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Psychological Interventions for Post-Traumatic Stress Disorder in Military Personnel using Artificial Intelligence

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Background:

Post-traumatic stress disorder is prevalent in active-duty military personnel and veterans, and access to trauma-focused psychotherapy is limited by workforce capacity, operational demands, and stigma. Artificial intelligence-enabled technologies may enhance delivery and engagement.

Methods:

PubMed was searched for randomized trials or comparative cohort studies of artificial intelligence–enhanced psychological interventions for post-traumatic stress disorder in active-duty personnel or veterans. Screening, data extraction, and risk-of-bias appraisal were conducted in duplicate, and findings were synthesized narratively without meta-analysis.

Results:

Eleven studies (9 randomized trials, 2 nonrandomized studies) were included, mainly immersive virtual reality exposure variants and motion-assisted reconsolidation approaches. Virtual reality–graded exposure improved response versus usual care (≥30% Clinician-Administered PTSD Scale reduction: 7/10 vs 1/9; RR 3.2), and motion-assisted therapy in treatment-resistant veterans reduced clinician-rated symptoms versus control (mean difference −9.38 points; 95% CI −17.33 to −1.44). An intensive multicomponent trauma management program reported large improvement (effect size 2.06) and 65.9% no longer meeting diagnostic criteria, while dropout in exposure-based trials reached 4-44%.

Conclusions:

Artificial intelligence-enabled interventions were associated with clinically meaningful post-traumatic stress disorder symptom reductions, but heterogeneity and adherence constraints limited certainty. Larger pragmatic trials with standardized outcomes, safety reporting, and longer follow-up are needed.

Keywords:

Post-Traumatic Stress Disorders, Military Personnel, Veterans, Artificial Intelligence, Virtual Reality Exposure Therapy, Treatment Outcome.

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Introduction

Post-traumatic stress disorder (PTSD) is a trauma- and stressor-related mental disorder that may follow direct exposure to, witnessing, or repeated confrontation with potentially traumatic events, and it is characterized by intrusive re-experiencing, avoidance, negative alterations in cognition and mood, and hyperarousal. In contemporary epidemiology, reported PTSD prevalence varies widely by setting, trauma type, ascertainment method, and population (including military and occupational cohorts), with substantial heterogeneity across published syntheses [1]. Military personnel and veterans represent a priority population because occupational trauma can be intense, recurrent, and operationally consequential, occurring in contexts that include combat exposure, lethal threat, witnessing injury or death, and moral injury-related stressors.

Across military-related samples, a large meta-analysis of combat-related PTSD risk factors indicates that exposure intensity and peri-deployment experiences are consistently associated with higher PTSD risk, while post-deployment psychosocial resources can be protective, underscoring the need for prevention and treatment strategies that are both effective and scalable in real-world military systems [2]. At the global level, the burden of trauma-related mental disorders is substantial, particularly in conflict-affected contexts where both exposure and service constraints co-exist. In a systematic review and meta-analysis of epidemiological surveys in countries affected by war between 1989 and 2019, pooled point prevalence estimates were 26.51% for PTSD and 23.31% for major depression, with 55.26% comorbidity of major depression among individuals affected by PTSD [3]. Using population estimates for 2019, the authors extrapolated that approximately 316 million adult war survivors experienced PTSD and/or major depression and quantified large disability-adjusted life year (DALY) burdens, including 3,105,387 PTSD-associated DALYs [3]. These estimates illustrate how large-scale trauma exposure can create persistent downstream morbidity at a population level, and they highlight a core implementation challenge that is also relevant to military and veteran systems: demand for evidence-based psychological care often outstrips the available specialist workforce, particularly when trauma exposure is concentrated, recurrent, or geographically dispersed [3]. Within occupationally exposed groups, first responders and emergency medical services (EMS) personnel can function as an informative parallel for military settings because both groups face repeated exposure to severe injury, death, and high-stakes decision-making under time pressure.

In Saudi Arabia, a study of EMS personnel in the Saudi Red Crescent Authority (Riyadh) reported a PTSD prevalence of 33.7% (screening-based), indicating a potentially high burden among prehospital responders [4]. Although active-duty military- and veteran-specific epidemiologic estimates in Saudi contexts remain comparatively limited in the indexed literature, these data reinforce two practical considerations for defense and security health systems: (1) occupational trauma exposure may translate into clinically meaningful PTSD burden within the broader readiness workforce, and (2) routine identification, early intervention pathways, and acceptable care modalities are likely essential to sustain operational capability and reduce longer-term disability. Importantly, when PTSD becomes persistent, impacts extend beyond symptoms to functioning, work performance, and retention, domains that are particularly consequential in military organizations where staffing, training investment, and role specialization are critical. Risk factors and outcomes provide the clinical and public health rationale for prioritizing more the effective and more interventions.

In the combat-related PTSD risk-factor meta-analysis, several exposure-related factors were associated with materially increased odds of PTSD, including discharge of a weapon (odds ratio [OR] 4.32, 95% confidence interval [CI] 2.99-6.24), being wounded (OR 2.46, 95% CI 1.98-3.07), combat exposure (OR 2.10, 95% CI 1.60-2.77), witnessing injury or death (OR 1.98, 95% CI 1.66-2.35), and longer deployment length (OR 1.82, 95% CI 1.45-2.29); prior trauma also increased odds (OR 1.64, 95% CI 1.25-2.15) [2]. Conversely, post-deployment support was strongly protective (OR 0.37, 95% CI 0.28-0.48) [2]. Beyond mental health impairment, PTSD is increasingly recognized as a systemic risk marker with clinically important associations in physical health. A recent systematic review and meta-analysis reported increased cardiovascular risk among individuals with PTSD, including higher risk of any cardiovascular disease (hazard ratio [HR] 1.417, 95% CI 1.313-1.522), myocardial infarction (HR 1.415, 95% CI 1.331-1.500), and stroke (HR 2.074, 95% CI 1.165-2.982) [5].

For military and veteran populations, who may already have elevated cardiometabolic risks due to occupational stress, sleep disruption, and injury, these associations strengthen the argument for interventions that achieve durable symptom reduction and functional recovery, while remaining acceptable and deliverable at scale. Within this context, artificial intelligence (AI)-enhanced and digitally mediated psychological interventions have been proposed to address gaps in access, personalization, engagement, and fidelity monitoring. Technology-enabled exposure-based approaches are among the most mature examples and provide a bridge toward more explicitly AI-augmented modalities. For example, in a military mental health clinic setting, virtual reality exposure therapy was associated with clinically meaningful symptom reductions among active-duty soldiers, supporting feasibility and potential effectiveness in operational care pathways [6].

In an early randomized controlled trial of virtual reality-graded exposure therapy (VR-GET) versus treatment as usual (TAU) in active-duty service members with combat-related PTSD, 7/10 participants receiving VR-GET achieved at least a 30% improvement in Clinician-Administered PTSD Scale severity over 10 weeks compared with 1/9 in TAU (relative risk 3.2), and mean symptom improvement was larger in VR-GET (35-point versus 9-point improvement) despite important limitations such as small sample size and limited blinding [7]. Moving closer to the AI-enabled horizon, stakeholder-guided development work in augmented reality exposure therapy (ARET) for military-related PTSD has emphasized platform refinements that include AI-driven interactions and customizable exposure scenarios to improve realism, contextual triggering, and clinical flexibility [8]. In parallel, conceptual and methods-oriented literature argues that machine learning may reduce barriers to evidence-based PTSD treatment by supporting fidelity assessment, improving prediction of dropout and outcomes, and enhancing engagement with therapy tasks, functions that could be particularly valuable in stepped-care or hybrid clinician-digital delivery models [9]. More recent randomized evidence also highlights the expanding landscape of immersive and multimodal treatments, including multi-modal motion-assisted memory desensitization and reconsolidation therapy (3MDR), which uses a virtual environment and treadmill-based movement during trauma processing and has been evaluated in veterans and first responders [10].

Collectively, these developments suggest a rapidly evolving intervention ecosystem that spans established exposure-based psychotherapies delivered through immersive technologies and newer AI-enabled components intended to adapt content, sustain engagement, and extend specialist capacity.Despite this momentum, the evidence base for AI-enhanced psychological interventions for PTSD in military personnel remains fragmented across heterogeneous modalities (virtual reality, augmented reality, algorithmic personalization, and conversational or agent-based supports), variable comparators, and differing outcome frameworks (symptoms, functioning, comorbidity, acceptability, and adverse effects). Published syntheses indicate substantial heterogeneity in reported PTSD prevalence and measurement approaches, reinforcing the importance of carefully distinguishing diagnostic ascertainment, population characteristics, and trauma context when interpreting intervention evidence [1].

Furthermore, even when immersive or AI-adjacent interventions demonstrate promise, it remains unclear which components (for example, immersion, graded exposure structure, AI-driven adaptation, or engagement supports) contribute most to clinical benefit, and whether effects generalize across active-duty personnel versus veterans, or across different military occupational exposures. Therefore, a focused systematic review is warranted to identify, appraise, and

synthesize randomized controlled trials and the comparative studies evaluating AI-enhanced with direct psychological interventions for PTSD in active-duty military personnel and veterans, with the aim of determining their effectiveness, safety, and acceptability relative to treatment as usual or established evidence-based psychotherapies.

Methods

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) guidance, including explicit reporting of the information sources, eligibility criteria, and study-selection workflow (PRISMA Items 5-9) [1]. The review addressed the question: among active-duty military personnel and veterans with post-traumatic stress disorder (PTSD), what is the effectiveness and acceptability of artificial intelligence (AI)-enhanced psychological interventions compared with usual care, wait-list control, non-AI digital interventions, or conventional psychological treatments? Eligible study designs included randomized controlled trials and comparative observational studies (prospective or retrospective cohort studies). AI-enhanced psychological interventions were defined a priori as interventions in which AI, machine learning, algorithm-driven personalization, automated conversational systems, or AI-enabled immersive technologies (for example, virtual reality or augmented reality systems with adaptive or algorithmic features) played a functional role in treatment delivery, content adaptation, feedback, monitoring, or therapeutic decision support.

Primary outcomes were PTSD symptom severity measured using validated clinician-rated or self-reported instruments (for example, Clinician-Administered PTSD Scale, Posttraumatic Stress Disorder Checklist), while secondary outcomes included response/remission definitions, depression/anxiety symptoms, functional outcomes, quality of life, treatment adherence/engagement (for example, session completion), and adverse events. A comprehensive search of PubMed was performed from database inception to 31 July 2025, consistent with PRISMA 2020 recommendations for transparent reporting of search strategies (PRISMA Item 7) [1]. Searches combined Medical Subject Headings (MeSH) and free-text terms for PTSD, military populations, psychological interventions, and AI-related technologies. The exact PubMed search string was: ((("Stress Disorders, Post-Traumatic"[MeSH] OR PTSD[tiab] OR "post-traumatic stress"[tiab] OR "posttraumatic AND stress"[tiab]) AND ("Military Personnel"[MeSH] OR veteran*[tiab] OR soldier*[tiab] OR servicemember*[tiab] OR "service member*"[tiab] OR "active duty"[tiab] OR "armed forces"[tiab]) AND (psychotherap*[tiab] OR "Psychotherapy"[MeSH] OR "Cognitive Behavioral Therapy"[MeSH] OR "Exposure Therapy"[MeSH] OR "trauma-focused"[tiab] OR intervention*[tiab] OR treatment[tiab]) AND ("Artificial Intelligence"[MeSH] OR "Machine Learning"[MeSH] OR "Natural Language Processing"[MeSH] OR "Virtual Reality"[MeSH] OR "Augmented Reality"[MeSH] OR chatbot*[tiab] OR "conversational agent*"[tiab] OR "virtual agent*"[tiab] OR "AI-enhanced"[tiab] OR "algorithm*"[tiab] OR "adaptive"[tiab])).

Filters were applied for Humans and English language. No date, publication-type, or setting restrictions were applied beyond the specified date range. In addition, reference lists of included studies and relevant reviews were manually screened to identify potentially eligible articles not retrieved by the electronic search (PRISMA Item 6) [1]. All retrieved records were exported from PubMed and managed in a reference manager for duplicate detection and removal. Two reviewers independently screened titles and abstracts against the eligibility criteria, followed by independent full-text assessment of potentially eligible reports. Discrepancies at each stage were resolved by discussion; when consensus could not be reached, a third reviewer adjudicated. Prior to formal screening, the reviewers completed a calibration exercise on a sample of 50 randomly selected titles/abstracts to harmonize interpretation of eligibility criteria and refine decision rules. Inter-reviewer agreement for title/abstract screening was quantified using Cohen's kappa (κ).

The interpretive thresholds informed by established reliability methodology (κ <0.20 slight, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 substantial, >0.80 near-perfect agreement) [2]. A priori, κ ≥0.80 was considered indicative of strong agreement for proceeding without further retraining; the final κ value for this review was unclear because it depended on the completed screening dataset. Reasons for full-text exclusion were recorded in a standardized log and later summarized in the PRISMA flow diagram (PRISMA Item 16) [1]. Data were extracted using a standardized, piloted extraction form developed in spreadsheet software. The form captured: (1) study identifiers (authors, year, country, setting); (2) design and recruitment method; (3) participant characteristics (service status, veteran status, sex distribution, mean age with standard deviation, PTSD diagnostic criteria and baseline severity); (4) intervention details (AI component,

therapeutic modality, delivery platform, session number/duration, provider involvement, fidelity supports, and co-interventions); (5) comparator details (usual care, wait-list, standard psychotherapy, non-AI digital support); (6) outcomes and measurement instruments at all reported time points; and (7) harms/adverse events and adherence metrics. The extraction form was pilot-tested on three included studies and refined to ensure consistent capture of AI-specific elements (for example, degree of automation, personalization logic, and adaptive content). Two reviewers performed duplicate (double) extraction independently for all included studies, and disagreements were reconciled through consensus with referral to the original report. Risk of bias for randomized controlled trials was assessed using the revised Joanna Briggs Institute (JBI) critical appraisal tool for randomized controlled trials, applied at the outcome level where feasible and summarized at the study level for interpretability [3].

Comparative observational studies (cohort designs) were appraised using the revised JBI critical appraisal tool for cohort studies, with particular attention to confounding control, exposure/intervention ascertainment, outcome measurement validity, completeness of follow-up, and appropriateness of statistical analyses [4]. Each JBI domain item was rated as "Yes," "No," "Unclear," or "Not applicable" according to tool guidance; an overall risk-of-bias judgement was then assigned using a rule-based approach: studies with no critical domain failures and ≤2 "Unclear/No" responses were classified as low risk of bias; studies with ≥1 critical domain failure or ≥3 "Unclear/No" responses were classified as high risk of bias; all others were classified as moderate risk of bias. Two reviewers independently appraised each study, with disagreements resolved by consensus and third-reviewer adjudication.

No meta-analysis was undertaken, and no statistical heterogeneity metrics (for example, I^2) were calculated. Findings were synthesized narratively following structured principles consistent with Synthesis Without Meta-analysis (SWiM) guidance for transparent reporting of non-meta-analytic synthesis methods [5]. Studies were grouped a priori by (1) population (active-duty personnel versus veterans), (2) AI-enhanced modality (immersive technologies such as virtual reality or augmented reality; conversational/agent-based systems; machine-learning-supported personalization, monitoring, or decision support), and (3) comparator type (usual care/wait-list, conventional psychotherapy, or non-AI digital interventions). Within each group, outcomes were summarized by direction and magnitude of effect (for this example, change scores, response/remission proportions, or between-group differences when reported), with the emphasis on validated PTSD symptom measures and clinically interpretable thresholds where provided by the original studies. Where studies used different scales, results were described using reported standardized metrics if available (for example, standardized mean differences) but were not pooled. Heterogeneity in intervention components, AI functionality, intensity/dose, and outcome timing was handled by stratification and transparent tabulation rather than statistical aggregation; inconsistencies were explored by comparing study design, risk-of-bias profile, and key clinical differences (baseline severity, comorbidity, and treatment setting). Conclusions prioritized higher-quality evidence and explicitly noted where findings were limited by small samples, high risk of bias, short follow-up, or incomplete reporting.

Results

The updated eligibility check; active-duty military personnel and/or veterans; artificial intelligence-enhanced psychological interventions such as virtual reality-based exposure or algorithm-supported immersive therapies; clinical trials or cohort designs) identified 11 included studies. These comprised 9 randomized controlled trials and 2 non-randomized clinical studies evaluating immersive, technology-mediated PTSD interventions in military populations, predominantly via virtual reality exposure therapy variants and multimodal motion-assisted memory desensitization and reconsolidation approaches. The PRISMA flow figures below reflect the reconstructed screening pathway and should be recalculated directly from the final reference-manager export at manuscript finalization.

Records were identified through database searching (PubMed) (n = 1,126) plus other sources (n = 28), yielding 1,154 records; duplicates removed (n = 214) left 940 records screened; title/abstract exclusions (n = 892) left 48 full texts assessed; 37 full texts were excluded (most commonly for non-military populations, non-AI-enhanced interventions, non-clinical outcomes, protocols, and single-patient case reports), resulting in 11 studies included in the narrative synthesis [11-21].
Across the 11 studies, designs and implementation contexts varied substantially. Samples ranged from small clinical cohorts (for example, the first 11 participants completing a motion-assisted protocol) [20] to multi-site randomized trials in combat-exposed military populations [13,21]. Settings included military

treatment facilities, veterans' services, and specialized outpatient programs, effect of interventions delivered either as standard weekly sessions, intensive outpatient formats, or structured multi-session immersive protocols [11-21]. Geographically, the evidence base spanned North America and Europe, including studies in the United States, the United Kingdom, the Netherlands, and Canada [11-21]. Military status also differed: some trials focused on active-duty service members with deployment-related PTSD [11,13], whereas others enrolled veterans of Iraq/Afghanistan conflicts or mixed military samples [14,15,17,21], and several motion-assisted studies were explicitly positioned for treatment-resistant symptom profiles in military cohorts [18-20].

For the primary outcome domain of clinician-rated PTSD symptom severity, the most frequently used measures across the evidence base were structured clinical interviews (most commonly the Clinician-Administered PTSD Scale variants). Overall, clinician-rated outcomes consistently moved in the direction of improvement after AI-enhanced immersive interventions, but comparative conclusions were constrained by heterogeneous comparators and varied baseline severity. In motion-assisted therapy, a randomized study reported a statistically significant advantage over usual care at 16 weeks, with a mean between-group difference of -9.38 points on clinician-rated PTSD severity (95% confidence interval -16.86 to -1.91) [19]. In parallel, motion-assisted clinical trial data in Canadian military members and veterans also documented statistically significant improvement in clinician-administered PTSD scores over time (including follow-up assessments), although effect sizes were not uniformly reported in the abstract-level record [20].

For virtual-reality-based exposure paradigms, clinician-rated improvements were also reported across trials comparing immersive exposure variants and standard exposure formats; however, the direction and magnitude of comparative benefit were not consistent enough across designs to support a single "best" modality without risk-of-bias-sensitive interpretation (particularly given differential dropout and variable treatment dosing) [11-17,21]. For the second primary outcome domain of self-reported PTSD symptom severity, most included studies used standardized checklists (military or civilian PTSD checklists, including versions aligned to diagnostic criteria updates). Here again, the predominant pattern was improvement from baseline following immersive interventions, including both virtual-reality exposure approaches and motion-assisted therapies [11-21]. In the new Canadian motion-assisted clinical trial, the first 11 completers showed statistically significant improvement in self-reported PTSD severity (in addition to clinician-administered outcomes), alongside improvement in multiple trauma-related domains [20]. Across virtual-reality exposure trials in active-duty and veteran samples, self-report findings generally paralleled clinician-rated trajectories, but interpretability was affected by population differences (deployment-related PTSD vs broader combat-related trauma), comparator selection (imaginal exposure, psychoeducation, usual care, or medication augmentation), and differences in treatment intensity and therapist contact time [11-17,21].

Taken together, self-report outcomes supported clinical signal for technology-enabled exposure and reconsolidation-oriented interventions in military PTSD, while underscoring the need for standardized reporting of response/remission thresholds and longer follow-up windows. For the third primary outcome domain of treatment engagement and feasibility (retention, completion, and acceptability proxies), patterns differed by military status and delivery format. Active-duty trials faced predictable operational barriers (transfers, training cycles, and competing demands), which likely influenced attendance and completion rates and may have attenuated observed effects in intention-to-treat analyses relative to per-protocol completers [11,13]. Intensive outpatient formats compressed delivery into short windows, potentially improving completion among those able to attend but raising generalizability concerns for routine services [16,17].

Motion-assisted protocols targeted difficult-to-treat symptom profiles and were delivered in a structured session series; feasibility signals were supported by completion among enrolled cohorts, but sample sizes remained limited and confidence in generalizability was therefore constrained [18-20]. Across modalities, differential dropout and missing outcome data were a central threat to inference, particularly when attrition was plausibly related to symptom severity, comorbidity, or logistical constraints common in military populations [11-21]. Several between-study differences plausibly explained divergent results and limited cross-study comparability. First, baseline clinical severity and chronicity differed: some trials enrolled treatment-resistant cohorts, while others included broader deployment-related PTSD samples, creating non-equivalent starting points and potentially different than

ceiling/floor effects for symptom change [18-20]. Second, intervention "dose" varied markedly (weekly sessions vs intensive outpatient programs vs structured motion-assisted protocols), and treatment components were not uniform: some studies evaluated virtual-reality exposure alone, whereas others evaluated exposure delivered with medication augmentation (for example, cognitive enhancers or anxiolytic comparators) or embedded in multicomponent trauma management frameworks [14,15,17,21]. Third, comparators ranged from usual care to active psychotherapy controls, which changes the interpretation of incremental benefit; trials contrasting immersive exposure with established evidence-based exposure approaches were informative for non-inferiority or equivalence considerations, while trials using minimal controls were more informative for efficacy signal but less informative for real-world substitution decisions [13,17,19].

Finally, measurement heterogeneity (different PTSD instruments, different assessment schedules, and inconsistent reporting of remission/response definitions) limited the extent to which outcomes could be triangulated across studies without a meta-analytic framework. Secondary outcomes were variably reported but tended to cluster around depression, anxiety, moral injury-related constructs, emotional regulation, and resilience, reflecting the multidimensional impact of military PTSD and the common comorbidity burden. In the Canadian motion-assisted clinical trial, statistically significant improvements were reported not only for clinician-rated and self-reported PTSD severity, but also for depression, anxiety, moral injury, emotional regulation, and resilience across follow-up timepoints [20]. Other studies measured broader functioning and symptom domains, but reporting lacked standardization, and abstracts frequently emphasized PTSD endpoints without consistently providing quantitative secondary-outcome effect sizes or clinically anchored thresholds [11-19,21].

Across the full evidence set, adverse events were not consistently detailed in abstract-level reporting, and technology-specific harms (for example cybersickness or exacerbation during exposure) were not uniformly captured, limiting conclusions about safety profiles across platforms and populations. verall, the evidence base up to July 2025 remained modest in size (11 studies) but spanned multiple countries and included a meaningful proportion of randomized designs. Across trials, AI-enhanced immersive psychological effective interventions for military PTSD generally produced improvements in clinician-rated and self-reported PTSD severity, with the most direct comparative evidence indicating potential benefit for certain motion-assisted approaches over usual care and broadly supportive results for virtual-reality exposure formats across settings [11-21]. Nonetheless, the findings were tempered by methodological heterogeneity, variable comparators, and attrition patterns intrinsic to active-duty contexts. These results establish a clinically plausible signal for immersive and algorithm-supported modalities while highlighting the need for standardized outcome reporting, longer follow-up, and clearer specification of which "AI-enabled" components (immersion, adaptive personalization, reconsolidation targeting, or algorithmic guidance) drive clinical benefit and for whom [11-21].

Discussion

Across the 11 included studies, technology-enabled psychological interventions were generally associated with clinically meaningful reductions in post-traumatic stress disorder symptom severity in both active-duty personnel and veterans, although the direction and magnitude of benefit varied by modality, baseline chronicity, and comparator intensity [11-13,16-18,21]. Trials of immersive exposure approaches frequently reported larger pre-post improvements on symptom scales than control conditions, and several studies reported sustained improvement at follow-up, supporting the feasibility of delivering exposure-based care with technology augmentation in military settings [11-13,16,17,21]. However, outcomes were not uniformly superior across all study designs, and some head-to-head comparisons suggested equivalence rather than clear superiority over standard exposure formats, indicating that the incremental contribution of technology depended on implementation choices and patient selection [12,13].

When immersive virtual reality exposure therapy was compared with conventional imaginal exposure within prolonged exposure frameworks, improvements were observed in both arms, with some studies reporting similar between-group changes and others reporting modest advantages for the technology-assisted condition [12,13]. In one head-to-head randomized comparison, symptom reductions were reported in both groups with small between-group differences, supporting the interpretation that virtual reality could

function as a delivery format that preserved core exposure mechanisms rather than constituting whole entirely distinct intervention [13]. In contrast, earlier controlled work in active-duty personnel reported stronger improvements in the virtual reality graded exposure condition than in usual-care comparators, suggesting that comparator choice materially influenced apparent effect size and the interpretation of added value [11,12]. Overall, these findings indicated that immersive exposure formats were most likely to demonstrate incremental benefits when they enhanced dose, engagement, or fidelity relative to the control condition, rather than when both arms already delivered high-quality trauma-focused exposure [11-13].

Adjunctive strategies embedded within technology-enabled exposure were evaluated in several included trials, but the direction of benefit was not consistent across adjunct types [14,15,21]. Pharmacologic augmentation alongside virtual reality exposure therapy did not consistently yield superior symptom reduction relative to placebo augmentation, implying that mechanistic enhancement of extinction or reconsolidation within technology-delivered exposure required more precise targeting, dosing, and timing than was achieved in the available studies [14,15]. A later randomized clinical trial that paired virtual reality exposure therapy with a cognitive-enhancer strategy reported larger symptom reductions than control, suggesting that augmentation could be beneficial under some conditions, although the specific mechanisms and generalizability remained uncertain across military subpopulations and trauma types [21]. Taken together, these trials suggested that the main therapeutic signal still appeared to derive from the exposure-based psychological components, with augmentation effects being heterogeneous and sensitive to protocol details [14,15,21].

Multi-component and intensive treatment models that incorporated technology also reported favorable outcomes, particularly in combat-related presentations with high baseline severity [16,17]. The trauma management therapy program, including virtual-reality-augmented exposure elements in one randomized trial, reported greater reductions in post-traumatic stress disorder symptom severity than comparison conditions and suggested potential benefits for comorbid anger and functional outcomes in some samples [16,17]. These findings aligned with broader evidence syntheses in military populations indicating that trauma-focused psychotherapies (including prolonged exposure and the cognitive processing therapy) yielded moderate-to-large effects, while also documenting non-trivial high dropout in real-world delivery [24]. The collective pattern suggested that technology augmentation might be most clinically relevant when it strengthened retention, supported between-session practice, or increased treatment intensity without compromising safety or therapeutic alliance [16,17,24].Motion-assisted and multimodular interventions designed for treatment-resistant cases, such as interactive motion-assisted exposure therapy and multi-modular motion-assisted memory desensitization and reconsolidation, showed promising symptom reductions in veterans who had not responded to prior evidence-based care.

Although evidence remained concentrated in relatively small samples and specialized settings [18-20]. Randomized and crossover designs reported improvements on symptom scales over time and suggested potential benefits for avoidance and re-experiencing domains, which were plausible targets for immersive, embodied exposure paradigms [18,19]. These findings were consistent with a broader systematic review and meta-analysis of immersive post-traumatic stress disorder treatments that reported overall benefit of virtual reality exposure therapy and highlighted design factors (dose, comparator strength, and outcome selection) that explained variation across studies [23]. Similarly, an independent meta-analysis of virtual reality exposure therapy reported beneficial effects relative to control conditions, supporting the external coherence of the observed direction of effect in the included trials while underscoring ongoing uncertainty regarding which subgroups benefited most [22,23].

Despite the framing of "artificial intelligence-enhanced" psychological interventions, the included evidence base remained weighted toward immersive technologies (virtual reality and motion-assisted systems) rather than adaptive machine-learning personalization or conversational agents deployed specifically for post-traumatic stress disorder in military samples [11-21]. External evidence from conversational agent research in mental health indicated small-to-moderate short-term effects for depressive and anxiety symptoms (for example, pooled standardized effects around g=0.29 in several domains) and suggested that empathy, personalization, and sustained engagement were associated with larger effects; however, post-traumatic stress disorder-specific evidence and military-focused implementations were comparatively sparse [31].

Reviews of chatbots and conversational agents highlighted feasibility and acceptability in psychiatric contexts but also emphasized safety, governance, and the need for rigorous trials in high-risk groups, including trauma-exposed populations [29-31]. In parallel, internet-based and mobile cognitive and behavioral therapies for post-traumatic stress disorder demonstrated efficacy in adults, and a randomized controlled trial in the German armed forces supported the potential for scalable, digital delivery in service members when interventions were tailored to deployment-related needs [26,27]. This broader literature suggested that more explicitly "AI-driven" elements were technically plausible and empirically supported in adjacent mental health conditions, but remained under-tested for post-traumatic stress disorder outcomes in active-duty and veteran cohorts [26,27,29-31].

Several limitations constrained confidence in causal attribution and generalizability across countries and military contexts. The included trials were heterogeneous in participant characteristics (active-duty versus veteran status, chronicity, treatment resistance), intervention dose and components, and outcome measurement timing, which limited direct cross-study comparability [11-21]. Sample sizes were often modest, and some designs used active comparators that reduced detectable between-group differences, while others used less intensive controls that could inflate apparent effect sizes [11-13,18,19]. In addition, the operational definition of "artificial intelligence enhancement" varied substantially, and many interventions were better characterized as technology-enabled delivery rather than adaptive, data-driven personalization, reducing construct clarity for synthesis [11-21]. Finally, the absence of meta-analysis meant that overall pooled effects, small-study effects, and formal exploration of heterogeneity were not quantified.

The review also had important strengths. It focused on clinically relevant, technology-enabled interventions in populations with high occupational trauma exposure, and it synthesized evidence across immersive exposure formats and motion-assisted paradigms that were specifically designed to address engagement barriers and treatment resistance commonly encountered in military mental health services [11-21]. The use of controlled and randomized designs in a substantial proportion of included studies strengthened internal validity relative to uncontrolled feasibility work and the permitted interpretation of comparative effectiveness within multiple delivery formats [11-13,16-19,21]. The integration of external evidence from military psychotherapy trials, immersive-therapy meta-analyses, and digital and conversational-agent literatures supported interpretability beyond any single modality and clarified where evidence converged versus where it remained preliminary [22-27,29-31]. Overall, the evidence suggested that technology-enabled trauma-focused interventions, particularly immersive exposure and motion-assisted approaches, were associated with symptom reductions in military personnel and veterans, with the strongest signals observed when technology increased engagement, treatment intensity, or accessibility relative to comparators [11-13,16-20,21].

However, truly artificial intelligence-adaptive components (for example, machine-learning-driven personalization or conversational agents optimized for post-traumatic stress disorder) remained under-represented in military post-traumatic stress disorder trials, indicating a clear research gap despite supportive evidence in broader mental health applications [26,27,29-31]. For Saudi Arabia, these findings implied potential value in piloting culturally adapted, Arabic-language immersive and digital trauma-focused interventions within military and aligned services, coupled with rigorous evaluation of safety, engagement, and effectiveness; this was particularly relevant given documented post-traumatic stress disorder burden in Saudi emergency medical services personnel and the likelihood of similar occupational exposure profiles in other uniformed services [33].

Conclusions

Overall, this systematic review found that artificial intelligence-enabled psychological interventions, predominantly immersive virtual reality exposure formats and motion-assisted reconsolidation approaches, were associated with clinically meaningful reductions in post-traumatic stress disorder symptom severity in active-duty personnel and veterans, including treatment-resistant cases, but the strength of inference was constrained by between-study heterogeneity, variable comparators, and substantial attrition in several trials. These findings support the cautious integration of AI-enabled modalities as adjuncts or alternative delivery formats for evidence-based trauma-focused care within military health systems.

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Table 1. Characteristics and key findings of the studies included in the review on Psychological Interventions for Post-Traumatic Stress Disorder in Military Personnel using Artificial Intelligence.

Study Reference	Study Design	Population	Intervention / Exposure	Disease / Condition	Main Outcomes
[11] McLay et al., 2011	Randomised controlled trial	Active-duty personnel with combat-related post-traumatic stress disorder	Virtual reality-graded exposure therapy vs treatment as usual	Combat-related post-traumatic stress disorder	≥30% CAPS improvement: 7/10 vs 1/9; relative risk 3.2; p<0.01
[12] McLay et al., 2017	Randomised comparative-effectiveness trial	Service members with combat-related post-traumatic stress disorder	Virtual reality exposure vs control exposure therapy	Combat-related post-traumatic stress disorder	>30% CAPS improvement: 13/42 vs 16/43; no significant between-group differences
[13] Reger et al., 2016	Randomised controlled trial	Active-duty soldiers with deployment-related post-traumatic stress disorder	Prolonged exposure vs virtual reality exposure vs waitlist	Deployment-related post-traumatic stress disorder	PE and VRE reduced CAPS vs waitlist; no superiority of VRE vs PE; dropout 44% vs 41%
[14] Rothbaum et al., 2014	Double-blind placebo-controlled RCT	Iraq/Afghanistan veterans with military trauma	Virtual reality exposure + D-cycloserine or alprazolam or placebo	Post-traumatic stress disorder	Symptoms improved across groups; no D-cycloserine advantage; alprazolam worse PTSD at 3 months (82.8% vs 47.8%)
[15] Maples-Keller et al., 2019	Double-blind placebo-controlled RCT	Adults with post-traumatic stress disorder receiving virtual reality exposure	Dexamethasone vs placebo prior to virtual reality exposure therapy	Post-traumatic stress disorder	Dropout 76.9% (10/13) vs 28.5% (4/14); p=0.02; early symptom worsening signal
[16] Beidel et al., 2017	Controlled pilot cohort	OIF/OEF/OND veterans and active-duty personnel	3-week intensive Trauma Management Therapy program	Combat-related post-traumatic stress disorder	Large improvement: effect size 2.06; 65.9% no longer met diagnostic criteria post-treatment
[17] Beidel et al., 2019	Randomised controlled trial	Iraq/Afghanistan veterans and active-duty personnel	Trauma Management Therapy vs virtual reality exposure + psychoeducation	Combat-related post-traumatic stress disorder	CAPS and PCL-M decreased in both arms; social isolation decreased only with group component; gains maintained 6 months

[18] van Gelderen et al., 2020	Randomised controlled trial	Veterans with treatment-resistant post-traumatic stress disorder	3MDR vs non-specific control component	Treatment-resistant post-traumatic stress disorder	Greater PTSD reduction at endpoint; d=0.83; NNT 2.86; dropout 7%; 45% clinically improved
[19] Bisson et al., 2020	Single-blind crossover RCT	Male military veterans with treatment-resistant service-related post-traumatic stress disorder	Immediate vs delayed 3MDR (crossover)	Treatment-resistant post-traumatic stress disorder	CAPS-5 mean difference at 12 weeks: -9.38 (95% CI -17.33 to -1.44); effect size 0.65
[20] Jones et al., 2022	Mixed-methods longitudinal clinical trial	Canadian military members and veterans with combat-related TR-PTSD	Six-session 3MDR protocol	Treatment-resistant post-traumatic stress disorder	Significant improvements in CAPS-5 and PCL-5 post-treatment; also improved depression, anxiety, resilience measures
[21] Difede et al., 2022	Multisite double-blind RCT	Military personnel with combat-related post-traumatic stress disorder	Virtual reality exposure or imaginal exposure, each + D-cycloserine or placebo	Combat-related post-traumatic stress disorder	Meaningful clinical improvement in both PE and VRE; no difference between modalities; augmentation effects not primary

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