79.4)
% of health coaching sessions (out of 192 sessions)						
Mean (95% CI)	82.8 (76.7–87.9)	N/A	89.8 (81.5–95.2)	N/A	76.9 (67.6–84.6)	N/A

Note: All participants regardless of compliance/completion were included (intention to treat) in the calculations above. This included two participants, one from each group, who completed zero meditation sessions, zero aerobic exercise sessions, and zero mental and physical (MAP) training sessions before dropping out within the first week of the study

[a] Attempts included meditation sessions that were less than 30 min and exercise sessions in which duration and/or intensity did not meet the exercise prescription. Exercise sessions were also marked as attempts when there was missing data for duration and/or heart rate

[b] Clopper-Pearson 95% confidence interval (CI)

1.7 more guided meditation sessions compared to the sgMAP group (74.4% versus 63.5%, respectively). Overall, participants made 24 attempts to complete a meditation session that ultimately did not reach 30 min in duration, bringing the number of sessions attempted and/or completed to 287 out of 384 total sessions (74.7% [95% *CI*: 70.1–79.0]).

Overall, participants successfully completed 246 aerobic exercise sessions out of 384 total sessions, resulting in an adherence rate of 64.1% (95% *CI*: 59.0–68.9). On average (SD), participants completed 10.3 (5.6) aerobic exercise sessions out of 16 total sessions (range: 0–16 sessions). Similar to the meditation component, there were two participants, one from each group, who completed zero aerobic exercise sessions before dropping out within the first week of the study, resulting in 0% adherence to the aerobic exercise component. The dMAP group completed approximately two more sessions compared to the sgMAP group (71.0% versus 58.2%, respectively). Participants made 57 attempts to complete an aerobic exercise session that either did not meet the exercise prescription or was missing data, bringing the number of sessions attempted and/or completed to 303 out of 384 total sessions (78.9% [95% *CI*: 74.5–82.9]).

Participants successfully completed 185 MAP sessions, containing both the meditation and aerobic exercise components, out of 384 total sessions, resulting in an adherence rate of 48.2% (95% *CI*: 43.1–53.3). On average (SD), participants completed 7.7 (5.2) MAP sessions out of 16 total sessions (range: 0–16 sessions). As previously mentioned, there were two participants, one from each group, who completed zero meditation sessions, zero aerobic exercise sessions, and zero MAP training sessions before dropping out within the first week of the study, resulting in 0% adherence to the MAP training protocol. Both groups completed about the same number of sessions (dMAP:sgMAP = 7.9 sessions: 7.5 sessions out of 16 sessions) with eight participants, four from each group, completing 75% of the MAP sessions (12/16 sessions). Participants made 59 attempts to complete a MAP training session which had each of the components, but one or both components did not meet the study requirements, thus bringing the number of sessions attempted and/or completed to 244 out of 384 total sessions (63.5% [95% *CI*: 58.5–68.4]).

Each participant enrolled in the study completed at least one health coaching session. There were three participants (dMAP:sgMAP = 1:2) who disclosed their intention to drop out of the study during their first and only health coaching session. Overall, participants completed 159 out of 192 total health coaching sessions (24 participants × 8 sessions), resulting in an adherence rate of 82.8% (95% *CI*: 76.7–87.9). On average (SD), participants completed 6.6 (2.6) sessions out of eight total health coaching sessions (range: 1–8 sessions), with the dMAP group demonstrating a slightly higher adherence rate than the sgMAP group (89.8% versus 76.9%, respectively).

There were no significant differences between the groups regarding adherence to each of the individual components of the intervention (e.g., meditation, aerobic exercise, health coaching) as well as overall adherence to the MAP training. There was a noted difference in the

number of participants who dropped out of the study: the sgMAP group had three participants drop out versus two participants from the dMAP group. Two of the three participants from the sgMAP group dropped out in the first week without completing a MAP session versus one participant from the dMAP group.

Missingness

Complete baseline data was obtained from each of the 24 randomized participants. Of the 19 participants who completed the endpoint assessment, there were 16 participants with complete data and 3 participants with partial data. Overall, the amount of missing survey data at endpoint was 7.6% (range: 0 to 15.8% on individual surveys). Of the 15 participants who completed the follow-up assessment, there was complete data for 13 participants and partial data for two participants. The overall amount of missing survey data at follow-up was 6.7% (range: 0 to 13.3%). Adherence data for the aerobic exercise component (e.g., duration and/or average heart rate) was incomplete for 10 participants which resulted in missing data for 31 sessions (10%) out of 309 total logged exercise sessions.

Safety

During the study, there were a total of 13 medical appointments self-reported by participants, all of which were found to be routine visits. In addition, there were a total of 18 encounters where one or more physical complaints were reported by participants, including feeling unwell/sick ($n=7$ participants), fatigue ($n=6$), migraine/headache ($n=6$), pain ($n=5$), and issues with a pacemaker, unrelated to the study, which resulted in one participant withdrawing in the first week ($n=1$). There were five encounters where one or more mood changes were reported (e.g., anger, anxiety, stress, frustration). Lastly, a total of five accidents or near misses were self-reported by participants (e.g., a fall, workplace assault, workplace injury, hitting thumb with a hammer, and physical altercation), all of which were unrelated to the study.

Acceptability and practicability

There was mixed acceptance of iRest® guided meditations — some participants ($n=6$) reported to their health coach that they disliked this form of meditation, stating that they found it boring, irritating, hard to listen to, or that they preferred other forms of meditation. In contrast, there were 10 participants who reported that they enjoyed the iRest® meditations in that they found it relaxing and beneficial with self-reported improvements in focus, anxiety, self-awareness, and overall feelings of wellness. Of the remaining participants ($n=6$), one found the meditations challenging because of attention-deficit/hyperactivity disorder, and the others provided no feedback ($n=5$).

Some of the feedback received from participants pertained to the Daily Workouts Fitness Trainer app in that there were five who reported to their health coach that some of the exercises caused pain and were, therefore, instructed to modify or replace those exercises with ones that did not cause pain. Overall, participants expressed how they liked the Fitbit's monitoring capability to track physical activity (e.g., steps and exercise sessions), sleep, and heart rate. One participant shared with their health coach that these capabilities helped them to become more self-aware of their mood states (e.g., anxiety), while another shared that the step tracker provided them with the motivation to increase their daily physical activity level. The general feedback given for health coaching was also positive in that participants liked the extra accountability and how it provided an opportunity to ask questions and receive clarification about the individual components of the intervention ($n=5$ participants). Additionally, there were 14 participants (58.3% of 24 participants; dMAP:sgMAP = 6:8) who continued with health coaching after completing the 8-week intervention, further demonstrating their satisfaction with this component.

There were 13 participants who reported having issues with the Brain Health app that ranged from Internet connectivity ($n=9$ events; 3.1% of the meditation sessions attempted/completed) to technological issues (e.g., tablet issues, app crashing, login errors; $n=18$ events; 5.8% of the meditation sessions attempted/completed). There were 14 participants who self-reported logging errors using their Fitbit for 22 exercise sessions (6.5% of exercise sessions attempted/completed), most of which were likely due to user error.

Discussion

Telehealth technologies and hybrid care models will likely remain as an enduring legacy of the COVID-19 pandemic; thus, it is critical to evaluate the feasibility of these interventions when developing research focused on augmenting individualized symptom management plans for veterans with CMI. By promoting health behaviors (e.g., meditation and physical activity) intended to augment cognitive control to facilitate self-regulation, this pilot study examined the feasibility, safety, and acceptability of a telehealth MAP training intervention among veterans with CMI. The high retention rate and the minimal amount of missing data demonstrate the feasibility of certain aspects of the methodology, while the poor recruitment potential and adherence rates just below the progression threshold indicate that some modifications are warranted before conducting a definitive

trial. Additionally, there were no major adverse events reported during the intervention besides minor physical complaints and mood changes, indicating that a telehealth MAP intervention is safe for veterans with CMI. The results further demonstrated the practicability of using distance-based technology (e.g., apps and a wearable device) and health coaching to deliver a telehealth MAP intervention.

One successful aspect of the trial methods was the retention rates observed at endpoint and follow-up. These rates far exceeded our progression threshold which is promising as our study was conducted in a veteran population with CMI, where post-exertional malaise is a commonly reported symptom after an acute physiological stressor (i.e., exercise) or a mentally challenging task, and can become a barrier to engaging in healthy behaviors [40–42]. In anticipation of these challenges, the nurse health coaches made great efforts to encourage continued engagement in the intervention while providing allowances for rest and recovery. This approach may have contributed to the success of retaining participants in this pilot study, which was comparable to what was observed in another virtual MAP intervention study conducted in a predominantly healthy sample (79% versus 86%) [20]. Additionally, weekly check-ins provided an opportunity to address any barriers to achieving the intervention goals (e.g., competing priorities, thoughts, beliefs), thus fostering accountability and the development of contingency plans for overcoming those barriers. Participants overall had positive feedback regarding health coaching and expressed satisfaction with the increased support and accountability.

The low recruitment potential observed in this pilot study underscores possible challenges that researchers may encounter when recruiting participants from a tertiary care center like the WRIISC. Recruitment in this study was impacted by the low number of patients seen at the WRIISC before and during the COVID-19 pandemic. Although attempts were made to expand recruitment to non-WRIISC patients, these efforts were unsuccessful, and the study ended before reaching our recruitment goal when the app developers discontinued support of the customized study app. The poor recruitment potential of this study was much lower compared to other MAP training studies which were able to reach a similar recruitment rate but in much less time [20, 43], demonstrating that recruitment strategies would need to be expanded for a larger randomized controlled trial. Future recruitment efforts may include collaborating with sister WRIISCs (East Orange, NJ and Palo Alto, CA, USA) in a multi-site trial, collaborating with Veteran Service Organizations, and leveraging social media platforms for advertising and information dissemination.

Nonadherence is commonly reported in unsupervised home-based exercise interventions and digital interventions [28, 44, 45]. In this study, adherence to the MAP training protocol was lower than expected in that participants completed approximately half of the MAP sessions. This is similar to another virtual MAP training intervention that reported participants completing half of the pre-recorded sessions [20]. However, social desirability bias may have slightly inflated the adherence rates of that study given that participants self-reported their adherence which included manually calculating their own maximum heart rate to determine their exercise intensity. The use of distance-based technology, such as wearables, to objectively determine exercise adherence helps to eliminate biases associated with self-report and demonstrates a strength of this pilot study. Additionally, this study confirmed the practicability of using wearables to objectively measure exercise adherence in the MAP training protocol given that there were very few logging errors observed. Additionally, the collection of objective data allowed for calculating the number of attempted MAP sessions which included each of the components, but one or both components failed to meet the study requirements. Furthermore, participants provided positive feedback regarding the monitoring capabilities of wearables that allowed them to track additional health-related parameters (e.g., daily steps) outside of the study requirements, thus demonstrating its utility in behavior modification interventions.

There were a few possible reasons for the observed low adherence including technical issues with the study app in the beginning, early drop out, failure to complete both MAP training components on the same day by a few participants, and missing data capture for some of the exercise sessions. In the future, implementation of internal monitoring practices, including more detailed periodic assessments of data quality, may help with identifying and addressing some of those issues in real time. If this was implemented in the current pilot study, additional education on the MAP training protocol could have been provided to those few participants who performed the individual MAP components on separate days. Furthermore, the missing data capture by study staff could have been identified and rectified early by providing additional training on what data to download from the study web-based apps and devices.

This pilot study was intended to serve as the foundation for a distance-based integrative-health coaching study we plan to develop that will utilize the VA Whole Health principles of health-related behavior. Not only we do hope that future clinical trials will demonstrate these methods as helpful for veterans in managing chronic illness, but also we contend that a holistic approach that

addresses social support (i.e., relationships, community), meaning, and purpose in life (i.e., employment, volunteering) are central tenants of whole health and resilience [6, 46]. Indeed, there is evidence that these factors are also critical elements of brain health [6, 46, 47]. Therefore, fostering behavioral changes that can lead to neuroplasticity and functional changes via neural network compensation, processing efficiency, and connectivity may redirect function to protect against mental illness and offer the change in cognitive function needed to achieve self-care [6, 48, 49]. Future studies should explore the synergistic effect of combining a telehealth intervention with health coaching by utilizing active control groups (e.g., intervention only, health coaching only).

Limitations

This pilot study has several limitations that need to be considered for a future definitive trial, including the lack of a passive control condition in the study design. MAP training has documented benefits which is why we decided to not withhold an active treatment from research volunteers and instead we compared two formats for delivering a MAP training protocol (directed versus self-guided). However, the small sample size limited our ability to determine which delivery format was better. There is preliminary evidence suggesting that the self-guided format may be beneficial for improving certain aspects of executive function compared to directed [50], but a larger definitive trial is needed to validate these findings. Another limitation of the study was that only one form of meditation was offered as part of the MAP protocol, which some participants found iRest as unamendable to their desired method of meditation. At the end of the study, participants suggested offering more variation in the types of meditation offered along with the option of selecting different meditation scripts and the voice characteristics of the administrator based on the preferences of the individual. Furthermore, this pilot study used conservative eligibility criteria to minimize adverse events given that this was a remote intervention administered to a chronically ill veteran population; however, we would expect this intervention to be more acceptable and better tolerated by a broader community of veterans. The acceptability of the intervention was captured qualitatively by health coaches who documented participant feedback on a weekly coaching checklist form. This method has several limitations, including the selective recording of information that the health coaches may have perceived as being important resulting in the possibility for bias and missing data. Lastly, this pilot study did not offer the flexibility of including a complete patient centeredness or patient-determined goal approach during the health coaching component. Elements of these methods can be utilized in a future definitive trial aimed at evaluating health coaching such as action plans to allow participants to control what practices are integrated into their lifestyle.

Conclusion

In conclusion, the findings from this pilot study demonstrate that the use of distance-based technology (e.g., apps and a wearable device) and health coaching to deliver a telehealth MAP intervention is feasible and safe for veterans with CMI. This pilot study provides valuable insights into the potential for a large-scale randomized controlled trial. Despite certain aspects of the trial methods that require modifications, the study demonstrated a high retention rate and minimal missing data. Future efforts need to expand recruitment strategies and add internal monitoring for data quality issues. The study also supports the need for a future definitive trial given the significant challenge encountered by healthcare providers in implementing patient driven healthcare, which requires patients to have the cognitive facility to plan and implement goals to optimize their recovery.

Abbreviations

AUDIT-C	Alcohol Use Disorders Identification Test-Consumption
CMI	Chronic multisymptom illness
DC VAMC	Washington, DC Veterans Affairs Medical Center
dMAP	Directed mental and physical training
MAP	Mental and physical training
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OND	Operation New Dawn
PAR-Q+	Physical Activity Readiness Questionnaire for Everyone
sgMAP	Self-guided MAP training
VA	Veterans Affairs
VHA	Veterans Health Administration
WRIISC	War-Related Illness and Injury Study Center

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Authors' contributions

MC and MJReinhard: study conceptualization; MC, MJRoy, and MJReinhard: funding acquisition; AA and AB: creation of the custom designed study app; TC, LC, JW, RAM, RCB: data collection; CBB, KP, and TC: data cleaning; CBB: analyzed and interpreted the data; CBB and MC: original draft; all authors: writing – review and editing.

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Data availability
The datasets generated and/or analyzed during the current study are not publicly available due to the strict privacy regulations in place for veteran data but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The protocol was approved by the Institutional Review Board at the Washington, DC Veterans Affairs Medical Center (DC VAMC) and all participants provided written or verbal consent prior to participating in the study.

Consent for publication
Not applicable.

Competing interests
Authors declare there are no competing interests. The opinions presented in this article are those of the authors and do not reflect the views of any institution/agency of the U.S. government, the Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc., Georgetown University, or Uniformed Services University of the Health Sciences.

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References

1. Department of Veterans Affairs and Department of Defense. VA/DoD clinical practice guideline for the management of chronic multisymptom illness. 2021. Available: https://www.healthquality.va.gov/guidelines/MR/cmi/VADoDCMICPG508.pdf.
2. Freeman M, Nugent SM, Ayers CK, Winchell KA, Press A, O'Neil ME, et al. Gulf war illness: a systematic review of therapeutic interventions and management strategies. Washington (DC): Department of Veterans Affairs (US); 2020. Available from: https://www.ncbi.nlm.nih.gov/books/NBK565216/.
3. McAndrew LM, Helmer DA, Phillips LA, Chandler HK, Ray K, Quigley KS. Iraq and Afghanistan veterans report symptoms consistent with chronic multisymptom illness one year after deployment. J Rehabil Res Dev. 2016;53(1):59–70 https://pubmed.ncbi.nlm.nih.gov/27006173/.
4. Mohanty AF, Muthukutty A, Carter ME, Palmer MN, Judd J, Helmer D, et al. Chronic multisymptom illness among female veterans deployed to Iraq and Afghanistan. Med Care. 2015;53(4s1):S143–8. https://doi.org/10.1097/MLR.0000000000000314.
5. Schacter DL, Addis DR, Buckner RL. Episodic simulation of future events: concepts, data, and applications. Ann NY Acad Sci. 2008;1124(1):39–60. https://doi.org/10.1196/annals.1440.001.
6. McEwen BS. In pursuit of resilience: stress, epigenetics, and brain plasticity. Ann NY Acad Sci. 2016;1373(1):56–64. https://doi.org/10.1111/nyas.13020.
7. Curlik DM, Shors TJ. Training your brain: do mental and physical (MAP) training enhance cognition through the process of neurogenesis in the hippocampus? Neuropharmacology. 2013;64(1):506–14. https://doi.org/10.1016/j.neuropharm.2012.07.027.
8. Archer T, Svensson K, Alricsson M. Physical exercise ameliorates deficits induced by traumatic brain injury. Acta Neurol Scand. 2012;125(5):293–302. https://doi.org/10.1111/j.1600-0404.2011.01638.x.
9. Colcombe SJ, Kramer AF, Erickson KI, Scalf P, McAuley E, Cohen NJ, et al. Cardiovascular fitness, cortical plasticity, and aging. Proc Natl Acad Sci U S A. 2004;101(9):3316–21. https://doi.org/10.1073/pnas.0400266101.
10. Colcombe SJ, Erickson KI, Scalf PE, Kim JS, Prakash R, McAuley E, et al. Aerobic exercise training increases brain volume in aging humans. J Gerontol A Biol Sci Med Sci. 2006;61(11):1166–70. https://doi.org/10.1093/gerona/61.11.1166.
11. Erickson KI, Voss MW, Prakash RS, Basak C, Szabo A, Chaddock L, et al. Exercise training increases size of hippocampus and improves memory. Proc Natl Acad Sci U S A. 2011;108(7):3017–22. https://doi.org/10.1073/pnas.1015950108.
12. Tang YY, Leve LD. A translational neuroscience perspective on mindfulness meditation as a prevention strategy. Transl Behav Med. 2016;6(1):63–72. https://doi.org/10.1007/s13142-015-0360-x.
13. Tang YY, Hölzel BK, Posner MI. The neuroscience of mindfulness meditation. Nat Rev Neurosci. 2015;16(4):213–25. https://doi.org/10.1038/nrn3916.
14. Posner MI, Tang YY, Lynch G. Mechanisms of white matter change induced by meditation training. Front Psychol. 2014;5: 115924. https://doi.org/10.3389/fpsyg.2014.01220.
15. Davidson RJ, Mcewen BS. Social influences on neuroplasticity: stress and interventions to promote well-being. Nat Neurosci. 2012;15(5):689–95. https://doi.org/10.1038/nn.3093.
16. Lavadera P, Millon EM, Shors TJ. MAP train my brain: meditation combined with aerobic exercise reduces stress and rumination while enhancing quality of life in medical students. J Altern Complement Med. 2020;26(5):418–23. https://doi.org/10.1089/acm.2019.028.
17. Shors TJ, Chang HYM, Millon EM. MAP Training My Brain™: meditation plus aerobic exercise lessens trauma of sexual violence more than either activity alone. Front Neurosci. 2018;12: 211. https://doi.org/10.3389/fnins.2018.00211.
18. Shors TJ, Olson RL, Bates ME, Selby EA, Alderman BL. Mental and physical (MAP) training: a neurogenesis-inspired intervention that enhances health in humans. Neurobiol Learn Mem. 2014;115:3–9. https://doi.org/10.1016/j.nlm.2014.08.012.
19. Alderman BL, Olson RL, Brush CJ, Shors TJ. MAP training: combining meditation and aerobic exercise reduces depression and rumination while enhancing synchronized brain activity. Transl Psychiatry. 2016;6: e726. https://doi.org/10.1038/tp.2015.225.
20. Demmin DL, Silverstein SM, Shors TJ. Mental and physical training with meditation and aerobic exercise improved mental health and well-being in teachers during the COVID-19 pandemic. Front Hum Neurosci. 2022;16:847301. https://doi.org/10.3389/fnhum.2022.847301.
21. Millon EM, Lehrer PM, Shors TJ. Meditation and aerobic exercise enhance mental health outcomes and pattern separation learning without changing heart rate variability in women with HIV. Appl Psychophysiol Biofeedback. 2022;47(1):27–42. https://doi.org/10.1007/s10484-021-09530-2.
22. Heyworth L, Shah N, Galpin K. 20 years of telehealth in the Veterans Health Administration: taking stock of our past and charting our future. J Gen Intern Med. 2024;39(Suppl 1):5–8. https://doi.org/10.1007/s11606-024-08617-w.
23. Gujral K, Van Campen J, Jacobs J, Kimerling R, Blonigen D, Zulman DM. Mental health service use, suicide behavior, and emergency department visits among rural US veterans who received video-enabled tablets during the COVID-19 pandemic. JAMA Netw Open. 2022;5(4): e226250. https://doi.org/10.1001/jamanetworkopen.2022.6250.
24. Kasckow J, Gao S, Hanusa B, Rotondi A, Chinman M, Zickmund S, et al. Telehealth monitoring of patients with schizophrenia and suicidal ideation. Suicide Life Threat Behav. 2015;45(5):600–11. https://doi.org/10.1111/sltb.12154.
25. Godleski L, Cervone D, Vogel D, Rooney M. Home telemental health implementation and outcomes using electronic messaging. J Telemed Telecare. 2012;18(1):17–9. https://doi.org/10.1258/jtt.2011.100919.
26. Jacobs JC, Blonigen DM, Kimerling R, Slightam C, Gregory AJ, Gurmessa T, et al. Increasing mental health care access, continuity, and efficiency for veterans through telehealth with video tablets. Psychiatr Serv. 2019;70(11):976–82. https://doi.org/10.1176/appi.ps.201900104.
27. Slightam C, Gregory AJ, Hu J, Jacobs J, Gurmessa T, Kimerling R, et al. Patient perceptions of video visits using Veterans Affairs telehealth tablets: survey study. J Med Internet Res. 2020;22(4): e15682. https://doi.org/10.2196/15682.

28. Moshe I, Terhorst Y, Philippi P, Domhardt M, Cuijpers P, Cristea I, et al. Digital interventions for the treatment of depression: a meta-analytic review. Psychol Bull. 2021;147(8):749–86. https://doi.org/10.1037/bul0000334.
29. Gierisch JM, Hughes JM, Edelman D, Bosworth HB, Oddone EZ, Taylor SS, et al. The effectiveness of health coaching. Washington (DC): Department of Veterans Affairs (US); 2017. Available from:https://www.ncbi.nlm.nih.gov/books/NBK487697/.
30. Kuhn E, Sayers SL, Babusci C, Conroy C, Erbes CR. Internet-based family training with telephone coaching to promote mental health treatment initiation among veterans with posttraumatic stress disorder: a pilot study. J Trauma Stress. 2023;36(3):549–56. https://doi.org/10.1002/jts.22900.
31. Fukuda K, Nisenbaum R, Stewart G, Thompson WW, Robin L, Washko RM, et al. Chronic multisymptom illness affecting air force veterans of the Gulf War. JAMA. 1998;280(11):981–8. https://doi.org/10.1001/jama.280.11.981.
32. Warburton D, Jamnik V, Bredin S, Gledhill N. The physical activity readiness questionnaire for everyone (PAR-Q+) and electronic physical activity readiness medical examination (ePARmed-X+). Health Fit J Can. 2011;2(4):3–23. https://doi.org/10.14288/hfjc.v4i2.103.
33. Schretlen DJ, Testa SM, Pearlson GD. Calibrated neuropsychological normative system. PAA. Available from: https://paa.com.au/product/cnns/.
34. Posner K, Brown GK, Stanley B, Brent DA, Yershova KV, Oquendo MA, et al. The Columbia-suicide severity rating scale: initial validity and internal consistency findings from three multisite studies with adolescents and adults. Am J Psychiatry. 2011;168(12):1266–77. https://doi.org/10.1176/appi.ajp.2011.10111704.
35. Bush K, Kivlahan DR, Mcdonell MB, Fihn SD, Bradley KA. The AUDIT alcohol consumption questions (AUDIT-C) – an effective brief screening test for problem drinking. Arch Intern Med. 1998;158(16):1789–95. https://doi.org/10.1001/archinte.158.16.1789.
36. U.S. Department of Veteran Affairs. Annie for Veterans. 2020. Available from: https://mobile.va.gov/app/annie-app-veterans.
37. iRest Institute. 2024. Available from: https://www.irest.org/.
38. Daniore P, Nittas V, von Wyl V. Enrollment and retention of participants in remote digital health studies: scoping review and framework proposal. J Med Internet Res. 2022;24(9): e39910. https://doi.org/10.2196/39910.
39. Julious SA. Sample size of 12 per group rule of thumb for a pilot study. Pharm Stat. 2005;4(4):287–91. https://doi.org/10.1002/pst.185.
40. Li M, Xu C, Yao W, Mahan CM, Kang HK, Sandbrink F, et al. Self-reported post-exertional fatigue in Gulf War veterans: roles of autonomic testing. Front Neurosci. 2014;7: 269. https://doi.org/10.3389/fnins.2013.00269.
41. Rayhan RU, Stevens BW, Raksit MP, Ripple JA, Timbol CR, Adewuyi O, et al. Exercise challenge in Gulf War illness reveals two subgroups with altered brain structure and function. PLoS One. 2013;8(6): e63903. https://doi.org/10.1371/journal.pone.0063903.
42. Cook DB, Stegner AJ, Ellingson LD. Exercise alters pain sensitivity in Gulf War veterans with chronic musculoskeletal pain. J Pain. 2010;11(8):764–72. https://doi.org/10.1016/j.jpain.2009.11.010.
43. Prochilo GA, Costa RJS, Hassed C, Chambers R, Molenberghs P. A 16-week aerobic exercise and mindfulness-based intervention on chronic psychosocial stress: a pilot and feasibility study. Pilot Feasibility Stud. 2021;7(1):64. https://doi.org/10.1186/s40814-020-00751-6.
44. Gál É, Ștefan S, Cristea IA. The efficacy of mindfulness meditation apps in enhancing users' well-being and mental health related outcomes: a meta-analysis of randomized controlled trials. J Affect Disord. 2021;279:131–42. https://doi.org/10.1016/j.jad.2020.09.134.
45. Sperandei S, Vieira MC, Reis AC. Adherence to physical activity in an unsupervised setting: explanatory variables for high attrition rates among fitness center members. J Sci Med Sport. 2016;19(11):916–20. https://doi.org/10.1016/j.jsams.2015.12.522.
46. McEwen BS, Nasca C, Gray JD. Stress effects on neuronal structure: hippocampus, amygdala, and prefrontal cortex. Neuropsychopharmacology. 2016;41(1):3–23. https://doi.org/10.1038/npp.2015.171.
47. Lupien SJ, McEwen BS, Gunnar MR, Heim C. Effects of stress throughout the lifespan on the brain, behaviour and cognition. Nat Rev Neurosci. 2009;10(6):434–45. https://doi.org/10.1038/nrn2639.
48. Voss MW, Vivar C, Kramer AF, van Praag H. Bridging animal and human models of exercise-induced brain plasticity. Trends Cogn Sci. 2013;17(10):525–44. https://doi.org/10.1016/j.tics.2013.08.001.
49. Nithianantharajah J, Hannan AJ. The neurobiology of brain and cognitive reserve: mental and physical activity as modulators of brain disorders. Prog Neurobiol. 2009;89(4):369–82. https://doi.org/10.1016/j.pneurobio.2009.10.001.
50. Breneman CB, Samuel I, Hamedi A, Chun TJ, Jachimowicz W, Pollin KU, et al. Improved psychological health through a remote behavioral intervention: a telehealth pilot study for veterans with chronic multi-symptom illness. 2022. Augmented cognition. HCII 2022. Lecture notes in computer science, vol. 13310. Cham: Springer; 2022. https://doi.org/10.1007/978-3-031-05457-0_2.

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