https://doi.org/10.6063/motricidade.41463

Review Article

Characteristic Signs of Overtraining Syndrome in Military Personnel: A Scoping Review of Original Studies

Short title: Overtraining Syndrome in Military: Key Signs

Francisco Lima D'Urso (https://orcid.org/0009-0006-9661-5609)[1*], Mariana Inocêncio Matos (https://orcid.org/0000-0002-2717-062X)[2,3], André Brand Bezerra Coutinho (https://orcid.org/0000-0002-3029-3022)[4], Silvio Rodrigues Marques Neto (https://orcid.org/0000-0001-5742-4646)[1,5,6], Thiago Teixeira Guimarães (https://orcid.org/0000-0001-6457-5098)[1]

[1] Stricto Sensu Graduate Program in Physical Activity Sciences – Salgado de Oliveira University (UNIVERSO), Niterói, Brazil

[2] Postgraduate Program in Exercise and Sport Sciences, Rio de Janeiro State University (UERJ), Rio de Janeiro, Brazil

[3] Department of Gymnastics, Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

[4] Biomedical Engineering Program, Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

[5] Postgraduate Program in Experimental Human Biology (BHEx), Clinical and Experimental Research Laboratory in Vascular Biology (BioVasc), Rio de Janeiro State University (UERJ), Rio de Janeiro, Brazil

[6] Postgraduate Program in Clinical and Experimental Pathophysiology (FISCLINEX), Rio de Janeiro State University (UERJ), Rio de Janeiro, Brazil

***Corresponding author:**

217 Marechal Deodoro Street, Block A, 2nd Floor, Niterói, Rio de Janeiro, Brazil – ZIP Code: 24030-060

E-mail: dursofld@gmail.com

DECLARATIONS

Conflicts of Interest:

nothing to declare.

DRAFT

Funding:

Salgado de Oliveira University.

CRediT authorship contribution statement:

Francisco Lima D'Urso: Conceptualization, Methodology, Supervision, Writing – review & editing
Mariana Inocêncio Matos: Investigation, Methodology, Data curation, Writing – original draft
André Brand Bezerra Coutinho: Formal analysis, Visualization, Supervision – review & editing
Silvio Rodrigues Marques Neto: Validation, Resources, Project administration
Thiago Teixeira Guimarães: Conceptualization, Methodology, Supervision, Project administration – review & editing

EDITORIAL INFORMATION

Received: 28 April 2025.
Accepted: 17 March 2026

Edited by:
Pedro Forte (https://orcid.org/0000-0003-0184-6780)
ISCE DOURO- Higher Institute of Education Sciences of Douro, Penafiel, Portugal

DRAFT

Abstract

This scoping review aimed to identify the main thematic areas and tools used in studies addressing signs of Overtraining Syndrome (OTS) in military personnel, and to explore the heterogeneity and applicability of these tools in operational contexts. A comprehensive search was conducted in nine databases, following the PRISMA-ScR guidelines. Original cross-sectional and experimental studies involving military populations were included. Data were categorised into thematic areas based on recurrence and similarity of outcomes and tools. From 2,633 initial records, 138 studies were included. Seventeen major thematic areas were identified, with “Mental Health,” “Fatigue Parameters,” “Physical Capacity,” and “Sleep Disturbances” being the most represented. Several tools were used to assess OTS signs; however, a lack of standardisation, particularly in the military context, was evident. Notably, most studies involved combat-exposed personnel, including active-duty service members deployed in operational environments and veterans with prior combat experience. The findings also revealed substantial conceptual overlap between trauma-related constructs and training-related maladaptation. Despite the growing interest in OTS among military personnel, the lack of standardised, validated tools for early detection remains a limitation. Developing context-specific strategies is essential to enhance monitoring, diagnosis, and prevention of OTS, especially in non-combat settings.

Keywords: Overtraining Syndrome; Military personnel; Fatigue; Psychological Stress; Performance monitoring.

DRAFT

INTRODUCTION

Overtraining Syndrome (OTS) is a maladaptive condition characterised by a persistent decline in physical performance, accompanied by psychological and physiological disturbances, that persists despite a substantial reduction in training load (Budgett, 1998; Kreher & Schwartz, 2012). OTS represents the final stage in a continuum of training stress that includes functional overreaching (FOR) and non-functional overreaching (NFOR). Functional overreaching is characterised by a temporary performance decrement followed by supercompensation after adequate recovery, whereas non-functional overreaching involves a more prolonged performance impairment without the expected performance rebound. When excessive training stress is maintained without sufficient recovery, this maladaptive process may progress to OTS, with recovery potentially requiring weeks or months (Halson & Jeukendrup, 2004; McGuigan, 2017). Recent consensus statements emphasise the importance of load–recovery balance and multidimensional monitoring in preventing maladaptive responses (Impellizzeri et al., 2019; Halson, 2019).

OTS is considered a multifactorial condition involving complex interactions between physiological, psychological, and environmental stressors. It is associated with a constellation of symptoms, including sleep disturbances, hormonal dysregulation, immunosuppression, persistent muscle soreness, anxiety, irritability, and depressive symptoms (Mackinnon, 2000; Guimarães et al., 2021; Guimarães et al., 2022). Neuroendocrine alterations, including changes in hypothalamic–pituitary–adrenal axis activity and neurotransmitter modulation — particularly serotonin — may contribute to mood alterations, fatigue perception, appetite disturbances, and sleep disruption (Rogero, Mendes & Tirapegui, 2005). Despite extensive investigation, the diagnosis of OTS remains challenging because no single biomarker or standardised diagnostic protocol has been universally validated (Urhausen & Kindermann, 2002; Tomazini, 2014). This diagnostic ambiguity complicates the differentiation between adaptive training responses, non-functional overreaching, and true OTS.

This complexity becomes particularly relevant in military populations, who are routinely exposed to high physical and cognitive demands in diverse operational contexts, including basic military training, field exercises, operational readiness activities, and combat deployment (Knapik et al., 2005; Miller et al., 2020). These environments are frequently characterised by sleep restriction, caloric deficits, environmental extremes, sustained vigilance demands, emotional strain, and limited opportunities for recovery (Lieberman et al., 2020; Miller et al., 2020; Chinoy et al., 2021). Such occupational stressors have been associated with chronic fatigue, attentional deficits, mood disturbances, impaired immune function, and increased risk of musculoskeletal injuries and infections, potentially increasing vulnerability to maladaptive training responses (Vasconcelos & Faria, 2009; Lieberman et al., 2020).

Importantly, the physiological and psychological responses expected during intense military training may overlap with early signs of non-functional overreaching and OTS, making early identification particularly difficult (Halson & Jeukendrup, 2004; Kreher & Schwartz, 2012). The absence of military-specific diagnostic criteria, combined with methodological heterogeneity across studies and variability in operational settings, further complicates the interpretation of findings and the standardisation of monitoring strategies (Guimarães et al., 2021; Impellizzeri et al., 2019).

Several approaches have been used to monitor signs suggestive of OTS in military personnel, including physiological biomarkers, performance-based assessments, subjective fatigue scales, and psychometric instruments targeting mood and well-being (Halson, 2019; Saw et al., 2017; Kellmann et al., 2018). However, the diversity of assessment tools and the lack of an integrated framework tailored to the military context limit comparability across studies and hinder the development of evidence-based monitoring protocols (Impellizzeri et al., 2019; Guimarães et al., 2022). Due to the absence of validated military-specific OTS diagnostic criteria, studies investigating multidimensional fatigue and stress-related maladaptation were also considered when aligned with the OTS continuum framework (Urhausen & Kindermann, 2002; Kreher & Schwartz, 2012).

Given these challenges, mapping the available evidence is essential to clarify which tools and indicators have been used to detect characteristic signs of OTS in military personnel and in which operational contexts (Impellizzeri et al., 2019; Kellmann et al., 2018). Therefore, this scoping review aims to systematically identify and synthesise original studies that have investigated tools and indicators associated with characteristic signs of OTS in military populations, providing a structured overview to support future research, prevention strategies, and operational health management.

It is expected that this review will reveal substantial heterogeneity in assessment approaches, highlight the absence of military-specific diagnostic frameworks, and provide a comprehensive mapping of the domains currently used to monitor maladaptation related to training stress in military personnel.

METHODS

To explore how characteristic signs of Overtraining Syndrome (OTS) have been investigated in military settings, a scoping review of original studies was conducted. This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines. The protocol was registered in the OSF Registries under the ID n4tzr (DOI: https://doi.org/10.17605/OSF.IO/N4TZR).

Search Strategy

The literature search was initially conducted in April 2023 and updated in March 2024 and January 2025. The following electronic databases were searched from inception to January 2025: National Library of Medicine (MEDLINE), SCIELO, Latin American and Caribbean Health Sciences Literature (LILACS), SCIENCE DIRECT, COCHRANE LIBRARY, EMBASE, SCOPUS, WEB OF SCIENCE, and the Physiotherapy Evidence Database (PEDro).

To identify relevant publications, the following terms were used: "Military," "Overtraining Syndrome," "Fatigue," and all related terms indexed in Medical Subject Headings (MeSH) and Health Sciences Descriptors (DeCS). Boolean operators "OR" were used to connect synonyms and "AND" to combine variables, resulting in the search phrase used in major databases: ((Military OR "Personnel, Military" OR "Military Personnel" OR "Armed Forces Personnel" OR "Personnel, Armed Forces" OR "Army Personnel" OR "Personnel, Army" OR "Navy Personnel" OR "Personnel, Navy" OR Soldiers OR Soldier OR "Air Force Personnel" OR "Personnel, Air Force" OR "Military Health" OR "Health, Military" OR "Health of Military Personnel" OR "Military Personnel Health" OR "Military Medicine" OR "Military Psychiatry" OR "Psychiatry, Military" OR "Military Science" OR "Armed Forces" OR "Military Sciences" OR "Science, Military" OR "Sciences, Military")) AND (("Overtraining Syndrome" OR "Syndrome, Overtraining" OR "Over-Training Syndrome" OR "Over Training Syndrome" OR "Syndrome, Over-Training" OR "Exercise Overtraining" OR "Overtraining, Exercise" OR Fatigue OR Lassitude))

Equivalent adaptations were applied to the databases in accordance with their indexing systems. No publication date restrictions were applied. Filters were limited to studies published in English or Portuguese. Additionally, reference lists of included articles were manually screened to identify potentially relevant studies.

Eligibility Criteria (PCC Framework)

The eligibility criteria were structured according to the PCC framework recommended for scoping reviews:

Population (P) - Active military personnel undergoing training, operational readiness activities, field exercises, or deployment.

Concept (C) - Assessment of physical and/or psychological features, biomarkers, performance indicators, or monitoring tools associated with overtraining syndrome, non-functional overreaching, or maladaptive fatigue responses.

Context (C) - Military training or operational environments.

Inclusion Criteria:

1. Original cross-sectional, longitudinal, or experimental studies;
2. Studies involving military personnel;
3. Studies evaluating indicators potentially related to OTS or maladaptive training responses.

Exclusion Criteria:

1. Articles not published in English or Portuguese;
2. Animal studies;
3. Review articles, editorials, commentaries, or case reports.

Study Selection

All identified records were imported into Rayyan software for duplicate removal. Two independent reviewers screened titles and abstracts for eligibility. Potentially relevant articles were assessed in full text. Disagreements were resolved through discussion or consultation with a third reviewer. The study selection process is presented in a PRISMA-ScR flow diagram.

DRAFT

Data Extraction

Data were independently extracted by two reviewers using a standardised data extraction form developed for this review. The following information was collected: Author and year of publication; Country; Study design; Sample characteristics; Military context; Assessment tools used; Main outcomes related to signs of OTS. Discrepancies were resolved by consensus.

Data Synthesis

Given the heterogeneity of study designs and outcome measures, a quantitative synthesis was not feasible. Therefore, findings were summarised descriptively using a narrative synthesis approach.

Studies were grouped according to the type of assessment tool employed (e.g., physiological markers, performance tests, subjective fatigue scales, psychometric instruments), enabling the identification of methodological trends and patterns across different military contexts.

Following data extraction, variables and assessment tools were grouped using an inductive thematic analysis approach. Categories were not predefined but were derived from the data based on conceptual similarity and frequency of occurrence. Two reviewers independently performed the grouping process, and discrepancies were resolved through consensus.

DRAFT

RESULTS

A total of 2,633 records were identified through database searches: 690 from MEDLINE, 18 from SCIELO, 22 from LILACS, 308 from ScienceDirect, 184 from the Cochrane Library, 1,170 from Embase, 141 from Scopus, 99 from Web of Science, and 1 from PEDro.

After removal of 1,044 duplicate records, 1,589 studies remained for screening. Following title and abstract screening, 1,443 studies were excluded for the following reasons: outside the scope of interest (n = 864), non-original study design (n = 307), outcomes unrelated to OTS (n = 134), non-military samples (n = 114), and language restrictions (n = 24). Full-text assessment resulted in the exclusion of eight additional studies (six due to inaccessible full texts and two due to inconsistency with the review scope). Ultimately, 138 original studies were included in the final synthesis (Figure 1).

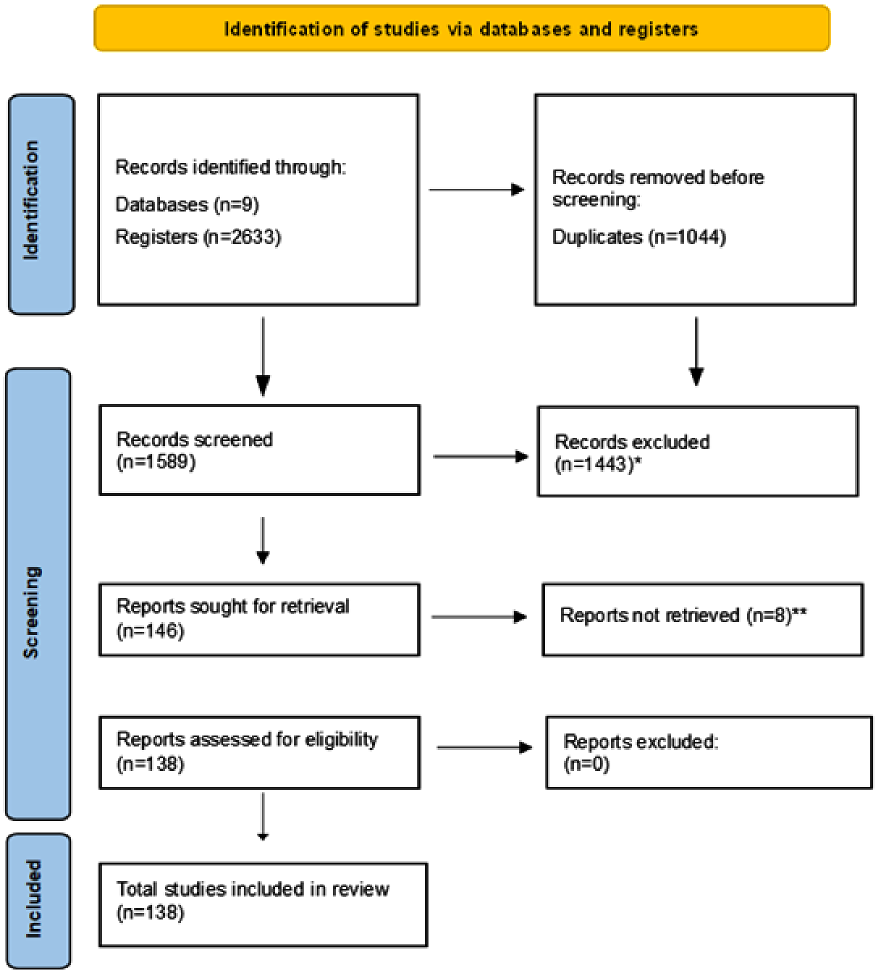

Figure 1. PRISMA flow diagram of included studies (2020). *: studies not related to the topic or systematic reviews; **: studies for which full-text access was not obtained or with inconsistent results.

The extracted methodological data from the included studies were analysed using an inductive thematic grouping process. Variables and assessment tools reported in the studies were initially extracted and then grouped according to conceptual similarity and recurrence across studies. This process resulted in the identification of 17 thematic categories (hereafter referred to as "major areas") representing domains in which signs potentially associated with OTS were evaluated.

The categorisation process was conducted independently by two reviewers, with discrepancies resolved through discussion to ensure conceptual consistency.

The 17 major areas identified were: Mental Health, Fatigue Parameters, Physical Capacity, Sleep Disturbances, Self-reported health, Blood Parameters, Physiological

Parameters, Workload, Cognitive Responses, Hormonal Parameters, Memory Parameters, Body composition, Welfare State, Pain Parameters, Dehydration Parameters, Temperature Parameters and Operational performance.

Figure 2 presents a schematic representation of the 17 major areas, illustrating the frequency with which each domain was assessed across the included studies and the specific variables evaluated within each category. To improve clarity, the figure organises the thematic areas hierarchically and highlights the most frequently investigated domains. Given the multidimensional fragmentation observed in the literature, this schematic model was intentionally designed to visually integrate domains that are otherwise reported in isolation. Table 1 summarises the main assessment tools used across the included studies, organised by the 17 thematic areas. This synthesis enables visualisation of methodological diversity and identifies the most commonly used instruments in military contexts.

DRAFT

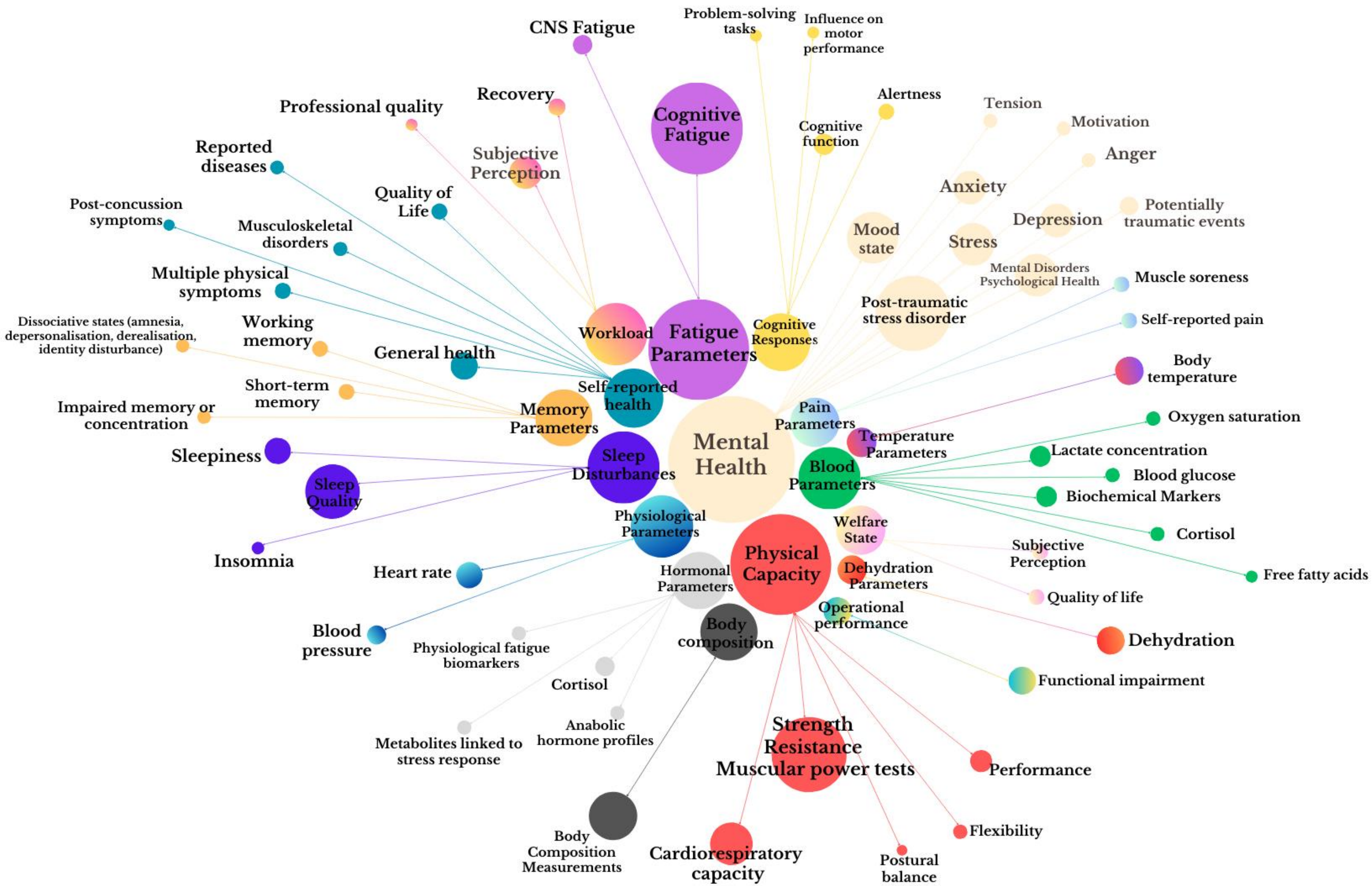

Figure 2. Schematic model of the categorisation of major thematic areas and the factors analysed in studies on signs of Overtraining Syndrome (OTS) in military personnel.

Table 1. Tools used to assess signs of Overtraining Syndrome (OTS) in military personnel, according to the major thematic areas.

	Major Thematic Areas	Analysed Factors	Assessment Tools	Studies
1	**Mental Health (n=120)**	Post-traumatic stress disorder (PTSD) (n=32)	Self-Rating Inventory for PTSD (SRIP)	7
			Posttraumatic Stress Disorder Checklist (PCL-C)	7
			PTSD Checklist-Military Version	4
			17- item National Centre for PTSD checklist	4
			PTSD Symptom Scale (PSS)	2
			Mississippi scale	2
			Response to Traumatic Event Scale (RTES)	1
			Primary Care PTSD (PC-PTSD) Screen	1
			Davidson Trauma Scale (DTS)	1
			PTSD Checklist for DSM-5 (PCL5)	1
			RAND Short Form 36 item Health survey (SF-36)	1
			Expanded Combat Exposure Scale	1
		Mood state (n=21)	Profile of Mood States (POMS)	21
		Stress (n=17)	Perceived Stress Scale (PSS)	3
			Short Recovery Stress Scale (SRSS)	3
			Inventário de Sintomas de Stress para Adultos de Lipp (ISSL)	2
			13-item checklist	2
			National Aeronautics and Space Administration task load index (NASA TLX)	2
			Brums (Brunel Mood Scale)	1
			Depression Anxiety and Stress Scale (DASS)-21	1
			Psychiatric Epidemiology Research Interview Life Events Scale – Brief	1
			Stress subjective perception (SSP)	1
			Cox –Mackay Stress Arousal Checklist (SACL)	1
		Mental Disorders Psychological Health (n=17)	General Health Questionnaire 12 (GHQ-12)	9
			Symptom Checklist (SCL-90)	2
			Acceptance and Action Questionnaire- AAQ-II	1
			Questionário (não especificado)	1
			Neuropsychological experiments (Stroop, Flanker, Go NoGo, Task Switch)	1
			Global Severity Index of the Brief Symptom Inventory	1
			Minnesota Multiphasic Personality Inventory-2 Hypochondriasis and Hysteria subscales (MMPI-2)	1
			Patient Heath Questionnaire (PHQ)	1
		Anxiety(n=14)	State-Trait Anxiety Inventory– Trait (STAI-T)	3
			Beck Anxiety Inventory	2
			Symptom Checklist (SCL-90)	2
			Generalized Anxiety Disorder Screener (GAD-7)	1
			Depression Anxiety and Stress Scale (DASS)-21	1
			Schedules for Clinical Assessment in Neuropsychiatry 2.1 (SCAN 2.1)	1
			face-to-face interview with psychologists	1
			Profile of Mood States (POMS)	1
			CSAI-2R self-evaluation questionnaire	1

DRAFT

	Major Thematic Areas	Analysed Factors	Assessment Tools	Studies
			9-item PHQ depression scale (PHQ-9)	1
		Depression (n=13)	Symptom Checklist (SCL-90-R)	5
			Beck's Depression Inventory	3
			Schedules for Clinical Assessment in Neuropsychiatry 2.1 (SCAN 2.1)	1
			Quick Inventory of Depressive Symptomatology (QIDS) questionnaire	1
			Center for Epidemiologic Studies Depression Scale (CES-D)	1
			Depression Anxiety and Stress Scale (DASS)-21	1
			9-item PHQ depression scale (PHQ-9)	1
		Potentially traumatic events (n=3)	Brief Trauma Questionnaire (BTQ)	2
			27-item short-form self-report Early Trauma Inventory (ETI)	1
		Anger (n=1)	State Trait Anger Expression Inventory State Anger Scale	1
		Motivation (n=1)	Escala Analógica Visual para mudanças no humor e ativação subjetiva	1
		Tension (n=1)	Profile of Mood States (POMS)	1
2	**Fatigue Parameters (n=58)**	Cognitive Fatigue (n=56)	Multidimensional Fatigue Inventory (MFI)	11
			Checklist of Individual Strength (CIS)	8
			Chalder Fatigue Scale	5
			Fatigue Assessment Scale	4
			Semi-structured interview	4
			Samn-Perelli Fatigue Scale	3
			Fatigue Severity Scale [FSS]	3
			Rating Perceived Exertion (RPE) / Fatigue subjective perception (FSP)	3
			Visual Analogue Scale to Measure Fatigue (VAS-F)	2
			NASA Task Load Index (NASA-TLX)	2
			Reaction time test (RT) and Tapping test (TT)	2
			Schedules for Clinical Assessment in Neuropsychiatry 2.1 (SCAN 2.1)	1
			Piper Fatigue Scale	1
			Profile of Mood States (POMS)	1
			Short Recovery Stress Scale (SRSS)	1
			Dutch 20-item Checklist Individual Strength (CIS20R)	1
			London Fibromyalgia Epidemiology Study Screening Instrument 6-item Questionnaire (LFESSQ-6)	1
			Fatigue Avoidance Scheduling Tool (FAST)	1
			Critical Stability Task (CST) Dual Task	1
			Rating-of-Fatigue (RoF) Scale	1
		Central Nervous System Fatigue(n=2)	Lafayette Instrument Flicker Fusion Control Unit	2
3	**Physical Capacity (n=58)**	Strength Resistance Muscular power tests (n=32)	Dynamometer	10
			Countermovement jump (CMJ)	6
			Electromyography (EMG) signals	5
			Maximum press-ups / Maximum curl-ups / Maximum quadriceps force	4
			Dynamometry	2
			Digital Myometer	2
			Horizontal Jump Test	1
			Maximal dynamic lift strength (MDLS)	1

DRAFT

	Major Thematic Areas	Analysed Factors	Assessment Tools	Studies
			Drop jump testing - Portable force plate	1
		Cardiorespiratory Capacity (n=19)	Maximal Incremental Treadmill Protocol	4
			stepping (40-cm platform for 3 minutes)	2
			progressive running test protocol	2
			Submaximal Marching Test	2
			2.4-km time-trial run	2
			cycle ergometre	1
			20-m shuttle run test	1
			The University of Montreal maximal multistage running track test	1
			Bruce protocol (American College of Sports Medicine)	1
			40-m sprint test	1
			3,000-m run	1
			maximal-effort 2,000-m run	1
		Performance (n=4)	Israel Defence Force fitness test	1
			2Km run	1
			four-choice reaction time	1
			Wall-building test, Grenade throwing, Stretching and Aerobic exercise, an Obstacle course, a Box lift exercise, Squat jumps, and Bench throws	1
		Flexibility (n=2)	The Coping Flexibility Scale	1
			Sit and Reach Trunk Flexibility Test Box	1
		Postural balance (n=1)	Force platform	1
4	**Sleep Disturbances (n=43)**	Sleep Quality (n=29)	ActiGraph	10
			Pittsburgh Sleep Quality Index (PSQI)	5
			5-point Likert scale	3
			Basic Nordic Sleep Questionnaire	3
			Actiwatch Spectrum	2
			Insomnia Severity Index	2
			apneahypopnea index (AHI)	2
			Fatigue Avoidance Scheduling Tool (FAST)	2
		Sleepiness (n=11)	Stanford Sleepiness Scale (SSS)	5
			Epworth Sleepiness Scale (ESS)	4
			ANAM Sleepiness Scale	1
			Karolinska 9-point scale questionnaire	1
		Insomnia (n=3)	Symptom Checklist (SCL-90-R)	3
5	**Self-reported health (n=26)**	General health (n=14)	36-item Short Form Health Survey (SF–36)	6
			Current Illness Checklist (CIC)	4
			Patient Health Questionnaire-9 (PHQ-9)	3
			12-item short-form health survey (SF-12)	1
		Multiple physical symptoms (n=4)	checklist of 50 non-specific symptoms / Rotterdam Symptom Checklist (RSCL) / Hopkins Symptom Checklist	3
			Environmental Symptoms Questionnaire (ESQ)	1
		Quality of life (n=4)	RAND 36-Item Health Survey (RAND-36)	2
			TBI-Quality of Life (TBI-QOL)	1

DRAFT

	Major Thematic Areas	Analysed Factors	Assessment Tools	Studies
			12-item Short-Form Health Survey (SF-12)	1
		Musculoskeletal disorders (n=3)	Medical Outcomes Study Short-Form-36 physical functioning subscale (SF-36 PF)	2
			Nordic Musculoskeletal Symptom Questionnaire	1
		Post-concussion symptoms (n=1)	Neurobehavioral Symptom Inventory (NSI)	1
6	**Blood Parameters (n=23)**	Lactate concentration (n=7)	Blood sample	6
			portable lactate analyzer	1
		Biochemical Markers (n=7)	Blood sample	7
		Blood glucose (n=4)	Blood sample	3
			Glucometer	1
		Oxygen saturation (n=2)	pulsioximeter	2
		Cortisol (n=2)	Blood sample	2
		Free fatty acids (n=1)	Blood sample	1
7	**Physiological Parameters (n=23)**	Heart rate (n=20)	HR monitor	12
			Electrocardiographic (ECG)	4
			Pulse oximeter	4
		Blood pressure (n=3)	Sphygmomanometer	3
8	**Workload (n=20)**	Subjective Perception (n=17)	Rating of Perceived Exertion (RPE)	16
			NASA Task Load Index (NASA-TLX)	1
		Recovery (n=2)	Short Recovery Stress Scale	2
		Professional quality (n=1)	Professional Quality of Life Scale (ProQOL-IV)	1
9	**Cognitive Responses (n=14)**	Cognitive function (n=8)	Attention concentration test (ACT)	2
			Psychomotor Vigilance Test (PVT)	1
			Task-Switching Test (TST)	1
			Visual Vigilance test	1
			Flight Fit (FF) cognitive test battery	1
			Paper-and-pencil tests	1
			Rotary Pursuit Test	1
		Alertness (n=4)	Psychomotor Vigilance Task (PVT)	2
			Attention Network Test (ANT)	1
			Visual vigilance	1
		Influence on motor performance (n=1)	Tapping test	1
		Problem-solving tasks (n=1)	10 "water jug" problems	1
10	**Hormonal Parameters (n=11)**	Cortisol (n=6)	saliva samples	5
			urine samples	1
		Physiological fatigue biomarkers (n=3)	urinalysis and blood tests	2
			saliva samples	1
		Anabolic hormone profile (n=1)	saliva samples	1
		Metabolites linked to stress response (n=1)	saliva samples	1
11	**Memory Parameters (n=10)**	Short-term memory (n=4)	Matching-to-Sample Test	2
			Delayed Matching-to-Sample (dMTS)	1
			Repeated Acquisition Test	1

DRAFT

	Major Thematic Areas	Analysed Factors	Assessment Tools	Studies
		Working memory (n=3)	N-back (task)	3
		Impaired memory or concentration (n=2)	Schedules for Clinical Assessment in Neuropsychiatry 2.1 (SCAN 2.1)	1
			Delayed Matching-to-Sample (dMTS)	1
		Dissociative states (amnesia, depersonalisation, derealisation, identity disturbance) (n=1)	Clinician-Administered Dissociative States Scale (CADSS)	1
12	**Body composition (n=10)**	Body Composition Measurements (n=10)	Bioimpedance	4
			Height, weight, waist and hip circumferences	2
			Dual-energy x-ray absorptiometry (DEXA)	2
			Calibrated electronic scale	1
			Tanita BC-545N Body Composition Monitor	1
13	**Welfare State (n=6)**	Subjective Perception (n=3)	Multi-Component Training Distress Scale (MTDS)	2
			Psychological wellbeing questionnaire - Hooper and Mackinnon (1995)	1
		Quality of life (n=3)	Short-Form SF-12v2	2
			General Health Questionnaire-12 (GHQ-12)	1
14	**Pain Parameters (n=6)**	Muscle soreness (n=3)	Schedules for Clinical Assessment in Neuropsychiatry 2.1 (SCAN 2.1)	3
		Self-reported pain (n=3)	Defense and Veterans Pain Rating Scale (DVPRS)	1
			London Fibromyalgia Epidemiology Study Screening Instrument 6-item Questionnaire (LFESSQ-6)	1
			Numerical Pain Rating Scale (NPRS)	1
15	**Dehydration Parameters (n=4)**	Dehydration (n=4)	Bioimpedance	2
			Weight loss	1
			Urine samples	1
16	**Temperature Parameters (n=4)**	Body temperature (n=4)	Digital infrared thermometer	4
17	**Operational performance (n=3)**	Functional impairment (n=3)	RAND Short Form 36 item Health survey (SF-36)	2
			mental health composite score (MCS)	1

DRAFT

DISCUSSION

This scoping review systematically mapped 138 original studies investigating indicators potentially associated with Overtraining Syndrome (OTS) in military populations. Beyond cataloguing assessment tools and thematic domains, the findings reveal a field marked by conceptual ambiguity, methodological fragmentation, and limited integration across physiological, psychological, and operational dimensions, a pattern previously described in the literature on OTS and training load monitoring (Urhausen & Kindermann, 2002; Kreher & Schwartz, 2012; Guimarães et al., 2021; Impellizzeri et al., 2019). Collectively, these features hinder the establishment of coherent, military-specific frameworks for early detection and prevention of maladaptive stress responses (Kellmann et al., 2018).

A striking finding was the overwhelming predominance of mental health–related domains (n = 120), particularly PTSD (n = 32). PTSD is a trauma-induced psychiatric disorder linked to exposure to life-threatening events (Hoge et al., 2004; Stein et al., 2012; Friedman, 2013), and is frequently investigated in military populations exposed to high operational stress (Lieberman et al., 2020). Its prominence within the OTS literature raises a fundamental conceptual issue: whether military studies are in fact investigating OTS itself or primarily examining trauma-related psychopathology within a broader fatigue or stress-related framework.

OTS is traditionally conceptualised as a maladaptive response to chronic imbalance between training load and recovery, positioned at the extreme end of the functional overreaching → non-functional overreaching → OTS continuum (Halson & Jeukendrup, 2004; Kreher & Schwartz, 2012; Guimarães et al., 2021). While psychological stress undoubtedly contributes to this trajectory, PTSD constitutes a distinct diagnostic entity with different etiological mechanisms. The conflation or parallel investigation of these constructs without explicit differentiation may reflect the unique stress ecology of military environments — where physical overload, sleep restriction, operational uncertainty, and emotional trauma coexist (Lieberman et al., 2020; Miller et al., 2020). However, without clear conceptual boundaries, the specificity of OTS as a performance-related syndrome risks dilution.

Moreover, the extensive heterogeneity of psychometric instruments used to assess PTSD and mood states (e.g., SRIP, PCL-C, POMS) underscores the absence of standardised monitoring approaches. In sport science, mood disturbance profiles have long been considered sensitive markers of non-functional overreaching (Halson, 2019; Kellmann et al., 2018). Yet, within military studies, psychological assessments were rarely embedded in multidimensional frameworks integrating performance decline and physiological dysregulation, despite

DRAFT

recommendations for combined monitoring approaches (Saw et al., 2017; Impellizzeri et al., 2019). These methodological siloing limits interpretative depth and diagnostic precision.

Sleep disturbance and fatigue emerged as highly recurrent themes, reflecting the intrinsic sleep disruption associated with military operations. Evidence consistently demonstrates that sleep restriction impairs vigilance, cognitive flexibility, reaction time, and emotional regulation — all critical to operational readiness (Halson, 2014; Miller et al., 2020; Chinoy et al., 2021). From a mechanistic perspective, chronic sleep loss may act both as a precipitating factor and as a perpetuating mechanism in maladaptive stress responses. Elevated sympathetic activity, hormonal dysregulation, and inflammatory alterations associated with sleep deprivation overlap with physiological changes observed in OTS (Mackinnon, 2000; Rogero et al., 2005; Guimarães et al., 2021). Despite this plausible mechanistic convergence, the reviewed literature rarely adopted longitudinal designs capable of disentangling cumulative sleep debt, training load progression, and performance decrement.

The absence of structured sleep–load interaction models represents a critical gap. Without systematic monitoring of recovery status, differentiating adaptive overload from pathological maladaptation becomes conceptually and practically difficult (Kellmann et al., 2018; Impellizzeri et al., 2019). This limitation is particularly relevant in military settings, where exposure to multiple concurrent stressors may accelerate the transition from functional adaptation to maladaptation.

Physical capacity was addressed in 49 studies, underscoring its recognised importance to operational performance. Adequate conditioning is associated with lower injury risk and improved mission effectiveness (Knapik et al., 2005; Sharp et al., 2002). However, the predominance of laboratory-based assessments, such as dynamometry and maximal aerobic testing, reveals a disconnect between evaluative protocols and real-world operational demands (Ikonen et al., 2020). Military tasks frequently involve load carriage, environmental extremes, cognitive strain, and sustained unpredictability, conditions that are not fully reproduced in controlled testing environments. The limited use of military-specific performance tests, with only one study employing the Israel Defence Forces Fitness Test (Hoffman, 1997), suggests insufficient ecological validity in current monitoring practices.

This methodological limitation is not trivial, as OTS is defined by a persistent decline in performance. When performance is assessed using decontextualised laboratory metrics, subtle yet operationally meaningful impairments may go undetected. Consequently, the lack of context-sensitive performance measures may contribute to the difficulty in identifying early signs of maladaptation in military populations.

DRAFT

Although 17 thematic areas were identified, most domains were explored in isolation rather than within integrative models. Biomarkers, autonomic indices, hormonal markers, immunological variables, cognitive performance, recovery indices, and body composition were inconsistently evaluated and rarely combined. This finding is consistent with previous literature describing OTS as a multidimensional condition involving neuroendocrine, immunological, psychological, and performance-related components (Urhausen & Kindermann, 2002; Kreher & Schwartz, 2012; Guimarães et al., 2022). The scarcity of longitudinal and multidomain monitoring frameworks severely constrains causal inference, limiting the ability to map progression along the overtraining continuum, contributing to the absence of validated, military-specific diagnostic criteria.

Another salient finding concerns the predominance of combat-exposed samples. While such contexts represent extreme stress models, they may not reflect the broader spectrum of military service, particularly in countries where direct combat exposure is limited. Differences in operational profile, mission type, and training routines may substantially influence the magnitude and duration of stress exposure (Vasconcelos & Faria, 2009). In contexts such as Brazil, where armed forces primarily engage in training, public safety, and logistical missions, the stress profile differs substantially, and extrapolating findings from combat veteran populations to non-combat military cohorts therefore requires caution. The current literature thus reflects both contextual concentration and population bias, highlighting the need for diversified operational sampling.

Taken together, the patterns observed across the 17 thematic areas identified in this review support the need to reconceptualise OTS assessment in military populations within an integrated stress–recovery paradigm. Such a model should incorporate objective performance decline, psychometric monitoring, sleep quantity and quality metrics, hormonal and autonomic markers, and operationally valid field simulations (Kellmann et al., 2018; Halson, 2019; Impellizzeri et al., 2019; Saw et al., 2017). Technological advances, including wearable physiological monitoring systems, load-tracking algorithms, and simulation-based performance testing, may enhance ecological validity and predictive capacity in operational environments (Lieberman et al., 2020).

Importantly, prevention strategies should prioritise early detection of non-functional overreaching before it progresses to chronic maladaptation. Establishing standardised, context-sensitive protocols may contribute not only to individual health preservation but also to operational sustainability and force readiness.

Strengths and Limitations

This review adhered to PRISMA-ScR guidelines and included a substantial body of original research, offering a comprehensive mapping of methodological trends. Nevertheless, restricting inclusion to English and Portuguese publications may have excluded relevant data. Furthermore, heterogeneity in design, measurement, and conceptual definitions limited cross-study comparability and precluded quantitative synthesis.

Despite these constraints, the present synthesis illuminates structural weaknesses in the field and provides a strategic roadmap for advancing OTS research within military contexts.

Final considerations

This scoping review provides a comprehensive mapping of 138 original studies investigating domains and tools potentially associated with signs of Overtraining Syndrome (OTS) in military populations. The synthesis reveals a field characterised by methodological heterogeneity, conceptual ambiguity, and a predominance of psychological and trauma-related constructs, particularly PTSD, often investigated alongside—but not clearly distinguished from—training-related maladaptation.

Although OTS has been extensively examined in athletic populations, the military environment presents a substantially different stress ecology. Operational stressors—such as sleep restriction, load carriage, environmental extremes, prolonged vigilance, and exposure to trauma—interact in ways that extend beyond conventional sport-based overtraining models. Consequently, direct transposition of sport-derived assessment tools to military contexts appears insufficient without contextual adaptation and validation.

The 17 thematic areas identified in this review illustrate the multidimensional nature of stress responses in military personnel. However, the fragmented manner in which these domains have been investigated—typically in isolation rather than through integrated monitoring systems—limits the development of standardised diagnostic pathways. Notably, few studies adopted longitudinal or multidomain approaches capable of distinguishing adaptive overload from non-functional overreaching or progression toward OTS (Saw et al., 2017; Kellmann et al., 2018; Gabbett et al., 2020).

Further critical consideration concerns operational context. The majority of included studies focused on combat-exposed populations, which may not reflect the physiological and psychological demands experienced by personnel engaged in routine training, peacekeeping missions, or administrative roles. Differences in exposure intensity and stress chronicity likely influence maladaptive trajectories, reinforcing the need for context-sensitive assessment frameworks.

DRAFT

An additional observation emerging from this synthesis is the apparent growth of research interest in fatigue, stress monitoring, and mental health in military populations over recent decades. However, this expansion has not yet translated into consensus-based diagnostic criteria or validated, military-specific monitoring protocols.

Future research should prioritise the development and validation of multidimensional assessment models that integrate objective performance decline, psychometric and mood profiling, sleep quantity and quality monitoring, physiological and hormonal markers and field-based operational simulations.

Such integrative frameworks would provide a more ecologically valid representation of stress–recovery balance and enhance early identification of maladaptive responses.

CONCLUSIONS

This scoping review sought to systematically identify and synthesise the main tools used to detect signs potentially associated with Overtraining Syndrome in military populations and to explore the heterogeneity and applicability of these tools in operational contexts. The findings demonstrate that, despite considerable research activity, the field remains structurally fragmented and lacks standardised, military-specific diagnostic strategies.

The central conclusion is not merely that standardisation is absent, but that current approaches often fail to clearly differentiate trauma-related psychiatric conditions, chronic occupational stress, and performance-related maladaptation along the functional overreaching → non-functional overreaching → OTS continuum.

To advance the field, future efforts must move beyond isolated measurement of psychological or physiological variables and toward integrated, context-sensitive monitoring systems that capture the complex stress ecology inherent in military service. Establishing operationally valid, multidimensional, and longitudinal assessment frameworks represents a critical step toward improving early detection, safeguarding service member health, and sustaining operational readiness.

Recognising OTS in military settings is therefore not an endpoint but a starting point for the systematic development of tailored diagnostic criteria, validated instruments, and preventive strategies aligned with the distinct realities of combat and non-combat environments.

REFERENCES

Budgett, R. (1998). Fatigue and underperformance in athletes: The overtraining syndrome. *British Journal of Sports Medicine, 32*(2), 107–110. https://doi.org/10.1136/bjsm.32.2.107

Chinoy, E. D., Cuellar, J. S., Huwa, K. E., Jameson, J. A., & Belenky, G. (2021). Performance impairment associated with sleep restriction and circadian misalignment: A meta-analysis. *Sleep, 44*(6), zsaa272. https://doi.org/10.1093/sleep/zsaa272

DRAFT

Friedman, M. J. (2013). Finalizing PTSD in DSM-5: Getting here from there and where to go next. *Journal of Traumatic Stress, 26*(5), 548–556. https://doi.org/10.1002/jts.21840

Gabbett, T. J., Hulin, B. T., Blanch, P., & Whiteley, R. (2020). High-training workloads alone do not cause sports injuries: How you get there matters. *British Journal of Sports Medicine, 54*(4), 215–217. https://doi.org/10.1136/bjsports-2019-100892

Guimarães, T. R., Paes, R. R. L., de Oliveira, L. F., & Tirapegui, J. (2021). Overtraining syndrome: Pathophysiological mechanisms and emerging diagnostic approaches. *Journal of Sport and Health Science, 10*(2), 123–130. https://doi.org/10.1016/j.jshs.2020.07.005

Guimarães, T. R., Soares, A. B., & Pereira, A. B. (2022). Multidimensional assessment of training stress in athletic and tactical populations. *Frontiers in Physiology, 13*, 890123. https://doi.org/10.3389/fphys.2022.890123

Halson, S. L. (2019). Monitoring training load to understand fatigue in athletes. *Sports Medicine, 49* (Suppl 2), 29–39. https://doi.org/10.1007/s40279-019-01142-0

Halson, S. L. (2014). Sleep in elite athletes and nutritional interventions to enhance sleep. *Sports Medicine, 44*(Suppl 1), S13–S23. https://doi.org/10.1007/s40279-014-0147-0

Halson, S. L., & Jeukendrup, A. E. (2004). Does overtraining exist? An analysis of overreaching and overtraining research. *Sports Medicine, 34*(14), 967–981. https://doi.org/10.2165/00007256-200434140-00003

Hoffman, J. R. (1997). The relationship between aerobic fitness and recovery from high-intensity exercise in infantry soldiers. *Military Medicine, 162*(7), 484–488. https://doi.org/10.1093/milmed/162.7.484

Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *New England Journal of Medicine, 351*(1), 13–22. https://doi.org/10.1056/NEJMoa040603

Ikonen, A. O., Walker, S., Marras, T., & Häkkinen, K. (2020). Physical fitness profiles and performance predictors in military personnel. *Military Medicine, 185*(11–12), e1985–e1992. https://doi.org/10.1093/milmed/usaa096

Impellizzeri, F. M., Tenan, M. S., & Meyer, T. (2019). Load-management in elite sport: Theory and practice. *International Journal of Sports Physiology and Performance, 14*(3), 210–216. https://doi.org/10.1123/ijspp.2019-0031

Kellmann, M., Bertollo, M., Bosquet, L., Brink, M., Coutts, A. J., Duffield, R., & Meeusen, R. (2018). Recovery and performance in sport: Consensus statement. *International Journal of Sports Physiology and Performance, 13*(2), 240–245. https://doi.org/10.1123/ijspp.2017-0759

Knapik, J. J., Sharp, M. A., Canham-Chervak, M., Hauret, K. G., Patton, J. F., & Jones, B. H. (2005). Epidemiology of exertion injuries among men and women in Basic Combat Training. *Medicine & Science in Sports & Exercise, 37*(8), 1365–1372. https://doi.org/10.1249/01.mss.0000170061.34045.88

Kreher, J. B., & Schwartz, J. B. (2012). Overtraining syndrome: A practical guide. *Sports Health, 4*(2), 128–138. https://doi.org/10.1177/1941738111434406

Lieberman, H. R., Shukitt-Hale, B., & Beaily, J. S. (2020). Effects of stress on cognitive and physical performance in military populations: A review. *Military Medicine, 185*(Supplement_1), 335–351. https://doi.org/10.1093/milmed/usz331

Mackinnon, L. T. (2000). Overtraining effects on immunity and performance in athletes. *Immunology and Cell Biology, 78*(5), 502–509. https://doi.org/10.1046/j.1440-1711.2000.00931.x

McGuigan, M. (2017). *Monitoring training and performance in athletes*. Champaign, IL: Human Kinetics..

Miller, K. E., Patil, S. K., & de Zambotti, M. (2020). Sleep, circadian rhythms, and performance in military operations: A systematic review. *Sleep Medicine Reviews, 53*, 101308. https://doi.org/10.1016/j.smrv.2020.101308

Mysliwiec, V., McGraw, L., Pierce, R. J., Reddy, R., & Ross, R. (2013). Sleep disorders in US military personnel: A high rate of comorbid insomnia and obstructive sleep apnea. *Chest, 144*(2), 549–557. https://doi.org/10.1378/chest.13-0614

Rogero, M. M., Mendes, R. R., & Tirapegui, J. (2005). Neuroendocrine and nutritional aspects of overtraining syndrome. *Journal of Sports Medicine and Physical Fitness, 45*(4), 453–461.

Saw, A. E., Main, L. C., & Gastin, P. B. (2017). Monitoring athletes through self-report: Factors influencing implementation and interpretation. *Journal of Sports Science & Medicine, 16*(4), 565–577. PMCID: PMC5683899

DRAFT

Sharp, M. A., Patton, J. F., Knapik, J. J., Hauret, K., Mello, R. P., Ito, M., & Jones, B. H. (2002). Comparison of the physical fitness of men and women in the U.S. Army. *Medicine & Science in Sports & Exercise, 34*(3), 432–437. https://doi.org/10.1097/00005768-200203000-00011

Stein, D. J., Koenen, K. C., Friedman, M. J., & McLaughlin, K. A. (2012). Dissociation and posttraumatic stress disorder: Evidence from the World Mental Health Surveys. *American Journal of Psychiatry, 169*(8), 808–817. https://doi.org/10.1176/appi.ajp.2012.11091468

Tomazini, F. (2014). Overtraining syndrome: Physiological and biochemical aspects. *Revista Brasileira de Medicina do Esporte, 20*(6), 497–503. https://doi.org/10.1590/1517-86922014200602061

Urhausen, A., & Kindermann, W. (2002). Diagnosis of overtraining: What tools do we have? *Sports Medicine, 32*(2), 95–102. https://doi.org/10.2165/00007256-200232020-00002

Vasconcelos, A. C., & Faria, A. F. (2009). Occupational stress and performance in military training: A review. *Journal of Military and Veterans' Health, 17*(4), 25–31.

DRAFT