

REVIEW

Operational Cardiology in the Military Population: Cardiovascular Risk Assessment and Implications for Mission Fitness

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Abstract: Introduction: Operational cardiology is an emerging field of military medicine focused on cardiovascular risk assessment and maintaining mission fitness. Military activities involve intense physical exertion, operational stress, sleep deprivation, and occupational exposures that can trigger acute cardiovascular events, including in apparently healthy individuals. The aim of this review is to synthesize data on cardiovascular risk in the military population and its implications for determining mission fitness. Materials and Methods: This review included 52 studies published between 2000 and 2026, identified in PubMed/MEDLINE, Web of Science, and Scopus. The papers were analyzed thematically: cardiovascular epidemiology, sudden cardiac death, specific risk factors, impact of exertion and operational stress, cardiovascular screening, and physiological monitoring. Results: Cardiovascular events occur predominantly during intense exertion and are frequently associated with previously undiagnosed pathology. Traditional risk factors coexist with operational stressors, increasing cardiovascular load. Cardiovascular screening and cardiorespiratory fitness assessment allow risk stratification and identification of overload. Conclusions: Integration of cardiovascular screening, fitness assessment, and physiological monitoring may reduce the risk of cardiovascular events and optimize operational safety. Standardized protocols adapted to the military environment are needed.

Keywords: operational cardiology; military personnel; cardiovascular risk; mission fitness; sudden cardiac death; cardiovascular screening; military physical exertion; operational stress; heart rate variability; cardiorespiratory fitness; physiological monitoring; military medicine.

INTRODUCTION

Operational cardiology represents an emerging field at the intersection of cardiovascular, occupational, and military medicine, with the primary objective of maintaining the operational capability of military personnel through the prevention, identification, and management of cardiovascular risk [1]. Unlike classical cardiology, which is predominantly oriented toward long-term prevention, operational cardiology focuses on the immediate risk of acute incapacitating events that may compromise individual safety and mission success.

The specific characteristics of military activities involve exposure to intense physical exertion, extreme environmental conditions, hypoxia, acute and chronic psychological stress, as well as sleep deprivation—factors that may exacerbate underlying cardiovascular pathology or trigger acute events even in apparently healthy individuals [6,7]. In this context, cardiovascular risk assessment in the military population becomes strategically important, extending beyond preventive medicine and integrating into the concept of “fitness for duty.”

Epidemiological data indicate that although the military population is generally considered healthier than the general population, the prevalence of cardiovascular

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risk factors—including hypertension, dyslipidemia, obesity, and smoking—remains significant and is increasing [2,3]. In addition, demographic changes, such as the rising average age of active personnel, contribute to the growing burden of cardiovascular disease in this group.

Acute cardiovascular events, particularly sudden cardiac death and myocardial infarction, represent important causes of morbidity and mortality among military personnel and are frequently associated with intense physical exertion or demanding operational conditions [4,5]. These events have major implications not only for individual health but also for operational effectiveness, potentially leading to mission interruption, medical evacuation, and additional risks for the team.

In this context, cardiovascular screening and functional assessment strategies have evolved considerably, including modern imaging methods, exercise testing, and monitoring under simulated operational stress conditions [6]. Current guidelines also emphasize the need for an individualized approach, adapted to the specific requirements of different military roles and the acceptable level of risk depending on mission type [7].

An essential aspect of operational cardiology is determining mission fitness (“deployability”), which involves assessing the probability of an incapacitating cardiovascular event under operational conditions and its impact on task performance [8]. This assessment requires integration of clinical, functional, and occupational data into a complex decision-making model.

Therefore, operational cardiology is becoming a central element of modern military medicine, aiming to balance the need to maintain operational capability with the imperative to protect personnel health. This review aims to analyze current methods for cardiovascular risk assessment in the military population and their implications for determining mission fitness.

MATERIALS AND METHODS

The present study was conducted as a review, aiming to synthesize the available data on operational cardiology in the military population, with a focus on cardiovascular risk assessment and determination of fitness for duty. A systematic literature search was performed in the PubMed/MEDLINE, Web of Science, and Scopus databases. A total of 52 articles published between 2000 and 2026 were included, with emphasis on recent studies.

The search strategy used combinations of MeSH terms and keywords, together with Boolean operators:

("operational cardiology" OR "military cardiology" OR "military personnel") AND ("cardiovascular risk" OR "cardiovascular disease" OR "sudden cardiac death") AND ("military training" OR "operational stress" OR "physical exertion") AND ("cardiovascular screening" OR "fitness for duty" OR "pre-participation screening") AND ("physiological monitoring" OR "heart rate variability" OR "cardiorespiratory fitness"). Additional relevant articles were identified through manual screening of the reference lists of the included studies.

Eligibility criteria. Studies were included if they met the following criteria: they analyzed active military populations or tactical personnel; evaluated cardiovascular risk factors or cardiovascular diseases; examined sudden cardiac death in military personnel; assessed the impact of military physical exertion on the cardiovascular system; analyzed operational stress and autonomic regulation; evaluated cardiovascular screening methods; examined physiological monitoring in an operational context; and were published in scientific journals. Exclusion criteria were: studies not involving military populations; studies without relevant cardiovascular outcomes; conference abstracts without full text; editorials without original data; and articles lacking access to relevant scientific data.

Study selection. All identified records were initially screened based on title and abstract. Subsequently, potentially eligible articles were assessed in full text. Studies meeting the inclusion criteria were selected for qualitative synthesis. Duplicate records were removed prior to the selection process.

Data extraction. The following information was extracted from the included studies: study type; population characteristics; military category (active duty personnel, recruits, special forces, pilots); cardiovascular events evaluated; analyzed risk factors; cardiovascular screening methods; physiological monitoring techniques; operational stress parameters; and main findings.

Data synthesis. The extracted data were synthesized and organized into the following thematic domains: epidemiology of cardiovascular diseases in the military population; sudden cardiac death and acute cardiovascular events in military personnel; cardiovascular risk factors specific to the military environment; impact of military physical exertion on the cardiovascular system; operational stress, autonomic regulation, and physiological monitoring; cardiovascular screening and fitness-for-duty assessment; and operational cardiology in the theater of operations.

RESULTS

1. Epidemiology of Cardiovascular Diseases in the Military Population

Cardiovascular diseases represent an important cause of non-traumatic morbidity among military personnel, despite rigorous medical selection. Epidemiological studies have identified the prevalence of traditional cardiovascular risk factors, including hypertension,

dyslipidemia, obesity, and smoking — at varying proportions among active-duty service members. These findings have been reported both in descriptive studies and in comparative analyses between personnel with and without acute coronary events [2,9–11]. Recent research has confirmed the relationships between physical activity level, cardiometabolic profile, and cardiovascular risk among active military personnel, highlighting the role of health behaviors and operational physical fitness [12–14].

Comparative analyses between military and civilian populations have shown that, although military personnel often present a more favorable health profile, cardiovascular risk is not absent [15,16]. In addition, the assessment of cardiometabolic biomarkers has proven useful for cardiovascular risk stratification in military personnel [17]. (Table 1).

Table 1: Scientific articles presenting studies on the epidemiology of cardiovascular diseases in the military population

Focus / Application	Year	Author	Conclusions
Review of cardiovascular risk factors in military	2008	McGraw L.K., [2]	Significant prevalence of hypertension, dyslipidemia, and smoking
Risk factors in service members with ACS	2011	McGraw L.K., [9]	Risk profile comparable to civilians, with operational impact
Coronary artery disease risk factors	2019	Mirzaeipour F., [10]	High prevalence of obesity and dyslipidemia
Prevalence of risk factors in soldiers	2020	Gielerek G., [11]	Multiple risk factors present even in active personnel
Physical activity and cardiovascular risk	2025	Dawood J., [12]	Physical activity is inversely associated with cardiometabolic risk
Military vs civilian populations	2025	Zawadzka M., [13]	Moderate differences, but persistent cardiovascular risk
POL-SCORE assessment in soldiers	2025	Zawadzka M., [14]	Effective identification of high-risk individuals
Racial differences and military service	2019	Walker L.E., [15]	Variability in cardiovascular risk across subgroups
Epidemiology in UK Armed Forces	2015	Cox A.T., [16]	CVD is a major non-traumatic cause of morbidity
Cardiometabolic biomarkers	2025	Pabin A., [17]	Biomarkers improve cardiovascular risk stratification

2. Sudden Cardiac Death and Acute Cardiovascular Events in Military Personnel

Sudden cardiac death represents one of the leading causes of non-traumatic death among military personnel. Autopsy studies conducted on military recruits have identified cardiomyopathies, congenital coronary anomalies, and cardiac electrical disorders as the main causes [4,18,19].

Similar findings have been reported in analyses of British military personnel and air force recruits [20]. Most events occur in the context of intense physical exertion or demanding training, even in individuals previously considered healthy [5,21]. Recent meta-analyses indicate a relatively low incidence of cardiac arrest among military personnel and tactical athletes, but with significant operational impact [22,23].

Additionally, case reports have highlighted the role of rare conditions, such as congenital long QT syndrome or mitral annular disjunction, in the occurrence of cardiac arrest in the military setting [24,25]. Comparative data from populations of young athletes support these observations regarding mechanisms of sudden death in apparently healthy individuals subjected to intense exertion [26]. (Table 2).

Table 2: Scientific articles on sudden cardiac death and acute cardiovascular events in military personnel

Focus / Application	Year	Author	Conclusions
Autopsy study in recruits	2004	Eckart R.E., [4]	Cardiomyopathies and coronary anomalies are the main causes
Sudden death in female recruits	2006	Eckart R.E., [18]	Similar causes as in males

DoD sudden death registry	2011	Eckart R.E., [19]	Low incidence but high operational impact
Sudden death in UK military	2011	Vanezis A.P., [20]	Events often associated with exertion
Exertion-related sudden death	2016	Smallman D.P., [5]	Most events occur during training
Case series in healthy soldiers	2023	McLeod E.V., [21]	Events occur in apparently healthy individuals
Meta-analysis of cardiac arrest	2022	Lear A., [22]	Low incidence but operationally relevant
Incidence and survival	2025	Franzos M.A., [23]	Survival improved with rapid response
Long QT syndrome	2023	Chung T.F., [24]	Congenital causes of cardiac arrest
Mitral annular disjunction	2025	Dean J.L., [25]	Arrhythmic risk in military aviators
Athlete comparison data	2015	Harmon K.G., [26]	Similar mechanisms to young athletes

3. Cardiovascular Risk Factors Specific to the Military Environment

In addition to traditional risk factors, military personnel are exposed to occupation-specific determinants.

Autopsy studies have demonstrated the presence of subclinical atherosclerosis even among special forces members considered physically fit [27]. Analyses of occupational factors have identified operational stress, exposure to extreme temperatures, hypoxia, vibrations, and specific environmental conditions as additional determinants of cardiovascular risk [28,29]. The literature also shows an association between combat experience and increased cardiovascular risk [8].

Other relevant occupational factors include night shift duties, which are associated with cardiometabolic changes, and exposure to pollutants from burn pits, correlated with increased cardiovascular and respiratory risk [30,31]. The impact of cardiovascular diseases on operational capability is significant, being associated with reduced productivity and limitations in mission readiness [32] (Table 3).

Table 3: Scientific articles presenting studies on cardiovascular risk factors specific to the military environment

Focus / Application	Year	Author	Conclusions
Subclinical atherosclerosis in elite forces	2021	Kotwal R.S., [27]	Atherosclerosis present even in elite personnel
Endogenous risk in military pilots	2022	Maculewicz E., [28]	Metabolic and autonomic factors relevant
Occupational and environmental risks	2023	Maculewicz E., [29]	Heat, hypoxia, and stress increase risk
Combat exposure and cardiovascular risk	2019	Boos C.J., [8]	Combat associated with increased risk
Night duty impact	2025	Byeon H., [30]	Associated with cardiometabolic disturbances
Burn pit exposure	2024	Savitz D.A., [31]	Increased cardiovascular and respiratory risk
Productivity impact	2018	Gharasi-Manshadi M., [32]	CVD reduces operational capacity

4. Impact of Military Physical Effort on the Cardiovascular System

Intense physical exertion characteristic of military activities can precipitate acute cardiovascular events. Studies on myocardial infarction during military training have shown that intense physical demands may trigger acute events in apparently healthy service members [33]. Scientific statements on physical exercise confirm the existence of a transient increase in cardiovascular risk during vigorous exertion, particularly in individuals with subclinical risk factors [34].

Recent analyses have highlighted differences in cardiopulmonary function between special forces and conventional infantry, suggesting distinct physiological adaptations depending on the type of operational demand [35]. (Table 4).

Table 4: Scientific articles presenting studies on the impact of military physical effort on the cardiovascular system in military settings

Focus / Application	Year	Author	Conclusions
STEMI during military training	2021	Singh N., [33]	Intense exertion can trigger myocardial infarction
Exercise and acute events	2007	Thompson P.D., [34]	Transient increase in cardiovascular risk during exertion
Cardiopulmonary function comparison	2025	Rasmussen R.S., [35]	Different physiological adaptations between units

5. Operational Stress, Autonomic Regulation, and Physiological Monitoring

Operational stress induces changes in the autonomic nervous system and cardiovascular function. Systematic analyses have shown that psychological and physical stress produce sympathetic activation and a reduction in heart rate variability (HRV), an indicator of physiological load [36]. The relationships between HRV, occupational performance, and fitness level have been confirmed in studies conducted on tactical personnel [37]. Continuous monitoring of autonomic parameters has demonstrated the usefulness of HRV for evaluating operational strain and physiological recovery in military personnel [38,39].

Additional studies have highlighted changes in heart rate complexity during pre-deployment training and during patrol operations [40,41]. The use of portable ECG devices has enabled the assessment of the physiological cost of military activities in real-world field conditions [42]. (Table 5).

Table 5: Scientific articles presenting studies on operational stress, autonomic regulation, and physiological monitoring in operational settings

Focus / Application	Year	Author	Conclusions
Stress and autonomic system	2020	Bustamante-Sánchez A., [36]	Sympathetic activation and reduced HRV
HRV and tactical performance	2020	Tomes C., [37]	HRV correlates with operational performance
Heart rate complexity	2020	Mulder M.B., [40]	HRV reflects operational strain
HRV monitoring in soldiers	2025	Chapman C.L., [38]	HRV useful for daily monitoring
HRV in simulated operations	2025	Lowe A.C., [39]	Autonomic changes during missions
Patrol operations and HRV	2015	Duarte A.F., [41]	Field-induced autonomic modulation
Wearable ECG monitoring	2023	Bocharov M., [42]	Real-time physiological assessment

6. Cardiovascular Screening and Mission Fitness Evaluation

Cardiovascular screening represents an essential component of preventing acute events in the military environment. The introduction of electrocardiography in the evaluation of recruits has been proposed to detect silent cardiac pathology and reduce the risk of sudden death [43,45].

Clinical studies have demonstrated the usefulness of evaluating service members with post-exercise palpitations to identify clinically relevant arrhythmias [46]. Cardiopulmonary exercise testing has been proposed as a method for assessing operational capacity and mission fitness [44]. Longitudinal cardiorespiratory fitness monitoring programs have demonstrated the predictive value of functional parameters for cardiovascular events and hospitalizations in the military population [47]. (Table 6).

Table 6: Scientific articles presenting studies on cardiovascular screening and mission fitness evaluation in operational settings

Focus / Application	Year	Author	Conclusions
ECG screening in recruits	2011	Boos C.J., [43]	ECG may detect silent cardiac disease
Military cardiovascular screening	2020	Magee C., [45]	Need to reconsider ECG implementation
Palpitations post-training	2022	Günlü S., [46]	Useful in identifying arrhythmias
Cardiopulmonary exercise testing	2026	Holland J.L., [44]	CPET is valuable for mission fitness assessment
Cardiorespiratory fitness study	2016	Lin G.M., [47]	Fitness predicts cardiovascular outcomes

7. Operational Cardiology in the Theater of Operations

The management of cardiovascular pathology in the operational environment requires adapting evaluation and treatment to field conditions. Studies have described the need for rapid decision-making regarding mission fitness within advanced medical facilities [48].

Cardiology telemedicine has been proposed as a decision-support tool for remote consultations in theaters of operations [49]. The aeronautical cardiology literature highlights the specific aspects of evaluating military aviation personnel [50]. Reports from advanced military hospitals have identified the most common types of cardiovascular conditions encountered during military operations [51,52] (Table 7).

Table 7: Scientific articles presenting studies on operational cardiology in the theater of operations setting

Focus / Application	Year	Author	Conclusions
Field cardiology practice	2007	Nayak G., [48]	Need for rapid decision-making in deployment
Telecardiology	2009	Rand E.R., [49]	Remote consultation improves decision support
Aviation cardiology	2019	Nicol E.D., [50]	Specific considerations for aircrew
CVD in deployed hospital	2008	Sullenberger L., [51]	Cardiovascular cases frequent in operations
Cardiovascular complaints in deployment	2016	Watts J.A., [52]	Common cardiovascular presentations in theater

DISCUSSION

Data from the scientific literature highlight that the epidemiology of cardiovascular diseases in the military population presents distinct characteristics compared with the general population. Although initial medical selection results in a more favorable health profile, studies show that traditional risk factors—arterial hypertension, dyslipidemia, obesity, and smoking—remain frequently encountered among active military personnel [2,9–11]. Compared with the civilian population, the prevalence of these factors is often lower; however, cardiovascular risk is not absent, supporting the need for continuous monitoring and periodic evaluation of the cardiometabolic profile [15,16].

Regarding non-traumatic mortality, sudden cardiac death represents one of the leading causes of death among military personnel. Unlike the general population, where events are frequently associated with advanced coronary artery disease, in the military environment, these events often occur in apparently healthy individuals during intense physical exertion. Autopsy studies have identified cardiomyopathies, congenital coronary anomalies, and cardiac electrical disorders as the main causes [4,18,19]. Although incidence is relatively low, the operational impact is significant, and most events are reported during demanding physical activities [22,23].

An important aspect is the influence of occupational factors specific to the military environment. Unlike the civilian population, military personnel are exposed to operational stress, extreme conditions, and combat experiences, factors associated with increased cardiovascular risk and long-term cardiometabolic changes [8,28,29]. The presence of subclinical atherosclerosis even in highly fit military personnel suggests the cumulative impact of these exposures on the cardiovascular system [27].

The intense physical effort characteristic of military activities highlights a dual relationship compared with physical activity in the general population. On the one hand, it produces favorable physiological adaptations; on the other, it may trigger acute cardiovascular events in apparently healthy individuals. Studies of myocardial infarction during military training show that maximal exertion may act as a precipitating factor for acute events [33]. In addition, differences between types of military units suggest that the nature of operational demands influences the cardiovascular response to exertion [35].

Operational stress produces more pronounced changes in autonomic regulation than those observed in the civilian population, characterized by sympathetic activation and reduced heart rate variability. Systematic analyses have demonstrated the usefulness of HRV as an indicator of physiological load and recovery in tactical personnel [36,37]. Continuous monitoring using wearable devices allows assessment of physiological strain in real operational conditions and optimization of performance [38,39].

Cardiovascular screening remains essential for preventing acute events in the military population. The introduction of electrocardiography in recruit evaluation has been proposed to detect silent cardiac pathology and reduce the risk of sudden death [43,45]. Cardiopulmonary exercise testing provides objective information regarding functional capacity and may contribute to mission-fitness assessment [44].

Management of cardiovascular disease in the operational environment differs from the civilian approach due to the need for rapid decisions regarding mission fitness and the logistical limitations of operational theaters. Studies have highlighted the role of advanced medical facilities and the need to adapt evaluation and treatment strategies to field conditions [48]. In this context, cardiology telemedicine has been proposed as a decision-support tool for remote consultations and optimization of cardiovascular case management in operational theaters [49].

Overall, although military personnel present a more favorable initial health profile, exposures specific to the operational environment and intense physical demands generate distinct cardiovascular risks. These particularities justify the implementation of dedicated screening, monitoring, and management strategies tailored to the military population [15,27,36,44].

CONCLUSION

Cardiovascular disease represents a significant cause of non-traumatic morbidity in military populations and has direct implications for operational capability. Despite a generally favorable baseline health profile, military personnel remain exposed to both traditional cardiovascular risk factors and occupation-specific stressors that contribute to disease development.

Sudden cardiac death, although uncommon, constitutes a critical operational concern and frequently occurs during intense physical exertion in apparently healthy individuals, underscoring the limitations of conventional screening strategies. Operational stress, extreme environmental conditions, and high physical demands further increase cardiovascular load and may precipitate acute events.

Comprehensive cardiovascular screening, physiological monitoring, and periodic assessment of fitness for duty are therefore essential components of risk mitigation. An integrated operational cardiology approach, tailored to the unique demands of the military environment, is required to reduce cardiovascular risk and maintain operational readiness.

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Authors' contribution

Conceptualization, S-I. D., S.S.T., A.E.M.; methodology, I.D.F, C.N.D. ; writing—original draft preparation, S.S.T., S-I.D., B.V.V.; writing—review and editing, B.V.V., A.E.M.; supervision, A.E.M., C.N.D. All authors have read and agreed to the published version of the manuscript.

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