

# Exercise to Reduce Posttraumatic Stress Disorder Symptoms in Veterans

Daniel J. Reis, PhD<sup>a,b,c</sup>; Melinda A. Gaddy, PhD<sup>a,d</sup>; and Guoqing J. Chen, PhD<sup>d</sup>

**Background:** Physical exercise offers benefits for treating psychological disorders, particularly depression. Exercise is associated with reduction of posttraumatic stress disorder (PTSD) symptoms in civilians. Given the comorbidities and unique trauma experiences of the veteran population, the current work aims to estimate the effect of exercise on PTSD symptoms in veteran samples.

**Observations:** A systematic review identified 6 single-arm studies and 3 randomized controlled trials (RCTs) using exercise as an interventional treatment among veteran samples with full or subsyndromal PTSD. Most single-arm studies used yoga-based interventions, whereas RCTs showed more variety and included yoga, aerobic activity, and resistance

exercises. Data synthesis of study results revealed a medium standardized mean difference for the single-arm trials (Hedges  $g$ ,  $-0.60$ ,  $P = .03$ ) and a small-to-medium standardized mean difference for the RCTs (Hedges  $g$ ,  $-0.40$ ,  $P = .06$ ). Single-arm studies were all rated at serious risk of bias. Only 1 RCT was rated at high risk of bias, although the remaining RCTs showed some concern of elevated bias.

**Conclusions:** There is preliminary evidence that exercise may be a useful treatment option for PTSD symptom reduction in veterans. Our review also highlights the need for additional high-quality randomized trials to confirm the benefits of exercise for PTSD symptom reduction in veterans.

Author affiliations can be found at the end of this article.

**Correspondence:**  
Daniel Reis  
(daniel.reis2@va.gov)

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Physical exercise offers preventative and therapeutic benefits for a range of chronic health conditions, including cardiovascular disease, type 2 diabetes mellitus, Alzheimer disease, and depression.<sup>1,2</sup> Exercise has been well studied for its antidepressant effects, its ability to reduce risk of aging-related dementia, and favorable effects on a range of cognitive functions.<sup>2</sup> Lesser evidence exists regarding the impact of exercise on other mental health concerns. Therefore, an accurate understanding of whether physical exercise may ameliorate other conditions is important.

A small meta-analysis by Rosenbaum and colleagues found that exercise interventions were superior to control conditions for symptom reduction in study participants with posttraumatic stress disorder (PTSD).<sup>3</sup> This meta-analysis included 4 randomized clinical trials representing 200 cases. The trial included a variety of physical activities (eg, yoga, aerobic, and strength-building exercises) and control conditions, and participants recruited from online, community, inpatient, and outpatient settings. The standardized mean difference (SMD) produced by the analysis indicated a small-to-medium effect (Hedges  $g$ ,  $-0.35$ ), with the authors reporting no evidence of publication bias, although an assessment of potential bias associated with individual trial design characteristics was not conducted. Of note, a meta-analysis by Watts

and colleagues found that effect sizes for PTSD treatments tend to be smaller in veteran populations.<sup>4</sup> Therefore, how much the mean effect size estimate in the study is applicable to veterans with PTSD is unknown.<sup>3</sup>

Veterans represent a unique subpopulation in which PTSD is common, although no meta-analysis yet published has synthesized the effects of exercise interventions from trials of veterans with PTSD.<sup>5</sup> A recent systematic review by Whitworth and Ciccolo concluded that exercise may be associated with reduced risk of PTSD, a briefer course of PTSD symptoms, and/or reduced sleep- and depression-related difficulties.<sup>6</sup> However, that review primarily included observational, cross-sectional, and qualitative works. No trials included in our meta-analysis were included in that review.<sup>6</sup>

Evidence-based psychotherapies like cognitive processing therapy and prolonged exposure have been shown to be effective for treating PTSD in veterans; however, these modalities are accompanied by high rates of dropout (eg, 40-60%), thereby limiting their clinical utility.<sup>7</sup> The use of complementary and alternative approaches for treatment in the United States has increased in recent years, and exercise represents an important complementary treatment option.<sup>8</sup> In a study by Baldwin and colleagues, nearly 50% of veterans reported using complementary or alternative approaches, and veterans

with PTSD were among those likely to use such approaches.<sup>9</sup> However, current studies of the effects of exercise interventions on PTSD symptom reduction are mostly small and varied, making determinations difficult regarding the potential utility of exercise for treating this condition in veterans.

### Literature Search

No previous research has synthesized the literature on the effects of exercise on PTSD in the veteran population. The current meta-analysis aims to provide a synthesis of systematically selected studies on this topic to determine whether exercise-based interventions are effective at reducing veterans' symptoms of PTSD. Our hypothesis was that, when used as a primary or adjuvant intervention for PTSD, physical exercise would be associated with a reduction of PTSD symptom scale scores. We planned a priori to produce separate estimates for single-arm and multi-arm trials. We also wanted to conduct a careful risk of bias assessment—or evaluation of study features that may have systematically influenced results—for included trials, not only to provide context for interpretation of results, but also to inform suggestions for research to advance this field of inquiry.<sup>10</sup>

### METHODS

This study was preregistered on PROSPERO and followed PRISMA guidelines for meta-analyses and systematic reviews.<sup>11</sup> Supplementary materials, such as the PRISMA checklist, study data, and funnel plots, are available online ([doi.org/10.6084/m9.figshare.c.5618437.v1](https://doi.org/10.6084/m9.figshare.c.5618437.v1)). Conference abstracts were omitted due to a lack of necessary information. We decided early in the planning process to include both randomized and single-arm trials, expecting the number of completed studies in the area of exercise for PTSD symptom reduction in veterans, and particularly randomized trials of such, would be relatively small.

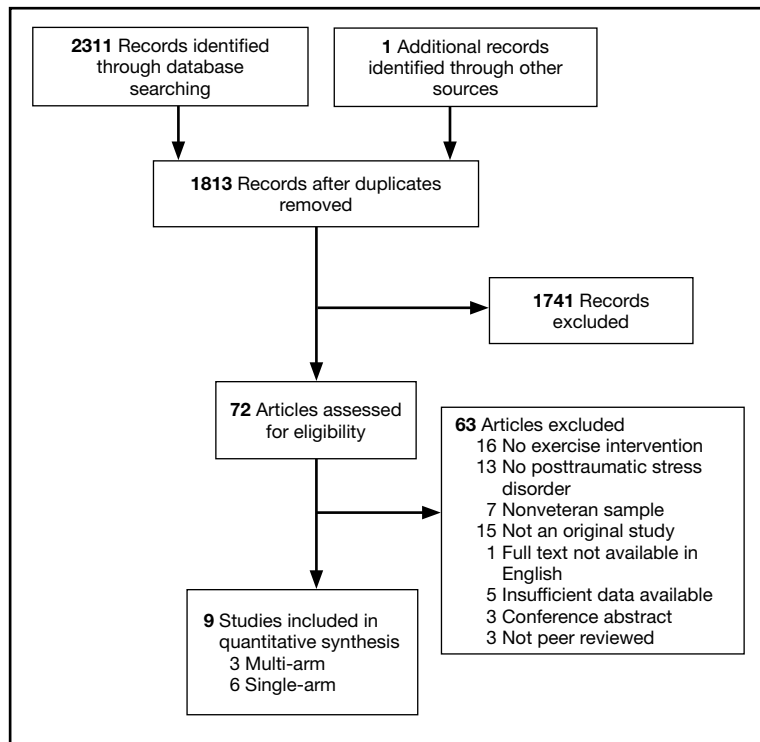
Studies were included if they met the following criteria: (1) the study was a single- or multi-arm interventional trial; (2) participants were veterans; (3) participants had a current diagnosis of PTSD or exhibited subthreshold PTSD symptoms, as estab-

lished by authors of the individual studies and supported by a structured clinical interview, semistructured interview, or elevated scores on PTSD symptom self-report measures; (4) the study included an intervention in which exercise (physical activity that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of physical fitness or health is an objective) was the primary component; (5) PTSD symptom severity was by a clinician-rated or self-report measure; and (6) the study was published in a peer-reviewed journal.<sup>12</sup> Studies were excluded if means, standard deviations, and sample sizes were not available or the full text of the study was not available in English.

The systematic review was conducted using PubMed, PsycINFO, and Cochrane Library databases, from the earliest record to February 2021. The following search phrase was used, without additional limits, to acquire a list of potential studies: (“PTSD” or “post-traumatic stress disorder” or “post-traumatic stress disorder” or “post traumatic stress disorder”) and (“veteran” or “veterans”) and (“exercise” or “aerobic” or “activity” or “physical activity”). The references of identified publications also were searched for additional studies. Then, study titles and abstracts were evaluated and finally, full texts were evaluated to determine study inclusion. All screening, study selection, and risk of bias and data extraction activities were performed by 2 independent reviewers (DR and MJ) with disagreements resolved through discussion and consensus (Figure 1). A list of studies excluded during full-text review and rationales can be viewed online ([doi.org/10.6084/m9.figshare.c.5618437.v1](https://doi.org/10.6084/m9.figshare.c.5618437.v1)).

### Data Collection

Data were extracted from included studies using custom forms and included the following information based on PRISMA guidelines: (1) study design characteristics; (2) intervention details; and (3) PTSD outcome information.<sup>11</sup> PTSD symptom severity was the primary outcome of interest. Outcome data were included if they were derived from a measure of PTSD symptoms—equivalency across measures was assumed for meta-analyses. Potential study bias for each outcome was evaluated using

**FIGURE 1** Flow and Selection of Studies

the ROBINS-I and Cochrane Collaboration's RoB 2 tools for single-arm and multi-arm trials, respectively.<sup>13,14</sup> These tools evaluate domains related to the design, conduct, and analysis of studies that are associated with bias (ie, systematic error in findings, such as under- or overestimation of results).<sup>10</sup> Examples include how well authors performed and concealed randomization procedures, addressed missing data, and measured study outcomes.<sup>13,14</sup> The risk of bias (eg, low, moderate, serious) associated with each domain is rated and, based on the domain ratings, each study is then given an overall rating regarding how much risk influences bias.<sup>13,14</sup> Broadly, lower risk of bias corresponds to higher confidence in the validity of results.

Finally, 4 authors (associated with 2 single- and 2 multi-arm studies) were contacted and asked to provide further information. Data for 1 additional multi-arm study were obtained from these communications and included in the final study selection.<sup>15</sup> These authors were also asked for information about any unpublished works of which they were aware, although no additional works were identified.

## Statistical Analyses

Analyses were performed with R Studio R 3.6.0 software.<sup>16</sup> An SMD (also known as Hedges *g*) was calculated for each study outcome: for single-arm trials, this was the SMD between pre- and postintervention scores, whereas for multi-arm trials, this was the SMD between postintervention outcome scores across groups. CIs for each SMD were calculated using a standard normal distribution. Combined SMDs were estimated separately for single- and multi-arm studies, using random-effects meta-analyses. In order to include multiple relevant outcomes from a single trial (ie, for studies using multiple PTSD symptom measures), robust variance estimation was used.<sup>17</sup> Precision was used to weight SMDs.

Correlations between pre- and postintervention scores were not available for 1 single-arm study.<sup>18</sup> A correlation coefficient of 0.8 was imputed to calculate the standard error of the of the SMDs for the Clinician-Administered PTSD Scale (CAPS) and the PTSD Checklist (PCL), as this value is consistent with past findings regarding the test-retest reliability of these measures.<sup>19-22</sup> A sensitivity analysis, using several alternative correlational values, revealed that the choice of correlation coefficient did not impact the overall results of the meta-analysis.

$I^2$  was used to evaluate between-study heterogeneity. Values of  $I^2 > 25%$ ,  $50%$ , and  $75%$  were selected to reflect low, moderate, and high heterogeneity, respectively, in accordance with guidelines described by Higgins and colleagues.<sup>23</sup> Potential publication bias was assessed via funnel plot and Egger test.<sup>24</sup> Finally, although collection of depressive symptom scores was proposed as a secondary outcome in the study protocol, such data were available only for 1 multi-arm study. As a result, this outcome was not evaluated.

## RESULTS

Six studies with 101 total participants were included in the single-arm analyses (Table 1).<sup>18,25-29</sup> Participants consisted of veterans with chronic pain, post-9/11 veterans, female veterans of childbearing age, veterans with a history of trauma therapy, and other veterans. Types of exercise included moderate aerobic exercise and yoga. PTSD symptom measures included the CAPS and the

PCL (PCL-5 or PCL-M versions). Reported financial sources for included studies included federal grant funding, nonprofit material support, outside organization support, use of US Department of Veterans Affairs (VA) resources, and no reported financial support.

With respect to individual studies, Shivakumar and colleagues found that completion of an aerobic exercise program was associated with reduced scores on 2 different PTSD symptom scales (PCL and CAPS) in 16 women veterans.<sup>18</sup> A trauma-informed yoga intervention study with 18 participants by Cushing and colleagues demonstrated veteran participation to be associated with large reductions in PTSD, anxiety, and depression scale scores.<sup>25</sup> In a study with 34 veterans, Chopin and colleagues found that a trauma-informed yoga intervention was associated with a statistically significant reduction in PTSD symptoms, as did a study by Zaccari and colleagues with 17 veterans.<sup>26,29</sup> Justice and Brems also found some evidence that trauma-informed yoga interventions helped PTSD symptoms in a small sample of 4 veterans, although these results were not quantitatively analyzed.<sup>27</sup> In contrast, a small pilot study (n = 12) by Staples and colleagues testing a biweekly, 6-week yoga program did not show a significant effect on PTSD symptoms.<sup>28</sup>

Three studies with 217 total veteran participants were included in the multi-arm analyses (Table 2).<sup>15,30,31</sup> As all multi-arm trials incorporated randomization, they will be referred to as randomized controlled trials (RCTs). On contact, Davis and colleagues provided veteran-specific results for their trial; as such, our data differ from those within the published article.<sup>15</sup> Participants from all included studies were veterans currently experiencing symptoms of PTSD. Types of exercise included yoga and combined methods (eg, aerobic and strength training).<sup>15,30,31</sup> PTSD symptom measures included the CAPS or the PCL-5.<sup>15,30,31</sup> Reported financial sources for included studies included federal grant funding, as well as nonprofit support, private donations, and VA and Department of Defense resources.

Davis and colleagues conducted a recently concluded RCT with > 130 veteran

**TABLE 1** Single-Arm Study Characteristics

Author, y	Sample Size, No.	Exercise Regimen	Duration, wk	PTSD Measure
Chopin, 2020 <sup>a</sup>	34	Yoga, primarily 60 min 1x/wk	Primarily 8	PCL-5
Cushing, 2018	18	Yoga, 60 min 1x/wk	6	PCL-M
Justice, 2019	4	Yoga, 90 min 1x/wk	10	PCL-5
Shivakumar, 2017	16	Moderate aerobic, 40 min 4x/wk	12	CAPS, PCL
Staples, 2013	12	Yoga, 60 min 2x/wk	6	PCL-M
Zaccari, 2020	17	Yoga, 60 min 1x/wk	10	PCL-5

Abbreviations: CAPS, Clinician-Administered PTSD Scale; PCL, PTSD Checklist; PCL-M, PTSD Checklist–Military Version; PTSD, posttraumatic stress disorder.

<sup>a</sup>Study had 12 yoga groups: the first 3 cohorts had longer sessions and/or durations; PCL-5 data not available for all participants.

**TABLE 2** Randomized Controlled Trials Characteristics

Author, y	Sample Size	Exercise Regimen	Duration, wk	Control Condition	PTSD Measure
Davis, 2020	131	Holistic yoga, 90 mins 1x/wk	16	Wellness Lifestyle Program	CAPS, PCL-5
Goldstein, 2018	38	Integrated exercise, 60 min 3x/wk	12	Waitlist	CAPS
Hall, 2020	48	Aerobic and strength, 60-90 min 3x/wk	12	Waitlist	PCL-5

Abbreviations: CAPS, Clinician-Administered PTSD Scale; PCL-5, PTSD Checklist for DSM-5; PTSD, posttraumatic stress disorder.

participants and found that a novel manualized yoga program was superior to an attention control in reducing PTSD symptom scale scores for veterans.<sup>15</sup> Goldstein and colleagues found that a program consisting of both aerobic and resistance exercises reduced PTSD symptoms to a greater extent than a waitlist control condition, with 47 veterans randomized in this trial.<sup>30</sup> Likewise, Hall and colleagues conducted a pilot RCT in which an intervention that integrated exercise and cognitive behavioral techniques was compared to a waitlist control condition.<sup>31</sup> For the 48 veterans included in the analyses, the authors reported greater PTSD symptom reduction associated with integrated exercise than that of the control condition; however, the study was not powered to detect statistically significant differences between groups.

**TABLE 3** Single-Arm Study Bias Risk

Author, y	PTSD Measure	Bias Levels of Risk							Overall
		Confounding	Selection	Classification	Deviations	Missing Data	Measurement	Selection of Results	
Chopin, 2020	PCL-5	Serious	Low	Low	Low	Moderate	Serious	Low	Serious
Cushing, 2018	PCL-M	Serious	Low	Low	Low	Moderate	Serious	Low	Serious
Justice, 2019	PCL-5	Serious	Low	Low	Low	Low	Serious	Low	Serious
Shivakumar, 2017	CAPS	Serious	Low	Low	Low	Moderate	Serious	Low	Serious
	PCL	Serious	Low	Low	Low	Moderate	Serious	Low	Serious
Staples, 2013	PCL-M	Serious	Low	Low	Low	Moderate	Serious	Low	Serious
Zaccari, 2020	PCL-5	Serious	Low	Low	Low	Moderate	Serious	Low	Serious

Abbreviations: CAPS, Clinician Administered PTSD Scale; PCL-5, PTSD Checklist for DSM-5; PCL-M, PTSD Checklist–Military Version; PTSD, posttraumatic stress disorder.

### Bias Assessment

Results for the risk of bias assessments can be viewed in Tables 3 and 4. For single-arm studies, overall risk of bias was serious for all included trials. Serious risk of bias was found in 2 domains: confounding, due to a lack of accounting for potential pre-existing baseline trends (eg, regression to the mean) that could have impacted study results; and measurement, due to the use of a self-report symptom measure (PCL) or CAPS with unblinded assessors. Multiple studies also showed moderate risk in the missing data domain due to participant dropout without appropriate analytic methods to address potential bias.

For RCTs, overall risk of bias ranged from some concerns to high risk. High risk of bias was found in 1 domain, measurement of outcome, due to use of a self-report symptom measure (PCL) with unblinded groups.<sup>31</sup> The other 2 studies all had some concern of bias in at least 1 of the following domains: randomization, missing data, and measurement of outcome.

### Pooled Standardized Mean Differences

Meta-analytic results can be viewed in Figure 2. The pooled SMD for the 6 single-arm studies (101 participants) and 3 RCTs (217 participants) was -0.60 ( $df = 4.41$ , 95% CI, -1.08 to -0.12,  $P = .03$ ), indicating a statistically significant reduction in PTSD symptoms over the course of an exercise intervention. Combining SMDs for the 3 included RCTs revealed a pooled SMD of -0.40 ( $df = 1.57$ ,

95% CI, -0.86 to 0.06,  $P = .06$ ), indicating that exercise did not result in a statistically significant reduction in PTSD symptoms compared with control conditions.

### Publication Bias and Heterogeneity

Visual inspection funnel plots and Egger test did not suggest the presence of publication bias for RCTs ( $t = 1.21$ ,  $df = 2$ ,  $P = .35$ ) or single-arm studies ( $t = -0.36$ ,  $df = 5$ ,  $P = .73$ ).

Single-arm studies displayed a high degree of heterogeneity ( $I^2 = 81.5\%$ ). Including sample size or exercise duration as variables in meta-regressions did not reduce heterogeneity ( $I^2 = 85.2\%$  and  $I^2 = 83.8\%$ , respectively). Performing a subgroup analysis only on studies using yoga as an intervention also did not reduce heterogeneity ( $I^2 = 79.2\%$ ). Due to the small number of studies, no further exploration of heterogeneity was conducted on single-arm studies. RCTs did not display any heterogeneity ( $I^2 = 0\%$ ).

## DISCUSSION

Our report represents an early synthesis of the first prospective studies of physical exercise interventions for PTSD in veterans. Results from meta-analyses of 6 single-arm studies (101 participants) and 3 RCTs (217 participants) provide early evidence that exercise may reduce PTSD symptoms in veterans. Yoga was the most common form of exercise used in single-arm studies, whereas RCTs used a wider range of interventions. The pooled SMD of -0.60 for

**TABLE 4** Randomized Controlled Trials Bias Risk

Author, y	PTSD Measure	Bias Levels of Risk					Overall
		Randomization	Deviations	Missing Data	Measurement of Outcome	Selection of Results	
Davis, 2020	CAPS	Low	Low	Some concerns	Low	Low	Some concerns
	PCL-5	Low	Low	Some concerns	Some concerns	Low	Some concerns
Goldstein, 2017	CAPS	Some concerns	Low	Some concerns	Low	Low	Some concerns
Hall, 2020	PCL-5	Low	Low	Low	High	Low	High

Abbreviations: CAPS, Clinician Administered PTSD Scale; PCL-5, PTSD Checklist for DSM-5; PTSD, posttraumatic stress disorder.

single-arm longitudinal studies suggest a medium decrease in PTSD symptoms for veterans who engage in exercise interventions. Analysis of the RCTs supported this finding, with a pooled SMD of -0.40 reflecting a small-to-medium effect of exercise on PTSD symptoms over control conditions, although this result did not achieve statistical significance. Of note, while the non-significant finding for RCTs may have been due to insufficient power caused by the limited number of included studies, possibly exercise was not more efficacious than were the control conditions.

Although RCTs represented a variety of exercise types, PTSD symptom measures, and veteran subgroups, statistical results were not indicative of heterogeneity. However, only the largest and most comprehensive study of exercise for PTSD in veterans to date by Davis and colleagues had a statistically significant SMD.<sup>15</sup> Of note, one of the other 2 RCTs displayed an SMD of a similar magnitude, but this study had a much smaller sample size and was underpowered to detect significance.<sup>30</sup> Additionally, risk of bias assessments for single-arm studies and RCTs revealed study characteristics that suggest possible inflation of absolute effect sizes for individual studies. Therefore, the pooled SMDs we report are interpretable but may exceed the true effect of exercise for PTSD symptom reduction in veterans.

Based on results of our analyses, it is reasonable, albeit preliminary, to conclude that exercise interventions may result in reduced PTSD symptoms among veterans. At the very least, these findings support the continued investigation of such interventions for veter-

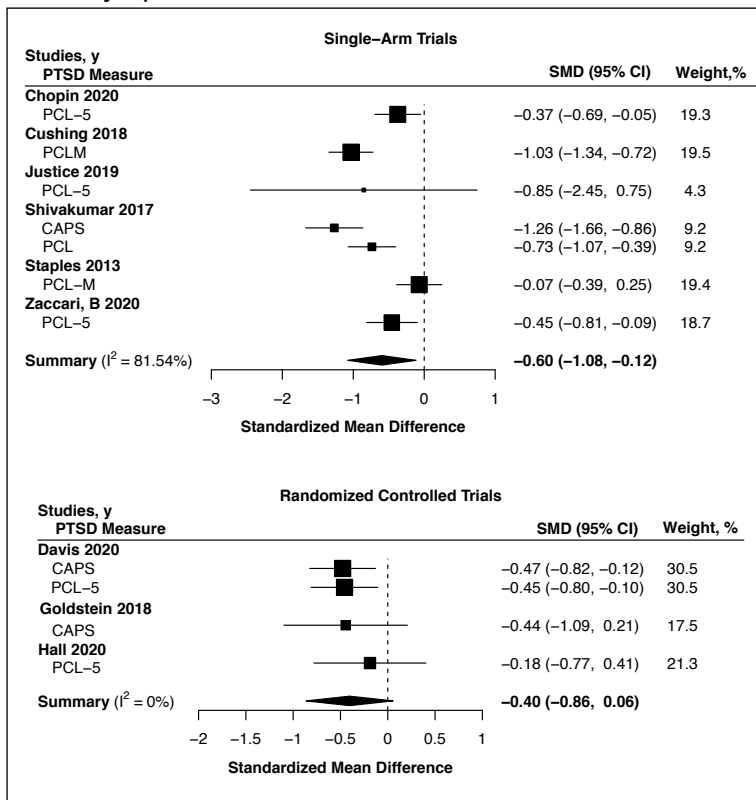
ans. Given the unique and salubrious characteristics of physical exercise, such results, if supported by further research, suggest that exercise-based interventions may be particularly valuable within the trauma treatment realm. For example, exercise can be less expensive and more convenient than attending traditional treatment, and for veterans reluctant to engage in standard treatment approaches such as psychiatric and psychosocial modalities, complementary approaches entailing exercise may be viewed as particularly acceptable or enjoyable.<sup>32</sup> In addition to possibly reducing PTSD symptoms, exercise is a well-established treatment for conditions commonly comorbid with PTSD, including depression, anxiety disorders, cognitive difficulties, and certain chronic pain conditions.<sup>6</sup> As such, exercise represents a holistic treatment option that has the potential to augment standard PTSD care.

### Limitations

The present study has several important limitations. First, few studies were found that met the broad eligibility criteria and those that did often had a small sample size. Besides highlighting a gap in the extant research, the limited studies available for meta-analysis means that caution must be taken when interpreting results. Fortunately, this issue will likely resolve once additional studies investigating the impact of exercise on PTSD symptoms in veterans are available for synthesis.

Relatedly, the included study interventions varied considerably, both in the types of exercise used and the characteristics of the exercises (eg, frequency, duration, and

**FIGURE 2** Forest Plots of Single-arm and Randomized Controlled Trials Investigating the Effect of Exercise on PTSD Symptoms



Abbreviations: CAPS, Clinician-Administered PTSD Scale; CI, confidence interval; PCL, PTSD Checklist; PCL-M, PTSD Checklist – Military Version; PCL-5, PTSD Checklist for DSM-5; SMD, standardized mean difference; PTSD, posttraumatic stress disorder.

intensity), which is relevant as different exercise modalities are associated with differential physical effects.<sup>33</sup> Including such a mixture of exercises may have given an incomplete picture of their potential therapeutic effects. Also, none of the RCTs compared exercise against first-line treatments for PTSD, such as prolonged exposure or cognitive processing therapy, which would have provided further insight into the role exercise could play in clinical settings.<sup>7</sup>

Another limitation is the elevated risk of bias found in most studies, particularly present in the longitudinal single-arm studies, all of which were rated at serious risk. For instance, no single-arm study controlled for preexisting baseline trends: without such (and lacking a comparison control group like in RCTs), it is possible that the observed effects were due to extraneous factors, rather than the exercise intervention. Although

not as severe, the multi-arm RCTs also displayed at least moderate risk of bias. Therefore, SMDs may have been overestimated for each group of studies.

Finally, the results of the single-arm meta-analysis displayed high statistical heterogeneity, reducing the generalizability of the results. One possible cause of this heterogeneity may have been the yoga interventions, as a separate analysis removing the only non-yoga study did not reduce heterogeneity. This result was surprising, as the included yoga interventions seemed similar across studies. While the presence of high heterogeneity does require some caution when applying these results to outside interventions, the present study made use of random-effects meta-analysis, a technique that incorporates study heterogeneity into the statistical model, thereby strengthening the findings compared with that of a traditional fixed-effects approach.<sup>10</sup>

### Future Steps

Several future steps are warranted to improve knowledge of exercise as a treatment for PTSD in veterans and in the general population. With current meta-analyses limited to small numbers of studies, additional studies of the efficacy of exercise for treating PTSD could help in several ways. A larger pool of studies would enable future meta-analyses to explore related questions, such as those regarding the impact of exercise on quality of life or depressive symptom reduction among veterans with PTSD. A greater number of studies also would enable meta-analysts to explore potentially critical moderators. For example, the duration, frequency, or type of exercise may moderate the effect of exercise on PTSD symptom reduction. Moderators related to patient or study design characteristics also should be explored in future studies.

Future work also should evaluate the impact that specific features of exercise regimens have on PTSD. Knowing whether the type or structure of exercise affects its clinical use would be invaluable in developing and implementing efficient exercise-based interventions. For example, if facilitated exercise was found to be significantly more effective at reducing PTSD symptoms than exercise completed independently, the

development of exercise intervention programs in the VA and other facilities that commonly treat PTSD may be warranted. Additionally, it may be useful to identify specific mechanisms through which exercise reduces PTSD symptoms. For example, in addition to its beneficial biological effects, exercise also promotes psychological health through behavioral activation and alterations within reinforcement/reward systems, suggesting that exercise regularity may be more important than intensity.<sup>34,35</sup> Understanding which mechanisms contribute most to change will aid in the development of more efficient interventions.

Given that veterans are demonstrating considerable interest in complementary and alternative PTSD treatments, it is critical that researchers focus on high-quality randomized tests of these interventions. Therefore, in addition to greater quality of exercise intervention studies, future efforts should be focused on RCTs that are designed in such a way as to limit potential introduction of bias. For example, assessment data should be completed by blinded assessors using standardized measures, and analyses should account for missing data and unequal participant attrition between groups. Ideally, pre-intervention trends across multiple baseline data-points also would be collected in single-arm studies to avoid confounding related to regression to the mean. It is also recommended that future meta-analyses use risk of bias assessments and consider how the results of such assessments may impact the interpretation of results.

## CONCLUSIONS

Findings from both single-arm studies and RCTs suggest possible benefit of exercise on PTSD symptom reduction, although confirmation of findings is needed. No study found increased symptoms following exercise intervention. Thus, it is reasonable to consider physical exercise, such as yoga, as an adjunct, whole-health consistent treatment. HCPs working with veterans with past traumatic experiences should consider incorporating exercise into patient care. Enhanced educational efforts emphasizing the psychotherapeutic impact of exercise may also have value for the veteran popu-

lation. Furthermore, the current risk of bias assessments highlights the need for additional high-quality RCTs evaluating the specific impact of exercise on PTSD symptom reduction in veterans. In particular, this field of inquiry would benefit from larger samples and design characteristics to reduce bias (eg, blinding when possible, use of CAPS vs only self-report symptom measures, reducing problematic attrition, corrections for missing data, etc).

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## Author affiliations

<sup>a</sup>Veterans Affairs Dwight D. Eisenhower Medical Center, Leavenworth, Kansas

<sup>b</sup>Rocky Mountain Mental Illness Research Education and Clinical Center for Veteran Suicide Prevention, Aurora, Colorado

<sup>c</sup>Department of Psychiatry, University of Colorado Anschutz School of Medicine, Aurora

<sup>d</sup>University of Kansas Medical Center, Department of Internal Medicine, Kansas City

## Author disclosures

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## Disclaimer

The opinions expressed herein are those of the authors and do not necessarily reflect those of *Federal Practitioner*, Frontline Medical Communications Inc., the US Government, or any of its agencies.

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