State of the Science Report
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CAN EXERCISE MANAGE PTSD?

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The aim for the report is to inform on what we currently know about exercise as a form of treatment for Post-Traumatic Stress Disorder (PTSD). This will include an objective overview of evidence for the benefits of exercise; the underlying mechanisms in explaining how exercise produces benefits; and how exercise should best be promoted/prescribed for this high-risk population. The report does not necessarily conclude that exercise is beneficial, and instead, reflects the current ‘state of the science’.

*Note. Expanded keys for tables and figures are presented in the Appendix.*
PTSD is an anxiety disorder that can occur in people who have experienced or witnessed a traumatic event such as a loss of a relative, sexual abuse, mass conflict, physical injury, or other violent personal assaults [1].

**INTRODUCTION**

Of the 223.4 million U.S adults who experience a traumatic event at least once in their lives, 20% develop PTSD.

8% - 24.4 million Americans have PTSD at any given time.

1/9 women develops PTSD (about twice as likely as men).

15% of Vietnam Veterans and 12% of Gulf War Veterans experience PTSD each year.

PTSD statistical sources [2, 3]
Diagnosis

PTSD diagnosis is characterized by four broad symptom clusters [1]:

- Intrusive thoughts
- Avoiding reminders
- Negative thoughts and feelings
- Arousal and reactive symptoms

Symptoms must cause clinically significant levels of impairment or distress in areas of psychosocial functioning and persist for more than a month and sometimes years.

A high prevalence of comorbid conditions is apparent among PTSD sufferers and may contribute to premature mortality [4]. These include chronic pain [5], major depressive disorder [6], substance use disorders [6], diabetes [7] and cardiometabolic diseases (CMD) [8]. For example, pooled prevalence of metabolic syndrome among people with PTSD is 38.7% (doubled increased risk compared to general population) [8]. Also, for every 10 PTSD symptoms endorsed, the odds of a subsequent metabolic syndrome diagnosis increase by 56% [9].

PTSD Treatment

The UK’s National Institute for Health and Care Excellence (NICE) recognize two forms of therapy as primary PTSD treatments [10]:

- Trauma-Focused Cognitive Behavioral Therapy (CBT)
- Eye Movement Desensitization and Reprocessing (EMDR)

These therapies typically involve weekly sessions lasting 60 to 90-min that are delivered by clinicians over a course of 8-12 weeks.
Many who suffer from PTSD face several barriers to treatment initiation, including perceived stigma attached to mental health treatment, low expectations of positive outcomes, accessibility, and cost of treatment [11]. Thus, the need for cost-effective and less stigmatized methods of coping are required.

Exercise is now recognized as a complementary treatment to potentiate the traditional method of psychotherapy. Due to the association between PTSD, depression and anxiety, promoting exercise may act as an invaluable coping method in treating individuals with PTSD [1].

**Strengths of exercise treatment [12]**

- Accessibility
- Low-cost
- No negative connotations

A 2015 meta-analysis review [13] evaluated the effectiveness of physical activity (PA) interventions in treating or managing PTSD and found:

PA more effective at reducing PTSD symptoms and depressive symptoms than control conditions.

‘Conventional treatment for PTSD can benefit from the addition of physical activity interventions as complementary treatments’ [13].
Despite beneficial effects evidenced, people with PTSD show declines in PA over time (Figure 1) [14]:

![Figure 1. Age-adjusted predicted physical activity trajectory over time by Trauma/PTSD group in full sample](image)

**Key.** Physical activity calculated in hours per week and standardized using z-score. PTSD sm=PTSD symptoms.

Following the onset of PTSD, substantial changes in PA occur (Figure 2 and 3) [15]:

Inadequate PA is the fourth-leading risk factor for mortality [16] and a dominant risk factor for CMD [17].

![Figure 2 and 3. Rate of physical activity participation and degree of participation before and after PTSD onset](image)

**Key.** Active subjects classified as exercising at least three times a week for a minimum of 20min at an adequate intensity (American College of Sports Medicine).
INACTIVITY CONSEQUENCES

Unhealthy lifestyle behaviors place people with PTSD at a greater risk for developing CMD [18] (Figure 4).

More importantly, reduced levels of PA after PTSD onset may be a route in which severe PTSD symptoms affect chronic disease risk [19].

Despite the evidence, focus of clinical research on PTSD populations has been on minimizing adverse health behaviors such as eating disorders and tobacco use. We should acknowledge prime health results from minimizing adverse health behaviors AND addressing health-promoting behaviors (Figure 5) [20].
Multiple factors act as PA barriers that must be considered when forming PA interventions (Figure 6). The majority reported by those suffering from PTSD appear to be individual-related...

**Table 1.** Factors negatively affecting PA participation in PTSD population [15]:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Before PTSD</th>
<th>After PTSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of time</td>
<td>14%</td>
<td>39%</td>
</tr>
<tr>
<td>Lack of motivation</td>
<td>24%</td>
<td>71%</td>
</tr>
</tbody>
</table>

Systematic review of studies reporting association between low PA participation among PTSD sufferers and [21]:

- Fibromyalgia (chronic pain and tiredness)
- Sleep disruption
- Hyperarousal symptoms
- Anxiety
- Low mental and physical quality of life

Despite these barriers, people with PTSD highly rate, and feel prepared to adopt a healthier lifestyle.

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...Addressing barriers through modified PA programs could enable people with PTSD to improve long-term physical health trajectories and quality of life [21].
**AEROBIC EXERCISE**

Longitudinal research shows individuals diagnosed with PTSD who engage in strenuous intensity exercise (i.e. vigorous running and cycling), show significantly less avoidance/numbing and hyperarousal symptoms via improved sleep quality; reduced substance abuse; less pain, compared to less active subjects [22].

Randomized controlled trials demonstrate the role of the endocannabinoid (eCB) system that might mediate positive outcomes in PTSD treatment involving aerobic activity.

30 minutes of moderate intensity aerobic activity activated the eCB system in individuals with and without chronic PTSD [23], suggesting the eCB system is dysregulated in PTSD [24]. Aerobic activity elicited greater improvements in mood and reductions in pain in individuals with PTSD (Figure 7). A later study found, unlike in controls, one main eCB (2-arachidonylglycerol) did not increase in response to exercise or psychosocial stress in those with PTSD (Figure 8) [25]. This may suggest adults with PTSD have a blunted eCB response upon exposure to different forms of stress compared to healthy controls.

Additional research is needed if exercise is used to treat mental health outcomes among individuals with PTSD, because adults with PTSD show a blunted mobilization of 2-AG in response to aerobic exercise.

**KEY FINDINGS**

- **Indirect effects via improved sleep quality is of clinical value considering insomnia co-occurs with PTSD and persists even after successfully treating PTSD symptoms.**
- **Exercise intensity is an important factor in producing benefits.**

**Figure 7 and 8.** Effect size changes from pre- to post-exercise for the control and PTSD groups for mood states, pain responses and two main endocannabinoids: AEA and 2-AG.

**Figure 7.**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>PTSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Mood Disturbance</td>
<td>-1.5</td>
<td>-1.4</td>
</tr>
<tr>
<td>Pain</td>
<td>-1.3</td>
<td>-1.2</td>
</tr>
</tbody>
</table>

**Figure 8.**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>PTSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEA</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>2-AG</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Key.** Cohen’s d effect sizes are <0.2=trivial, ≥2 to <0.5=small, ≥0.5 to <0.8=moderate, ≥0.8 to <1=large, ≥1=perfect, >1=difference between two means is larger than one standard deviation.
WHAT DOES THE RESEARCH SHOW?

AEROBIC EXERCISE

Whether an individual with PTSD is accentuated or distracted from somatic arousal during aerobic exercise, *implicit interoceptive exposure* is likely to augment beneficial effects [26]:

- Quick onset of mental health benefits precipitated by aerobic exercise.

Other mechanisms of action evidenced:

- Strategies to maintain exercise motivation are needed as PTSD individuals are at risk of discontinuing exercise post-intervention.

KEY FINDINGS

- **SENSE OF ACHIEVEMENT**
- **MEANINGFUL ACTIVITY RE-ENGAGEMENT**
- **INCREASED ENDORPHIN PRODUCTION**
- **REPRIEVE FROM EVERYDAY ANXIETY**

- 33 PTSD-affected patients were randomized into three exercise groups each with a different attentional focus.

- Towards somatic arousals
- Distraction from somatic arousal
- No distraction/interoceptive prompts

- All groups completed two weeks of six, 20-minute aerobic exercise sessions.

- Significant improvements in:
  - Total PTSD symptom severity
  - PTSD symptom clusters
  - Anxiety sensitivity

INTEROCEPTIVE EXPOSURE

- Exposing patients to feared physiological symptoms in the context of PA increases tolerance for such symptoms.

- Repeated exposure reinforces that sensations may be discomforting but do not pose a threat.

**Hyperventilation**
**Rapid heart rate**
**Muscular tension**
**Sweating**

Exercise?

Panic attack?
Resistance training (RT) serves as an alternative when aerobic exercise is undesired and may produce a net therapeutic effect on PTSD.

✓ A randomized controlled feasibility trial [27] supported the anxiolytic effects of 3 weeks of RT for individuals with PTSD (Table 2).

Research cataloging the effects of exercise dose (i.e., intensity, frequency, and duration) on PTSD and other psychological outcomes are necessary before any optimal exercise prescription recommendations can be made.

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### Table 2. Group comparison for sleep quality, PTSD, anxiety, and depression symptoms

<table>
<thead>
<tr>
<th></th>
<th>RT, Mean</th>
<th>Control, Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
</tr>
<tr>
<td><strong>Sleep quality</strong></td>
<td>11.3</td>
<td>7.1</td>
</tr>
<tr>
<td><strong>Sleep latency</strong></td>
<td>2.4</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>PTSD symptoms</strong></td>
<td>37.8</td>
<td>25.6</td>
</tr>
<tr>
<td><strong>Anxiety</strong></td>
<td>54.7</td>
<td>46.2</td>
</tr>
<tr>
<td><strong>Depression symptoms</strong></td>
<td>15.1</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Key. RT=Resistance training. A decrease in mean scores indicates improvements for all measures. * denotes significant group differences at p<0.05.
WHAT DOES THE RESEARCH SHOW?

AUGMENTATION PROGRAMS

Given the high prevalence of CMD among people with PTSD, augmentation programs may be a promising tool to elicit a dual-health impact.

A 12-week exercise intervention (three 30-minute resistance-training sessions/week and a pedometer-based walking program) in addition to usual care, compared to usual care alone, demonstrated significant between-group differences favoring the intervention group for mental and physical health outcomes in inpatients diagnosed with PTSD (Table 3) [28].

Exercise as an augmentation to exposure therapy also has the potential to enhance psychological outcomes.

A small-scale randomized study testing the efficacy of exercise in aiding exposure therapy in adults suffering from PTSD, found greater reductions in PTSD symptoms, and a large impact on levels of brain-derived neurotropic factor (BDNF) compared to prolonged exposure alone (Figure 9) [29]. (Higher BDNF is associated with enhanced learning, cognition, and improved exposure-based treatment outcomes).

Exercise can therefore act as a cognitive enhancer, particularly for those who have suboptimal response to routine treatment, via promotion of synaptic plasticity.

| Table 3. Significant between-group differences for mental and physical health outcomes |
|-----------------------------------------------|----------------------------------|-----------------|
| Difference between groups                     | Effect size (g2 p)*               |                 |
| (intervention – usual care; 95% CI)            | Small 0.01 to <0.06 Medium 0.06 to <0.14 Large >0.14 |                 |
| PTSD symptoms                                 | -5.4 (-10.5 to -0.3), P = 0.04  | 0.07            |
| Depression                                    | -7.0 (-11.9 to -2.1), P = 0.006 | 0.15            |
| Anxiety                                       | -6.3 (-10.3 to -2.3), P = 0.003 | 0.17            |
| Stress                                        | -4.6 (-8.8 to -0.4), P = 0.03   | 0.09            |
| PTSD related sleep quality                    | -2.5 (-4.9 to -0.1), P = 0.04   | 0.08            |
| Body fat %                                    | -5.9 (-9.1 to -2.8), P = 0.001  | 0.31            |
| Waist circumference (cm)                      | -3.6 (-7.0 to -0.2), P = 0.04   | 0.12            |
| Time spent sitting per day (mins)             | -261 (-412 to -111), P = 0.001  | 0.2             |

Key. Difference between groups represented by the medium. Significance level at p<0.05. * effect size given as partial eta-squared (g2 p): 0.01 to <0.06 = small effect, 0.06 to <0.14 = medium effect, and 0.14 or higher is large effect size.

Figure 9. BDNF as a function of treatment condition

Key. Figure displays relative increase in BDNF means. BDNF = Brain derived neurotropic factor.
WHAT DOES THE RESEARCH SHOW?

YOGA

Yoga interventions have proven to treat a number of trauma populations including war veterans [30], tsunami survivors [31] and those with current full or subthreshold PTSD symptoms [32]. Findings show improvements for...

- PTSD symptoms
- Sleep quality
- Stress
- Positive affect
- Resilience
- Anxiety

Changes in interoceptive awareness is proposed as a mechanism behind the reductions in PTSD symptoms and increases in well-being [33].

KEY FINDINGS

‘Yoga for PTSD and the role of interoceptive awareness: A preliminary mixed-methods case series study’—Neukirch, Reid & Shires, 2019

INTERVENTION: 8 weeks of 1-hour trauma yoga intervention classes for people with PTSD [38].

MEASURES: PTSD symptoms, depression, anxiety, stress and interoceptive awareness assessed at baseline, week 2, 4, 6, 8, and week 2 and 8 post-intervention using quantitative and qualitative measures.

FINDINGS:
- Significant increases in interoceptive awareness (attention-regulation, self-regulation, and body-listening) and significant decreases in PTSD symptoms, depression, anxiety, and stress pre to post yoga.

“I felt grounded and in my body. I focused on myself unlike other classes where I just follow instructions”.

“I found a calm during practice where anxiety and depression can be put aside”.

CONCLUSION:
Improving interoceptive awareness through yoga helps trauma survivors regain mind-body connection that is commonly lost following traumatic events and assist in effective regulation of emotions and behaviours.

Large randomized control studies are needed to identify the direct interaction effects and mediating relationships.
Exercise-based interventions are considered a viable form of ‘alternative medicine’ for veterans’ mental health.

- Less than 10% of veterans attend recommended number of mental health appointments within first year of PTSD diagnosis [34].
- Veterans generally have blunted responses to traditional therapies compared to nonveteran populations [35].
- Perceptions of stigma and institutional-related barriers to care stop veterans with PTSD from seeking treatment (Table 3) [36].

Table 4. Unadjusted Means and Standard Deviations of Perceived Barriers to Care Subscales

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Total (N = 490) M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Institutional barriers</strong></td>
<td></td>
</tr>
<tr>
<td>SSS</td>
<td>1.61 (.71)</td>
</tr>
<tr>
<td>LB</td>
<td>1.59 (.50)</td>
</tr>
<tr>
<td>NFI</td>
<td>1.45 (.59)</td>
</tr>
<tr>
<td><strong>Stigma-related factors</strong></td>
<td></td>
</tr>
<tr>
<td>DHS</td>
<td>2.42 (.76)</td>
</tr>
<tr>
<td>CSC</td>
<td>2.24 (.86)</td>
</tr>
</tbody>
</table>

Key. SSS=Staff skill and sensitivity; LB=Logistic Barriers; DHS=Discomfort with help-seeking; NFI=Not fitting in to veteran affairs; CSC=Concerns about social consequences. Higher scores indicate more perceived barriers

PTSD symptom severity and avoidance symptoms hold unique positive associations with barriers to care, highlighting the impact of psychopathology on veterans’ experiences and perceptions with seeking help.

Exercise can reduce barriers to treatment by:

- Requiring minimal supervision or can be done at home;
- Being familiar to veterans;
- Naturally lending itself to the logistic barriers i.e. cost of treatment, scheduling, transport issues [37].
EXERCISE FOR MILITARY VETERANS

Structured Programs

Veterans (18-69y) meeting DSM-IV criteria for current PTSD [38]

Waitlist control condition (WL) (n=26)

Group-based Integrative Exercise (IE): combining aerobic, resistance and mindfulness-based exercise for 12 weeks (n=21)

Measurements (baseline, week 4, 8, 12)
PTSD symptoms (CAPS), quality of life, intervention feasibility & acceptability, leisure-time exercise

The feasibility and efficacy of structured exercise programs have also been evidenced among overweight veterans in addressing the constellation of CMD risk [39], and in women veterans [40]; an often-underrepresented group within exercise and mental health research [41].

Authors state:

“Finally, for patients with prominent avoidance related to their traumatic events, exercise may provide a safe and structured activity that can address social isolation and promote recovery”

KEY FINDINGS

Participants in IE evidenced:

✓ More exercise activity and greater reduction in PTSD symptom severity than WL (Table 5).
✓ Greater improvement in psychological quality of life among IE group, but smaller relative improvement in physical quality of life.
✓ High levels of satisfaction with intervention i.e. less stigmatizing and more practical, learning new skills, distraction from negative experiences (lowering hypervigilance).

Table 5. PTSD symptom severity and leisure-time exercise activity at intake and post-treatment

<table>
<thead>
<tr>
<th></th>
<th>Intake</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IE</td>
<td>WL</td>
</tr>
<tr>
<td></td>
<td>IE</td>
<td>WL</td>
</tr>
<tr>
<td>CAPS Total</td>
<td>64.25</td>
<td>58.5</td>
</tr>
<tr>
<td></td>
<td>(20.54)</td>
<td>(14.16)</td>
</tr>
<tr>
<td>CAPS Re-experiencing</td>
<td>16.65</td>
<td>17.12</td>
</tr>
<tr>
<td></td>
<td>(7.75)</td>
<td>(6.41)</td>
</tr>
<tr>
<td>CAPS Avoidance/Numbing</td>
<td>25.50</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>(9.97)</td>
<td>(8.92)</td>
</tr>
<tr>
<td>CAPS Hyperarousal</td>
<td>22.10</td>
<td>18.23</td>
</tr>
<tr>
<td></td>
<td>(7.50)</td>
<td>(6.80)</td>
</tr>
<tr>
<td>Leisure-time</td>
<td>23.90</td>
<td>26.00</td>
</tr>
<tr>
<td>exercise activity</td>
<td>(19.97)</td>
<td>(26.32)</td>
</tr>
</tbody>
</table>

Key: CAPS, Clinician-Administered PTSD Scale; IE, Integrative Exercise; WL, Waitlist Control. Values are presented as mean (standard deviation).
16 war veterans with PTSD took part in a study investigating how surfing may influence veterans’ psychological health beyond the medical emphasis on treating symptoms and disorder [42].

Using interviews and participant observation, psychological well-being increased via two main mechanisms (Figure 7).

These findings exemplify how exercise can add to life - through positive experiences - rather than eliminating problems. Still, longitudinal research is required to examine changes in veterans’ mental health after their engagement with exercise-based approaches.
Given the strength and consistency of the emerging evidence, we suggest that exercise and PA broadly, offers hope as feasible, safe and effective components of care. However, exercise-based intervention research is still maturing, so we refrain from making damaging claims about exercise as a ‘miracle cure’ for PTSD. Instead, we recognise the impact of exercise on improving cardio-metabolic health, symptoms and well-being in PTSD sufferers, whilst acknowledging areas that warrant further attention.

**Exercise Prescription and Promotion: Using Current Evidence to Inform Future Practice**

**Exercise frequency, intensity, mode, and type**

Current guidelines and research examining exercise preferences for PTSD population [43, 44] suggest:

- 150min of moderate PA per week is unrealistic and discouraging for PTSD patients. Instead, start at a non-challenging level with something enjoyable (i.e. walking, yoga) and progress to include vigorous-intensity exercise (which appears effective in coping with hyperarousal symptoms).
- One-to-one exercise in private setting may help individuals suffering from avoidance symptoms build confidence before transitioning to small group settings (shown as helpful in addressing social barriers and motivation to exercise).
- Preference in location and form of exercise meeting the needs of PTSD individuals should be a guiding factor (i.e. distraction from thoughts during exercise using music or challenge of exercise; activate feelings of enjoyment through group-based exercise or exercising outdoors).

**Adherence to exercise**

Interventions should extend beyond the relationship with the clinician and include techniques in Self-Determination Theory to motivate continued exercise [45]. Promoting an autonomy-supportive environment is key:

- Opportunities for self-direction and choices (e.g. to opt-out/in during sessions).
- Participation in shaping sessions (e.g. proposing exercises).
- Experiencing personal mastery together with positive self and group experiences (e.g. feedback and encouragement from trainers and other participants, becoming aware of own skills and coping abilities).
Non-medical promotion

Promoting a ‘non-medical approach’ rather than ‘exercise as medicine’ is crucial for PTSD sufferers, and especially for veterans [46]. Benefits include:

- Positive associations of exercise with physical culture of military.
- Perceived distance from passive, clinically oriented approaches e.g. taking medication.
- Avoidance in constructing exercise as something ‘obligatory’.

Individualized treatment

Patient-specific exercise prescriptions are essential considering the medical complexities amongst the PTSD population [47, 48]. Exercise-based interventions should:

- Understand each client’s triggers and symptom severity to tailor instruction and activity appropriately.
- Provide a safe environment where clients can relax and focus on health and well-being during exercise.
- Offer adaptations within exercise prescriptions to address the diverse physical functioning needs (i.e. daily fluctuations in pain or mobility may mean rigid prescription is not feasible).
REFERENCES


Appendix 1: Expanded keys for tables

Table 2. Sleep quality and latency measured using Pittsburgh Sleep Quality Index; PTSD symptoms using Post-Traumatic Diagnostic Scale for DSM-5; anxiety using State-Trait Anxiety Inventory; depression using Centre for the Epidemiological Studies of Depression Short Form.

Table 3. PTSD symptoms measured using Post-Traumatic Stress Disorder Checklist-Civilian; depression, anxiety and stress using Depression Anxiety and Stress Scale; PTSD related sleep quality by Pittsburgh Sleep Quality Index Addendum for PTSD; body fat % obtained using a bio-impedance scale; waist circumference defined as the point mid-way between iliac crest and costal margin; time spent sitting per day assessed using the International Physical Activity Questionnaire-Short Form.

Table 4. Items were rated on a 4-point scale with 1=not at all, 2=slightly, 3=moderately, and 4=very much.

Table 5. Leisure-time exercise activity measured using Godin Leisure-Time Exercise Questionnaire.
Appendix 2: Expanded key for figures

**Figure 1.** Includes women with trauma/PTSD during follow-up, between 1989 and 2009 (n=15,353). Predicted values of physical activity are plotted.

**Figure 2 and 3.** Includes Brazilian patients with PTSD (n=50).

**Figure 7.** Total Mood Disturbance scores obtained from Profile of Mood States (POMS) questionnaire; pain measured using the McGill Pain Questionnaire-Short-Form (MPQ-SF).

**Figure 9.** Plasma BDNF analyzed by RayBiotech, Inc. (Norgross, GA) using a sandwich enzyme-linked immunosorbent assay (ELISA) kit.