English Edition

ISSN 2316-4891 (Online)
ISSN 2316-4833 (Print)

Coleção Meira Mattos

revista das ciências militares

Escola de Comando e Estado-Maior do Exército
v. 17 n. 59 May/August 2023

Coleção Meira Mattos

revista das ciências militares

v. 17 n. 59 May/August 2023
Rio de Janeiro

English Edition

ISSN 2316-4891 (Online)
ISSN 2316-4833 (Print)

ABOUT
The Coleção Meira Mattos is an academic not for profit publication circulated three times a year by the Military Sciences Post-Graduation Program of the Escola de Comando e Estado-Maior do Exército (ECEME) based on the policy of free access to information.

ADRESS AND CONTACT
Praça General Tibúrcio, 125, Praia Vermelha, Rio de Janeiro/RJ, Brasil.
CEP. 22290-270.
Tel: (21) 3873-3868 /Fax: (21) 2275-5895
e-mail: info.cmm@eceme.eb.mil.br

EDITORIAL SERVICES
Comunica

PRESS
Triunfal Gráfica e Editora

COVER GRAPHIC DESIGN
Designed by the Production, Publicity and Cataloging Section, based on art by Harerama Santos da Costa, ECEME Desktop Publishing Section.

DISPONÍVEL EM PORTUGUÊS / DISPONIBLE EN ESPAÑOL
<http://ebrevistas.eb.mil.br/index.php/RMM/index>

Cataloging in Publication (CIP)

C691 Coleção Meira Mattos : revista das ciências militares. — Vol. 1, n. 24- .
— Rio de Janeiro : ECEME, 2007-
v. : il. ; 28 cm.

Quarterly.
Published from no. 1-14 with the title Padeceme, and from no. 15-23 with the titles Padeceme and Coleção Meira Mattos.
Padeceme e Coleção Meira Mattos.
ISSN 2316-4891 (Online). — ISSN 2316-4833 (Print)

1. DEFENSE. 2. MILITARY SCIENCE. I. Escola de Comando Estado-Maior do Exército (Brasil).

CDD 355

CONTENTS

EDITORIAL DOI 10.52781/cmm.a096

Health and operability in Defense Studies and Military Sciences

Angela Nogueira Neves
Exército Brasileiro. Escola de Educação Física do Exército.
Rio de Janeiro, RJ, Brasil.
angelanneves@gmail.com

Samir Ezequiel da Rosa
Exército Brasileiro. Instituto de Pesquisa da Capacitação Física do Exército.
Rio de Janeiro, RJ, Brasil.
samirdarosa@hotmail.com

Received: May 26, 2023
Approved: May 30, 2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

The involvement of the Brazilian Armed Forces in war and/or peace operations can be attributed to the economic, social and political developments that have been observed in many nations throughout the twentieth and twenty-first centuries. Since World War II (1939-1945), when the Brazilian Expeditionary Force (FEB) took part in the conflict, there have been profound changes in the policy, strategies and characterization of conflicts. Even with these major changes, there is a perennial component: the military deployed on the ground. To them, the academic studies concerning peace and war have relegated, in our country, a space of lesser prestige.

The academic approach in the area of defense studies in Brazil originates in the 1990s, when social scientists began to problematize the area, seeking to understand the transformations in the national and international political contexts in the changing world. This origin has a strong connection with political science and international relations (MARQUES; FUCCILLE, 2015), which explains the fact that statements No. 1,295/2001 (BRASIL, 2001) and No. 147/2017 (BRASIL, 2017) place military sciences and defense, respectively, in the list of sciences studied in the country along with political sciences and international relations. However, more recent epistemological reflections recognize that studies on peace and war, notably pertaining to the area of defense, may be organized into networked knowledge structures, to which the studies of war materials belong; in technology, and military components; in administration and logistics (MEDEIROS, 2015). In addition, we may point out:

> From these elements, we can also highlight another point of possible intersection from the war, linked to the processes. There are valid processes from the administrative and logistical point of view, but also those related to the formation of human resources, training, qualification, formation. Sectors of knowledge linked to education, pedagogy or andragogy reverberate in this field. But other fields

> bordering this one are those of psychology and medicine, which are endowed by the needs of war, of human physical and psychological limits. These fields in turn are associated with those of sociology, with regard to the conflicts caused by ever human decisions, as well as the new faces of the defense exercise, in social sectors and support to the State. (MEDEIROS, 2015, p. 48, our translation, emphasis added)

Specifically, regarding the military sciences, Ordinance No. 734/2010 defines them as a "system of knowledge related to the art of warfare, obtained through scientific research, practices in the military sphere, experience and observation of the phenomena of wars and conflicts" (BRASIL, 2010), subordinated to the great area of defense knowledge. Along with this, 36 areas of study are established, including health, military instruction, human resources, military operations and physical education. Finally, it should be noted that:

> the research and study of Military Sciences in the Brazilian Army have as their purposes the formulation of the Terrestrial Military Doctrine, the advancement of knowledge in Defense and the preparation of military leaders, researchers, planners and managers of the resources made available to the Institution for the fulfillment of its constitutional mission, in time of peace and war. (BRASIL, 2010, our translation, emphasis added)

Revisiting the definition of defense studies and military sciences as a mean for a reflection on its scope, we argue that the research themes in these areas do not limit themselves to high politics, geopolitics, logistics, defense economics and the like, as would address the most traditional approach in Brazil. In fact, a survey in the literature ratifies this argument, since there is, in the international scenario, substantial scientific production in the areas of defense and military sciences, either in the scope of tactical dimensions or of the operational dimensions.

Specifically with regard to the themes of health and operability of military personnel, the Scopus[1] platform catalogs 40,065[2] articles, books, book chapters and congress abstracts, in a continuous growth since 1943 – the date of the first two publications on the subject –, which is more accentuated from 2001 (Figure 1).

The journals that most publish scientific articles on the topics are precisely the military journals, and military agencies are also the largest funders of research on the themes of health and operationality. Likewise, the researchers are mostly affiliated with military organizations (Figure 2, 3 and 4). Ergo, it is difficult not to infer that such topics are of interest to the Armed Forces, of military researchers or of military institutions, and are therefore legitimate in this context.

There is a marked predominance of North American institutes, organizations, journals and sponsors in the epistemological production. In turn, the Brazilian role has been

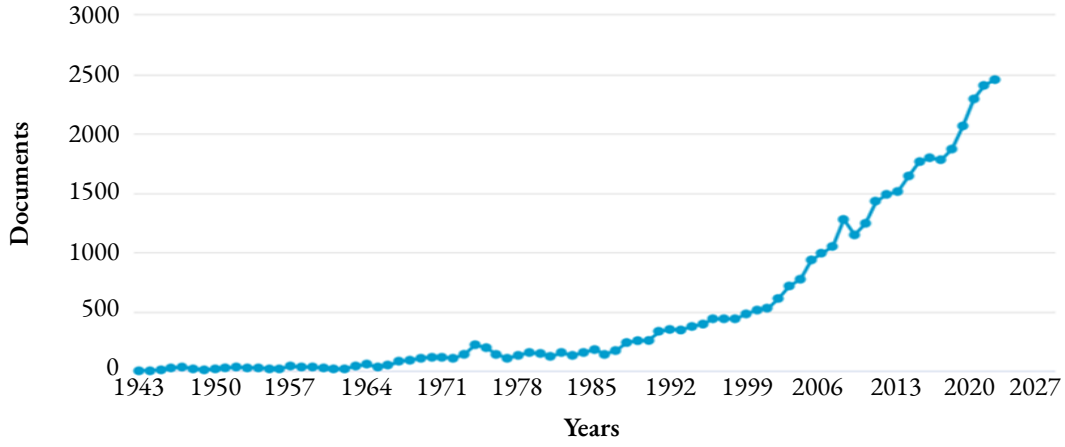
1 Scopus is a multidisciplinary search base that indexes five thousand publishers and more than 25 thousand scientific journals, books and chapters, review, notes, letters and conferences from the humanities, health sciences, earth sciences, biological sciences and exact sciences. Cf.: https://www.elsevier.com/?a=69451

2 Survey taken on May 22, 2023.

minimal, with 242 scientific productions in the said period (1943-2022), representing approximately 0.60% of the world publication.

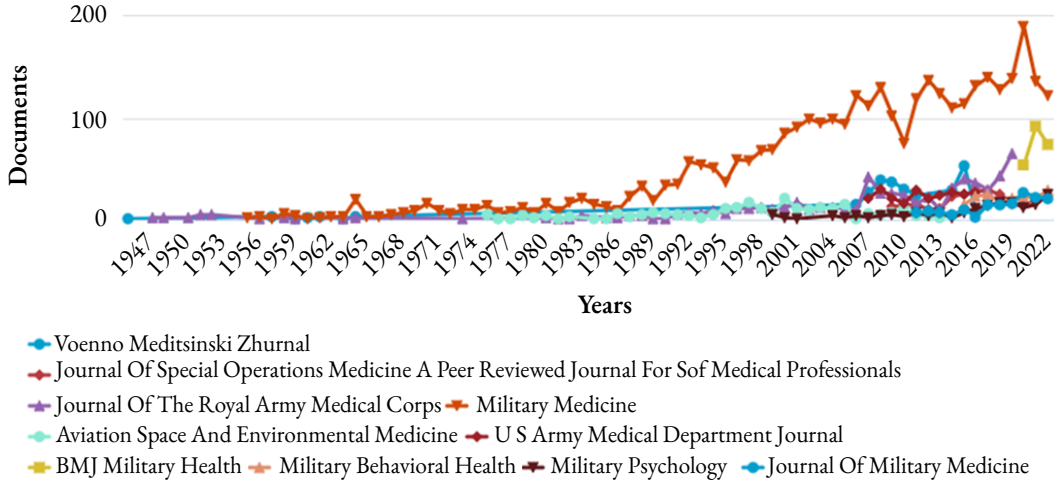
We do not ignore that the approach and characteristics of the current Brazilian academic production derive, to a large extent, from the direction of graduate courses dedicated to defense studies and military sciences – almost entirely linked to area 39 (political science and international relations) of the Coordination for the Improvement of Higher Education Personnel (Capes). Of all the courses and programs in civilian universities or military educational institutions, only one escapes the rule of studying military issues in the political-strategic perspective, directing its attention to operational human performance and being linked to area 21 of Capes (Physical Education). There is no criticism in this observation, it is a fact.

Figure 1 – Scientific documents published per year from 1943 onwards



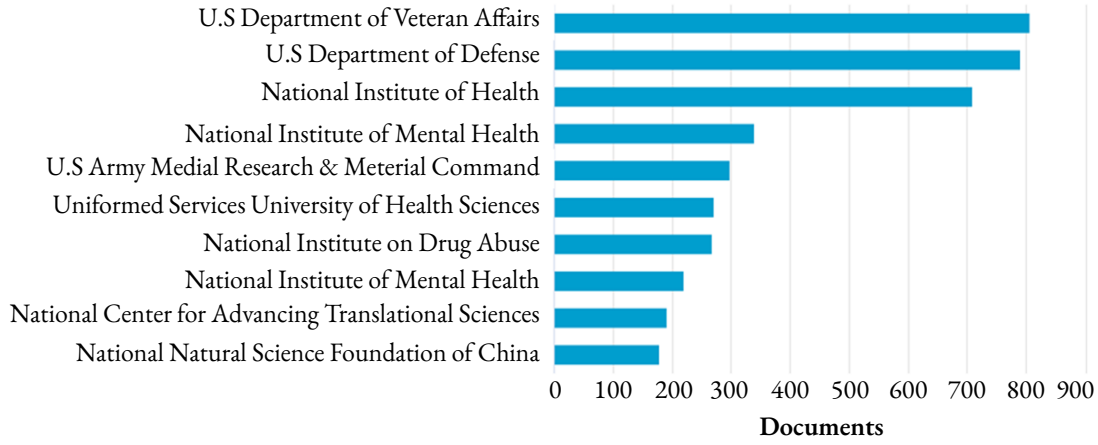
Source: Scopus, 2023

Figure 2 – The ten journals that most publish research articles on the subject



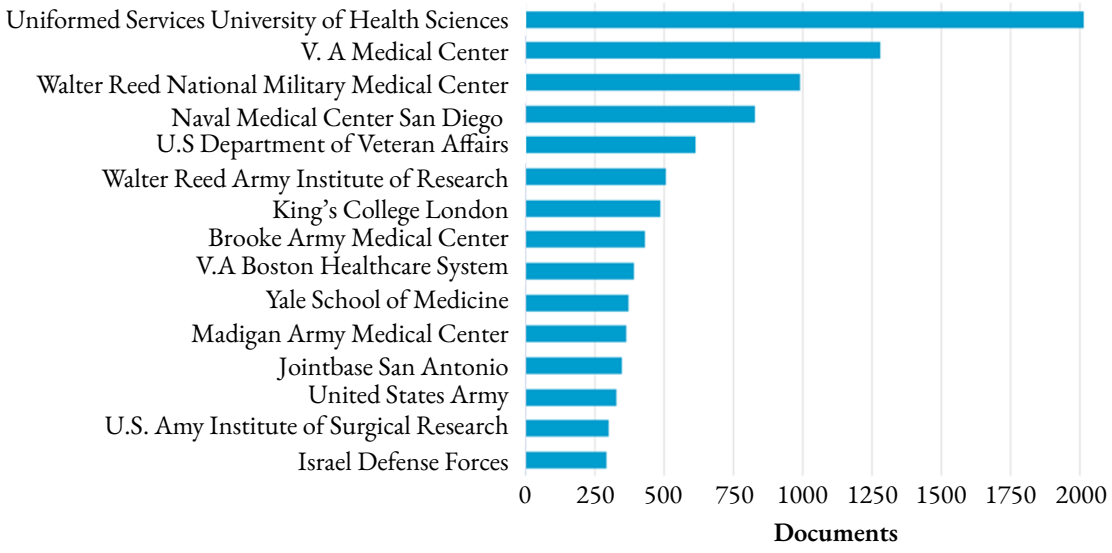
Source: Scopus, 2023

Figure 3 – Number of documents per sponsor (15 largest sponsors of research on the subject)



Source:Scopus, 2023

Figure 4 – The 15 institutions/organizations that publish the most on the subject



Source: Scopus, 2023

If Brazilian research in military sciences and defense studies starts adopting both the bottom-up and top-down perspectives to understand, analyze and suggest changes in the policy, strategy, preparation and employment of the troops, there is a possibility, with this, of expanding the exchange between researchers dedicated to the themes legitimately pertinent to the area. The recent changes caused by the covid-19 pandemic in the area of science have shown that the union of researchers from different backgrounds can bring great advances in less time. This movement alone could be a boost in our national production, and could strengthen military magazines for the defense area (FRANCHI, 2021).

The creation of this special issue was a move in this direction, that is, a call for the integration of perspectives in defense studies and military sciences. We sought, therefore, to present the readers of the Coleção Meira Mattos with other topics that are under debate and that are pertinent to the military sciences.

Finally, we emphasize that one should not overlook, especially in the study of military sciences and defense, the human dimension of the operational environment, since this would disregard a relevant part of the agents responsible for strategic and political decision-making. Therefore, it is necessary to bring the human dimension to the scope of research so that, during the planning and conducting of military operations, all levels – political, strategic, operational and tactical – are interconnected, generating a more accurate information framework for decision making. At the very least, one who does not know the troop may not deploy it well and, therefore, the best results are not achieved in the process of ensuring the sovereignty and effective presence of the State in the national territory.

REFERENCES

BRASIL. Conselho Nacional de Educação. Câmara de Educação Superior. **Parecer nº 1295, de 6 novembro de 2001**. Estabelece normas relativas à admissão de equivalência de estudos e inclusão das Ciências Militares no rol das ciências estudadas no país. Câmara de Educação Superior. Brasília, DF: Ministério da Educação, 2001. Available from: https://normativasconselhos.mec.gov.br/normativa/view/CNE_pces129501.pdf?query=EDUCA%C3%87%C3%83O%20ESPECIAL. Access on: May 26, 2023

BRASIL. Brazilian Army. **Portaria nº 734, de 19 agosto de 2010**. Conceitua Ciências Militares, estabelece a sua finalidade e delimita o escopo de seu estudo. Brasília, DF: Ministério da Defesa, 2010. Available from: https://www.decex.eb.mil.br/port_/leg_ensino/2_educacao_eb-decex/29_port_734_CmtEB_19Ago2010_ConcCienciasMil.pdf. Access on: May 26, 2023

BRASIL. Conselho Nacional de Educação. Câmara de Educação Superior. **Parecer n**º 147, de 4 de abril de 2017. Inserção da Defesa no rol das ciências estudadas no Brasil. Brasília, DF: Ministério da Educação, 20017. Available from: https://normativasconselhos.mec.gov.br/normativa/view/CNE_CNECESN1472017.pdf?query=EDUCA%C3%87%C3%83O%20ESPECIAL. Access on: May 26, 2023

FRANCHI, T. A necessidade do fortalecimento dos periódicos científicos da área de Defesa. **Coleção Meira Mattos**: Revista das Ciências Militares, Rio de Janeiro, v. 15, n. 52, p. 5-7, 2021. Available from: http://www.ebrevistas.eb.mil.br/RMM/article/view/6891/5955. Access on: May 26, 2023

MARQUES, A. A.; FUCCILLE, A. Ensino e pesquisa em Defesa no Brasil: estruturação do campo e desafios. **Revista Brasileira de Estudos de Defesa**, [*s. l*], v. 2, n. 2, p. 57-73, 2015. Available from: https://rbed.abedef.org/rbed/article/view/64674/37655. Access on: May 26, 2023

MEDEIROS, S. E. Da Epistemologia dos Estudos de Defesa e os seus Campos Híbridos. **Revista Brasileira de Estudos de Defesa**, [*s. l*], v. 2, n. 2, p. 43-55, 2015. Available from: https://rbed.abedef.org/rbed/article/view/63034/37660. Access on: May 26, 2023

ARTICLE DOI 10.52781/cmm.a097

Ergonomics for military combatants: an integrative review

Ergonomía para combatientes militares: una revisión integradora

Abstract: Ergonomics aims to prevent injuries and prevent health costs in military personnel. Thus, the aim of this study was to investigate the types of ergonomic assessments and interventions used for the prevention of musculoskeletal injuries in military combatants. An integrative review of observational and experimental studies was carried out. Therefore, a systematic literature search was performed in May 2020 and updated in August 2020 in the MEDLINE, LILACS, Cochrane, CINAHL, Sportdiscus, SCOPUS and Web of Science databases with the DeCS and MeSH military personnel, ergonomics, and load carriage. A total of 955 studies were found in the databases, however 14 studies were included (9 evaluation studies and 5 intervention studies). The following ergonomic assessments were recommended for military combatants: stress level, sedentary lifestyle, activity characteristics, presence of vibrations, posture during operational activities, evaluation of footwear, clothing and the load carried, the ration and the level of satisfaction with the job. As interventions: the realization of ergonomic guidelines and physical exercises, in addition to uniforms and protective equipment that provide a higher level of comfort during operational activities.

Keywords: military personnel; overuse injuries; ergonomics.

Resumen: La ergonomía pretende prevenir lesiones y costos de salud en el personal militar. De esta manera, el objetivo de este estudio fue investigar los tipos de evaluaciones e intervenciones ergonómicas utilizadas para la prevención de lesiones musculoesqueléticas en combatientes militares. Se promovió una revisión integradora de estudios observacionales y experimentales. Con eso, se realizó una búsqueda bibliográfica sistemática en mayo de 2020 y se actualizó en agosto de 2020 en las bases de datos MEDLINE, LILACS, Cochrane, CINAHL, Sportdiscus, SCOPUS y Web of Science con descriptores del DeCS y MeSH military personnel, ergonomics, y load carriage. Se encontraron un total de 955 estudios en las bases de datos, pero se incluyeron 14 (9 estudios de evaluación y 5 estudios de intervención). Se encontraron las siguientes evaluaciones ergonómicas para los combatientes militares: nivel de estrés, sedentarismo, características de la actividad, presencia de vibraciones, postura durante las actividades operativas, evaluación del calzado, vestimenta y carga transportada, ración y nivel de satisfacción con el trabajo. Como intervenciones, la realización de pautas ergonómicas y ejercicios físicos, además de uniformes y equipos de protección que brinden un mayor nivel de comodidad durante las actividades operativas.

Palabras clave: personal militar; lesiones por uso excesivo; ergonomía.

Priscila dos Santos Bunn
Marinha do Brasil.
Centro de Educação Física Almirante Adalberto Nunes (CEFAN).
Laboratório de Pesquisa em Ciências do Exercício e Performance (LABOCE).
Rio de Janeiro, RJ, Brasil.
priscilabunn@yahoo.com.br

Maria Elisa Koppke Miranda
Marinha do Brasil.
Centro de Educação Física Almirante Adalberto Nunes (CEFAN).
Laboratório de Pesquisa em Ciências do Exercício e Performance (LABOCE).
Rio de Janeiro, RJ, Brasil.
Universidade do Estado do Rio de Janeiro (UERJ). Programa de Pós-graduação em Ciências do Exercício e do Esporte
Rio de Janeiro, RJ, Brasil.
maria_koppke@yahoo.com.br

Received: 06 jan. 2022
Approved: 28 jun. 2022

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

Ergonomics aims at the use of methods and techniques in order to provide improvements in the relationship between the work environment and the individual, and may cover physical and psychological aspects of workers. In addition to adapting jobs, through an ergonomic evaluation of the activity, adjustments of work activities can be made in order to prevent musculoskeletal injuries and occupational diseases. The objective is to prevent workers from acquiring chronic occupational diseases, which can evolve with incapacity for work.

In the military environment, several activities are associated with a higher risk of injury, especially those with higher physical demands.

Combat activities are those carried out on an operational basis, constituting as exercises or employment of activities to combat an enemy (CAMERON; OWENS, 2016). Such operations often require soldiers to carry a high load (individual equipment), nimbly, often on marches on long trajectories and on uneven terrain (KNAPIK *et al.*, 2012), under conditions of need for immediate decision-making.

Combatant personnel often perform as physical training, cargo transportation, marches of 8, 16 and 32 km, and training maneuvers (POPOVICH *et al.*, 2000), making this population susceptible to a high incidence of various types of musculoskeletal injuries (CAROW *et al.*, 2016).

Musculoskeletal injuries are defined as any damage to the musculoskeletal system that promotes the need for medical attention, being related to operational activity and causing withdrawal from sports or work functions (HÄGGLUND *et al.*, 2005). As a result, injuries generate a large health cost, withdrawal from duties causes a reduction in performance (TOMES; ORR; POPE, 2017), premature dismissal of military personnel from active duty (LARSSON; TEGERN; HARMS-RINGDAHL, 2012), as well as reduced operational readiness (HÄGGLUND *et al.*, 2005; TAANILA *et al.*, 2015).

The military most exposed to injuries are women (ARMSTRONG *et al.*, 2004; BEDNO *et al.*, 2014; BLACKER; WILKINSON; RAYSON, 2009; FINESTONE *et al.*, 2008), individuals with prior injuries (HENDERSON *et al.*, 2000; KNAPIK *et al.*, 2013; MONNIER *et al.*, 2016), people with obesity or overweight (BMI) (TAANILA *et al.*, 2015), older military (HEIR; EIDE, 1997; HENDERSON *et al.*, 2000), individuals with lower aerobic fitness (MALLOY *et al.*, 2016; ROSENDAL *et al.*, 2003) and those with other risk factors (BOOTH-KEWLEY; LARSON; HIGHFILL-MCROY, 2009; KAZMAN *et al.*, 2015; MALLOY, 2016; ROY *et al.*, 2016; SCHOENFELD *et al.*, 2014).

There are injuries arising from operational activities (combat), and others that do not have direct contact with the enemy. Within this context, non-battle injuries are responsible for a large part (or majority) of time spent on treatment and the number of medical evacuations (CAMERON; OWENS, 2016). In this way, ergonomic strategies have been carried out in order to reduce the incidence of non-battle injuries associated with military combat activities (KNAPIK; REYNOLDS, 2010; LARSSON; TEGERN; HARMS-RINGDAHL, 2012; STEVENSON *et al.*, 2007).

Examples of ergonomic interventions used to reduce the number of injured military personnel include physical training and ergonomic orientations, as well as the recognition of musculoskeletal injuries (LARSSON; TEGERN; HARMS-RINGDAHL, 2012), use of different psychomotor performance materials and thermal comfort (MAJCHRZYCKA *et al.*, 2016) and employment of different vests and backpack adaptations (STEVENSON *et al.*, 2007). There is, therefore, a variety of ergonomic interventions that have been used in the military environment. Considering the importance of maintaining a greater number of individuals with adequate health conditions and physical performance for military activities, knowledge about ergonomic assessments and interventions has the potential to prevent injuries and health costs in military personnel. Thus, the objective of this review was to investigate the types of ergonomic assessments and interventions used in military combatants.

2 METHOD

2.1 Study design

An integrative review of the literature was carried out, in which the ergonomic evaluations and interventions used for the prevention of musculoskeletal injuries in military combatants were investigated.

2.2 Eligibility criteria

For the selection of studies, the PICOS strategy (participant, intervention, comparison, outcome and study design) described in Table 1 was used. In order to investigate the evaluations and interventions used for combatants, studies with military pilots, administrative and health professionals were excluded. It was considered a control group, whose participants do not perform any activity (passive control) or who perform some activity, common to the experimental group (active control). In this case, in addition to the common activity, the experimental group must have undergone some ergonomic intervention: preventive exercises, adaptation of clothing and/or individual load, modification of materials used in uniforms, backpacks and individual equipment, among others.

Table 1 – Inclusion Criteria – PICOS strategy

Acronym	Definition	Description
P	Participants	Military
I	Intervention	Ergonomic assessments or interventions
C	Comparison	Control
O	Outcome/result	Musculoskeletal injuries or symptoms
S	Study design	Not applicable

Source: The authors (2022).

2.3 Search Strategy

A systematic literature search was conducted in May 2020 and updated in August 2020 in the databases MEDLINE, LILACS, Cochrane, CINAHL, Sportdiscus, SCOPUS and Web of Science. The descriptors of DeCS and MeSH were used: military personnel, ergonomics, and load carriage, as well as words obtained in articles on similar topics. Table 2 lists the terms used in the search equations. The Boolean logic operators AND (between descriptors) and OR (between synonyms) were used. There was no language or time filter for the search.

Table 2 – Database search strategy

Military	OR		Ergonomics	OR
Military	OR		Ergonomics	OR
Armed Forces Personnel	OR		Human Factors and Ergonomics	OR
Army Personnel	OR		Human Engineering	OR
Marines	OR		Human Factors Engineering	OR
Marine	OR		Human Factors Engineerings	OR
Soldiers	OR		Cognitive Ergonomics	OR
Soldier	OR		Cognitive Ergonomic	OR
Recruit*	OR		Visual Ergonomics	OR
Recruits*	OR		Visual Ergonomic	OR
Submariners	OR		Organizational Ergonomics	OR
Submariner	OR		Organizational Ergonomic	OR
Sailors	OR		Physical Ergonomics	OR
Sailor	OR		Physical Ergonomic	
Military Deployment	OR			
Recruits*	OR			
Special Forces*	OR			
Special Operation	OR			
Load carriage	OR			
Weight Bearing	OR	AND		
Weightbearing	OR			
Load bearing	OR			
Load-bearing	OR			
Load Bearing	OR			
Load carrying	OR			
Backpacking	OR			
Hiking	OR			
Walking	OR			
Armor	OR			
Armour	OR			
Protective gear	OR			
Rucksack	OR			
Haverstock	OR			
Backpack	OR			
Duffel	OR			
Body protection	OR			
Heavy equipment				

Source: The authors (2022).

Legend: *Added terms in descriptor search

2.4 Data extraction process

The following data were extracted from the studies: sample characteristics (age, gender, armed force, specialty), military activities in which the ergonomic intervention was carried out (cargo loading, anti-aircraft exercises, special operations courses), ergonomic evaluations carried out, intervention protocol and control group, and the results obtained. The studies were categorized into two types: ergonomic assessment or ergonomic intervention.

2.5 Assessment of the quality of individual studies

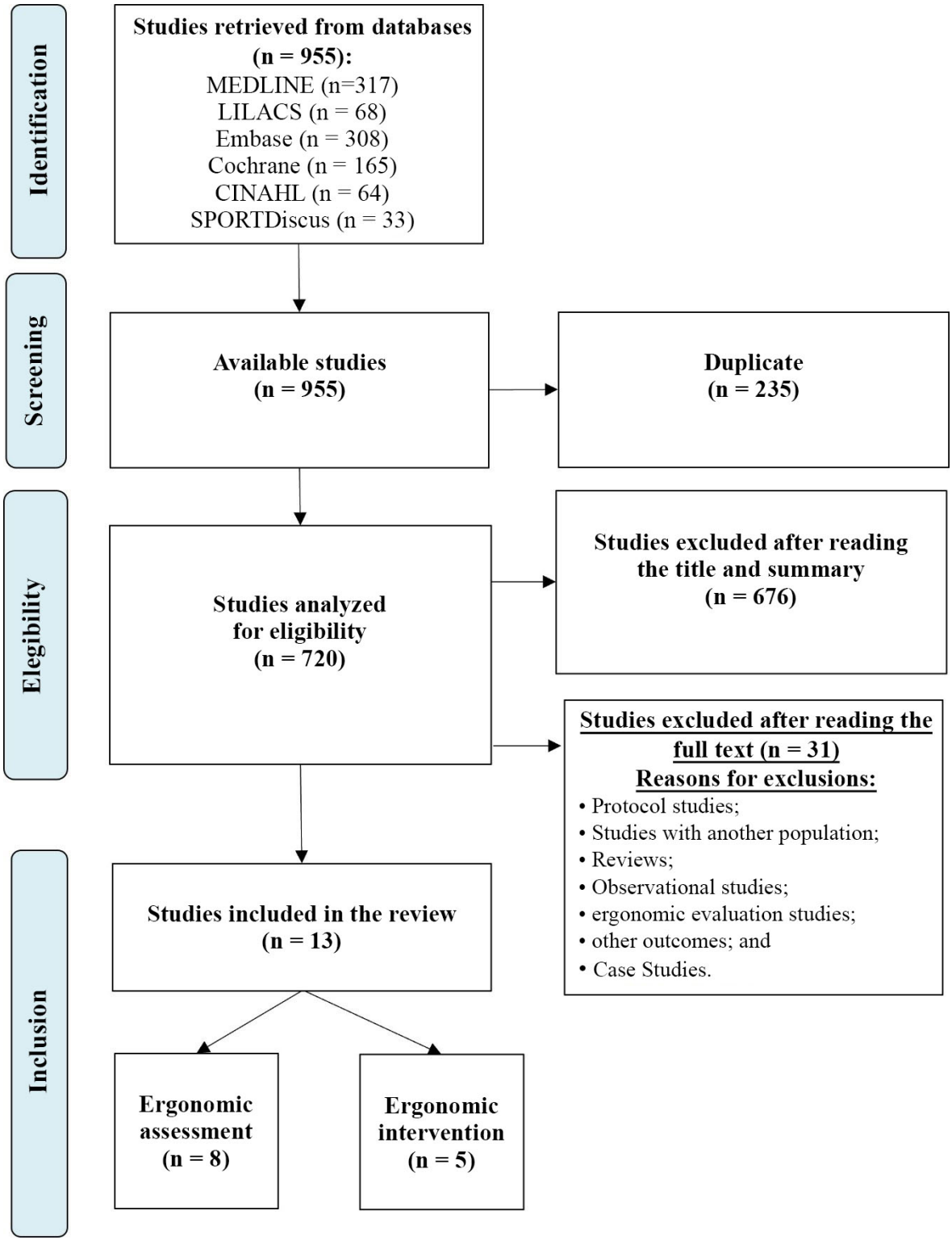
For the evaluation of the quality of the experimental studies, the Jadad scale of methodological evaluation was used (JADAD *et al.*, 1996), which consists of the sum of the score of three domains, namely: 1) randomization of participants; 2) double-blind evaluation; and 3) description of sample losses. Initially, one point was assigned for each question answered. If participant randomization and double-blind evaluation were not appropriate, one point was subtracted from domains 1 and 2. Therefore, the total score on the Jadad scale ranged from 0 to 5 points.

3 RESULTS

The flow diagram of the included studies is in Figure 1. The results of this review show that there are several ergonomic variables related to military activity. A total of nine studies involving firefighters, army soldiers, military police, armored personnel carriers, and others investigated the ergonomic variables associated with musculoskeletal discomfort in military combatants (Table 1). On the other hand, ergonomic orientations, use of insoles, exercises and cervical collars were interventions used in order to reduce painful symptoms, increase comfort and acceptability of the military (Table 2).

Among the studies, the activities of infantry, armored personnel carriers, cargo loading (backpack, personal protective equipment, clothing, weapons, etc.), missions in Iraq etc. were analysed. Despite the diversity of samples and activities, some factors were repeated in different studies.

Figure 1 – Flow diagram of the studies included in the Integrative review



Source: The authors (2022).

Table 1 - Characteristics of the studies included in the review that investigated ergonomic evaluations in military personnel

Study	Sample characteristics	Activity	Evaluation	Result
McCaig e Gooderson (1986)	n=2000 Soldiers.	Military operations in cold and humid climates.	Interviews: assess reasons for dissatisfaction.	Prolonged combat boots time; total weight loaded; physical fatigue.
Daniels *et al.* (2005)	n=279 Army servicemen (men and women).	Infantry, driver, construction equipment operator and repairman, vehicle mechanic, systems operator and nurse.	Factors associated with low back pain in Air Force activities.	Frequency of movements, such as bending, twisting, standing and sitting, is associated with low back pain.
Leyk *et al.* (2006)	n=1337 healthy Army candidates (301 women).	Environments with integration with machines, seated.	Anthropometry, hand grip test and isometric strength test for dominant forearm flexors and knee extensors in the sitting position.	There were differences between the sexes in all tests. Only 26% (knee extensors) and 3% (forearm flexors) of women generate forces greater than the corresponding 5 percentiles of men.
Rozali *et al.* (2009)	n=159 Drivers of armored vehicles.	Armored missions.	A self-administered questionnaire on specialty, low back pain symptoms and human vibration meter were used in this study.	The prevalence of low back pain among drivers of tracked armored vehicles was higher (81.7%) compared to drivers of wheeled armored vehicles (67.0%). Driving in a sitting posture with a forward tilt and exposure to vibration increased the chance of low back pain.
Vitari, Francisco e Mello (2012)	n=208 Military firefighters.	Military firefighter activities.	Questionnaire (age, gender, education, BMI, time of service, frequency of health tests, practice of physical activity, work environment and demands of the activity performed.	Most of the military were sedentary, with high BMI, with musculoskeletal symptoms and mental work overload, complained of the demands of work, environment and comfort.
Majchrzycka *et al.* (2013)	n=10 Military	Ergonomic evaluation of bulletproof vests and fragments.	An obstacle course and subjective ergonomic assessment questionnaires were used in the tests. Thermal discomfort and psychological evaluation.	The tests did not show any decrease in comfort wearing the new pads with better ballistic resistance compared to the currently used pads.
Nissen *et al.* (2014)	n=680 Soldiers on mission in Iraq	Mission in Iraq.	Questionnaire with demographic and personal characteristics, characteristics of missions, lifestyle and pre-employment health; aspects of leadership at work and relationship at work.	Age, poor support from leaders, psychological stress, inappropriate work postures and working in warehouses were associated with low back pain.
Ramstrand *et al.* (2016)	n=21 Police officers.	Loading cargo.	Biomechanical and self-report data were collected on two test occasions, comparing situations without and with loads (standard belt and ballistic protective vest; or a load-bearing vest with ballistic protective vest).	The load-bearing vest was associated with a significant reduction in the range of motion of the torso, pelvis and hip joints. Biomechanical changes associated with the load-bearing vest seemed to reduce with longer time of use. Self-report data indicated a preference for the load-bearing vest.

Source: The authors (2022).

Caption: BMI = body mass index.

Table 2 - Characteristics of the studies included in the review that investigated the effects of ergonomic interventions on military

Study	Sample characteristics	Activity	Evaluation	Intervention	Outcome	Result	Jadad Score
Larsen, Weidick e Lebo-euf-Yde (2002)	n=249 Recruits Age=21±1.5 years.	Military service.	Complaint of back pain.	EG: ergonomic orientations and passive spine extension exercises in the prone position daily. CG: no interventions.	Number of recruits with back pain.	GE: menor número de recrutas com dor nas costas em 3 meses (RR = 0,6 (0,5–0,9), 1 ano RR = 0,7 (0,4–1,1); e na busca pelo atendimento na enfermaria (RR = 0,3 (0,2–0,7).	3
House, Dixon e Allsopp (2004)	n=38 Marine Corps recruits.	Military service.	Comfort questionnaire.	Recruits were matched in pairs according to body mass and then randomly given a pair of shock-absorbing insoles with a thickness of 3mm (CG) or 6mm (EG).	Comfort level of footwear.	Both insoles promoted comfort in the military, but there was worsening in damp conditions.	1
Breeze *et al.* (2011)	n=71 Army cadets and marines.	Movement under fire.	Rifle shooting; simulation of movement under fire and climbing a 20 m firefighter lift carrying a simulated victim.	Six kinds of cervical collars from different countries.	Comfort and potential restriction of military performance.	Higher and stiffer collars showed the worst overall and designs with overlapping segments were the most comfortable when shooting.	1
Breeze *et al.* (2013)	n=10 Infantrymen.	Armed and equipped treadmill test.	Troop acceptability, heart rate, tympanic and skin temperatures.	6 kinds of protective collars for cervical: no neck protection; three-piece collar; two-piece collar; nape pad; ballistic scarf; EP-UBACS.	Comfort.	The ballistic scarf showed a comfort of 30%, while the other five types had a comfort of 90%.	0
Breeze *et al.* (2014)	n=20 Soldiers on mission in Afghanistan.	Mission in Afghanistan.	Comfort.	Three configurations of a combat shirt with neck protection (EP-UBACS) compared to the standard (UBACS) were compared.	Comfort, heat dissipation and overall acceptability.	Silk fabric was the most comfortable, but the collars did not hold up after repeated use. Crossover collars incorporating UHMWPE or felt had similar acceptance to standard UBACS.	0
EG = experimental Group; CG = control group; RR = relative risk; UBACS = body armour combat shirt; UHMWPE = a layer of ultra high molecular weight polyethylene							

Source: The authors (2022).

4 DISCUSSION

Factors such as stress and sedentary lifestyle were associated with musculoskeletal symptoms (VITARI; FRANCISCO; MELLO, 2012). At the same time, individuals with high physical demand had higher rates of low back pain (DANIELS *et al.*, 2005). In older individuals, under stress, and in inappropriate work positions, there were higher incidences of low back pain (NISSEN *et al.*, 2014). Factors such as model of footwear and excessive load carrying were reasons for dissatisfaction with work (MCCAIG; GOODERSON, 1986). In armored vehicle drivers, low back pain was associated with excessive vibration conditions (OR=1.95 and 95% CI = 1.02-3.69) and a sitting posture with anterior torso inclination (OR = 3.63 and 95% CI = 1.06-12.42).

Regarding prevention strategies (ergonomic interventions), a total of five studies were included, with 388 military participants. In this case, the samples were composed of marines, army cadets and marines, conscripts and soldiers on mission in Afghanistan. Interventions occurred during military service activities, cargo loading and crawling (Table 2).

For recruits, the risk of back pain was significantly decreased with interventions based on ergonomic guidelines and spinal extension exercises in the prone position. The interventions occurred in a period of 3 months (RR = 0.6 (0.5–0.9), 1 year RR = 0.7(0.4–1.1), in which search for care in the ward reduced considerably (RR = 0.3 (0.2–0.7) (LARSEN *et al.*, 2002).

The use of shock-absorbing insoles in military recruits marines seems to increase the comfort of the military, although there was no difference between the groups (thickness of 3 or 6 mm). In addition, there was worsening discomfort in conditions of increased foot dampness (HOUSE; DIXON; ALLSOPP, 2004).

The uniform and protective equipment were investigated in three studies (BREEZE *et al.*, 2011, 2013, 2014) in crawling tests, equipped armed cargo loading and in ordinary combat activities. The use of shorter and thinner cervical protectors were classified as more comfortable and the ballistic scarf presented a comfort of 30%, while the other five types had a comfort of 90%.

The results of the present study corroborate the high incidence of musculoskeletal symptoms in military combatants, whether related to risk factors (NISSEN *et al.*, 2014) or to the activity itself (MCCAIG; GOODERSON, 1986). In addition to a strong need for the regular practice of physical exercises, the control of stress, the loaded load, clothing care and factors related to organizational ergonomics (worker suitability for the activity, considering their expectations and qualifications) and cognitive ergonomics (in particular, stress), or in the employment of activities to combat an enemy (CAMERON; OWENS, 2016). It was also found that in situations related to training, injuries of the type non-battle are responsible for a large part (or majority) of musculoskeletal symptoms (CAMERON; OWENS, 2016).

Thus, strategies based on ergonomic orientations, exercises and adaptation of shoes and uniforms seemed to be effective.

However, this study is not free of limitations. First, despite the fact that all the military personnel included were combatants, there was a great diversity among the samples of the included studies. Thus, the heterogeneity between studies is great. There have been a small number of studies that objectively performed ergonomic interventions. At the same time, the studies showed low methodological quality. Of the five studies, only one (LARSEN *et al.*, 2002) presented a good evaluation by the jadad scale (three points), which demonstrates that the level of confidence that can be had as a result of the present study is low. Despite the difficulty in performing double blinding in ergonomic intervention studies, most studies failed because they did not perform adequate randomization of participants, with a consequent risk of selection bias. As strengths, this study conducted an extensive search of databases, including the main ones related to ergonomics and related areas.

5 CONCLUSION

The present review concludes that the following ergonomic evaluations have been performed for military combatants: stress level, sedentary lifestyle, activity characteristics, presence of vibrations, posture during operational activities, evaluation of footwear, clothing and the load carried, the ration and the level of satisfaction with the work. Regarding interventions, strategies of ergonomic orientations, use of insoles, physical exercises and cervical collars seem to reduce painful symptoms, increase comfort and acceptability of the military. Considering the low methodological quality of most of the included studies, these results should be extrapolated with caution. Thus, it is suggested to conduct new experimental studies with greater methodological rigor, especially in order to minimize selection biases and confusion.

AUTORIA E COLABORAÇÕES

Todos os autores participaram de modo equivalente na elaboração do artigo.

THANK

To the Admiral Adalberto Nunes Physical Education Center (CEFAN), Brazilian Navy.

REFERENCE

ARMSTRONG, D. W. 3RD *et al.* Stress fracture injury in young military men and women. **Bone**, New York, v. 35, n. 3, p. 806-816, Sep. 2004.

BEDNO, S. *et al.* Effects of personal and occupational stress on injuries in a young, physically active population: a survey of military personnel. **Military Medicine**, Washington, DC, v. 179, n. 11, p. 1311-1318, Nov. 2014. Available at: https://academic.oup.com/milmed/article/179/11/1311/4159905. Accessed: 17 Aug. 2022.

BLACKER, S. D.; WILKINSON, D. M.; RAYSON, M. P. Gender differences in the physical demands of British Army recruit training. **Military Medicine**, Washington, DC, v. 174, n. 8, p. 811-816, Aug. 2009. Available at: https://academic.oup.com/milmed/article/174/8/811/4335684. Accessed: 17 Aug. 2022.

BOOTH-KEWLEY, S.; LARSON, G. E.; HIGHFILL-MCROY, R. M. Psychosocial predictors of return to duty among marine recruits with musculoskeletal injuries. **Military Medicine**, Washington, DC, v. 174, n. 2, p. 139-152, Feb. 2009.

BREEZE, J. *et al.* Developmental framework to validate future designs of ballistic neck protection. **The British Journal of Oral & Maxillofacial Surgery**, Edinburgh, v. 51, n. 1, p. 47-51, Jan. 2013. Available at: https://www.bjoms.com/article/S0266-4356(12)00086-1/fulltext. Accessed: 16 Aug. 2022.

BREEZE, J. *et al.* Ergonomic assessment of enhanced protection under body armour combat shirt neck collars. **Journal of the Royal Army Medical Corps**, London, v. 160, n. 1, p. 32-37, Mar. 2014. Available at: https://www.researchgate.net/publication/257599996_Ergonomic_assessment_of_enhanced_protection_under_body_armour_combat_shirt_neck_collars. Accessed: 16 Aug. 2022.

BREEZE, J. *et al.* Face, neck, and eye protection: adapting body armour to counter the changing patterns of injuries on the battlefield. **The British Journal of Oral & Maxillofacial Surgery**, Edinburgh, v. 49, n. 8, p. 602-606, Dec. 2011. Available at: https://www.bjoms.com/article/S0266-4356(10)00316-5/fulltext. Accessed: 16 Aug. 2022.

CAMERON, K.; OWENS, B. (ed.). **Musculoskeletal injuries in the military**. New York: Springer, 2016.

CAROW, S. D. *et al.* Risk of lower extremity injury in a military cadet population after a supervised injury-prevention program. **Journal of Athletic Training**, Dallas, v. 51, n. 11, p. 905-918, Nov. 2016.

DANIELS, C. *et al.* Self-report measure of low back-related biomechanical exposures: clinical validation. **Journal of Occupational Rehabilitation**, [New York], v. 15, n. 2, p. 113-128, June 2005.

FINESTONE, A. *et al.* Overuse Injuries in Female Infantry Recruits during Low-Intensity Basic Training. **Medicine Science in Sport and Exercise**, [Madison], v. 40, p. 630-635, 2008. Suppl. 11.

HÄGGLUND, M. *et al.* Methods for epidemiological study of injuries to professional football players: developing the UEFA model. **British Journal of Sports Medicine**, London, v. 39, n. 6, p. 340-346, June 2005.

HEIR, T.; EIDE, G. Injury proneness in intantry conscripts undergoing a physical training programme: smokeless tobacco use, higher age, and low levels of physical fitness are risk factors. **Scandinavian Journal of Medicine & Science Sports**, Copenhagen, v. 7, n. 1 1, p. 304-311, Oct. 1997.

HENDERSON, N. E. *et al.* Injuries and injury risk factors among men and women in U. S. Army Combat Medic Advanced individual training. **Military Medicine**, Washington, DC, v. 165, n. 9, p. 647-652, 2000. Available at: https://bjsm.bmj.com/content/39/6/340. Accessed: 16 Aug. 2022.

HOUSE, C.; DIXON, S.; ALLSOPP, A. User trial and insulation tests to determine whether shock-absorbing insoles are suitable for use by military recruits during training. **Military Medicine**, Washington, DC, v. 169, n. 9, p. 741-746, Sep. 2004.

JADAD, A. *et al.* Assessing the quality of reports of randomized clinical trials: is blinding necessary? **Controlled Clinial Trials**, New York, v. 17, n. 1, p. 1-12, Feb. 1996.

KAZMAN, J. B. *et al.* Physical fitness and injury reporting among active duty and National Guard/Reserve women: associations with risk and lifestyle factors. **U.S. Army Medical Department Journal**, Fort Sam Houston, p. 49-57, Apr./June 2015.

KNAPIK, J. J. *et al.* A systematic review of the effects of physical training on load carriage performance. **Journal of Strength and Conditioning Research**, Champaign, IL, v. 26, n. 2, p. 585-597, Feb. 2012.

KNAPIK, J. J. *et al.* A prospective investigation of injury incidence and risk factors among army recruits in combat engineer training. **Journal of Occupational Medicine and Toxicology, London**, v. 8, n. 1, p. 1, Mar. 2013. Available at: https://occup-med.biomedcentral.com/articles/10.1186/1745-6673-8-5. Accessed: 16 Aug. 2022.

KNAPIK, J.; REYNOLDS, K. **Load carriage in military operations:** a review of historical, physiological, biomechanical and medical aspects. [Fort Sam Houston]: Borden Institute, 2010.

LARSEN, K.; WEIDICK, F.; LEBOEUF-YDE, C. Can passive prone extensions of the back prevent back problems? A randomized, controlled intervention trial of 314 military conscripts. **Spine**, Hagerstown, MD, v. 27, n. 24, p. 2747-2752, dez. 2002.

LARSSON, H.; TEGERN, M.; HARMS-RINGDAHL, K. Influence of the implementation of a comprehensive intervention programme on premature discharge outcomes from military training. **Work (Reading, Mass.)**, Amsderdam, v. 42, n. 2, p. 241-251, 2012.

LEYK, D. *et al.* Recovery of hand grip strength and hand steadiness after exhausting manual stretcher carriage. **European Journal of Applied Physiology**, Berlin, v. 96, n. 5, p. 593-599, Mar. 2006. Available at: https://www.researchgate.net/publication/7356541_Recovery_of_hand_grip_strength_and_hand_steadiness_after_exhausting_manual_stretcher_carriage. Accessed: 18 Aug. 2022.

MAJCHRZYCKA, K. *et al.* Ergonomics assessment of composite ballistic inserts for bullet- and fragment-proof vests. **International Journal of Occupational Safety & Ergonomics, Abingdon**, v. 19, n. 3, p. 387-396, Sep. 2013.

MAJCHRZYCKA, K. *et al.* Ergonomics Assessment of Composite Ballistic Inserts for Bullet- and Fragment-Proof Vests Ergonomics Assessment of Composite Ballistic Inserts for Bullet- and Fragment-Proof Vests. v. 3548, n. March, 2016.

MALLOY, P. *et al.* Hip external rotator strength is associated with better dynamic control of the lower extremity during landing tasks. **Journal of Strength and Conditioning Research, Champaign**, v. 30, n. 1, Jan. 2016.

MCCAIG, R. H.; GOODERSON, C. Y. Ergonomic and physiological aspects of military operations in a cold wet climate. **Ergonomics**, [London], v. 29, n. 7, p. 849-857, 1986.

MONNIER, A. *et al.* Risk factors for back pain in marines; a prospective cohort study. **BMC Musculoskeletal Disorders**, London, v. 17, p. 1-12, 2016. Available at: https://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-016-1172-y. Accessed: 18 Aug. 2022.

NISSEN, L. R. *et al.* Deployment-related risk factors of low back pain: a study among danish soldiers deployed to Iraq. **Military Medicine**, Washington, DC, v. 179, n. 4, p. 451-458, Apr. 2014.

POPOVICH, R. M. *et al.* Effect of rest from running on overuse injuries in army basic training. **American Journal of Preventive Medicine**, Amsterdam, v. 18, p. 147-155, Apr. 2000. Suppl. 3.

RAMSTRAND, N. *et al.* Evaluation of load carriage systems used by active duty police officers: Relative effects on walking patterns and perceived comfort. **Applied Ergonomics**, Oxford, v. 53 Pt A, p. 36-43, Mar. 2016.

ROSENDAL, L. *et al.* Incidence of injury and physical performance adaptations during military training. **Clinical Journal of Sport Medicine:** official journal of the Canadian Academy of Sport Medicine, New York, v. 13, n. 3, p. 157-163, May 2003.

ROY, T. C. *et al.* Heavy loads and lifting are risk factors for musculoskeletal injuries in deployed female soldiers. **Military Medicine**, Washintgon, DC, v. 181, n. 11, p. e1476-1483, Nov. 2016.

ROZALI, A. *et al.* Low back pain and association with whole body vibration among military armoured vehicle drivers in Malaysia. **The Medical Journal of Malaysia**, Kuala Lumpur, v. 64, n. 3, p. 197-204, Sep. 2009.

SCHOENFELD, A. J. *et al.* The influence of musculoskeletal conditions, behavioral health diagnoses, and demographic factors on injury-related outcome in a high-demand population. **The Journal of Bone and Joint Surgery**. American volume, Boston, v. 96, n. 13, 2014.

STEVENSON, J. M. *et al.* Development and assessment of the Canadian personal load carriage system using objective biomechanical measures. **Ergonomics**, London, v. 46, n. 12, p. 37-41, Oct. 2007.

TAANILA, H. *et al.* Risk factors of acute and overuse musculoskeletal injuries among young conscripts: a population-based cohort study. **BMC Musculoskeletal Disorders**, London, v. 16, p. 104, May 2015. Available at: https://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-015-0557-7. Accessed: 16 Aug. 2022.

TOMES, C.; ORR, R. M.; POPE, R. The impact of body armor on physical performance of law enforcement personnel: a systematic review. **Annals of Occupational and Environmental Medicine**, London, v. 29, May 2017.

VITARI, F. C.; FRANCISCO, H. S.; MELLO, M. G. da S. Ergonomic risks on the operational activities of firefighters from Rio de Janeiro. **Work**, Amsterdam, v. 41, p. 5810-5812, Feb. 2012. Suppl. 1.

YUAN, C.-K.; KUO, C.-L. Influence of hand grenade weight, shape and diameter on performance and subjective handling properties in relations to ergonomic design considerations. **Applied Ergonomics**, Oxford, v. 37, n. 2, p. 113-118, Mar. 2006.

ARTICLE DOI 10.52781/cmm.a098

Soldier of the Portuguese Army: equal or different profiles?

El Soldado del Ejército Portugués: perfiles iguales o diferentes?

Abstract: The Portuguese Army has experiencing a difficult renewal of human resources, in particular, in the rank of Private. With the purpose of studying the reasons that interfere in this target population, the present article aims at analyzing the socio-demographic profiles of young men incorporated, through the application of an internal questionnaire, of admission to the Army's Common General Training Course for enlisted men. The results allowed the identification of four groups of young volunteers for military service through the intersection between the zone of residence, academic background, reasons for joining and perceptions about the Institution. The data obtained revealed that during the recruitment phase, the promotion of military service should enhance the diffusion of the values and incentives it provides.

Keywords: Portuguese army; recruitment; ingress; military profile; attractiveness.

Resumen: El Ejército portugués ha registrado una difícil renovación de recursos humanos, en particular, en la categoría de Alistados. Con el propósito de estudiar los motivos que interfieren en esta población objetivo, este artículo tiene como objeto analizar los perfiles sociodemográficos de los jóvenes incorporados mediante la aplicación de un cuestionario interno, de carácter reservado, en el momento de su ingreso al Curso de Formación General Común de Alistados de Ejército. Los resultados permitieron identificar cuatro grupos de jóvenes voluntarios para el servicio militar a través de la intersección entre el área de residencia, la historia escolar, los motivos de ingreso y las percepciones sobre la Institución. Los datos obtenidos revelaron que, durante la fase de reclutamiento, la divulgación del servicio militar debe potenciar la difusión de los valores y los incentivos proporcionados por el mismo.

Palabras clave: Ejército Portugués; reclutamiento; ingreso; perfil militar; capacidad de atraer.

Miguel Andrade
Exército Português. Centro de Psicologia Aplicada do Exército (CPAE).
Queluz, AML, Portugal.
Universidade Autónoma de Lisboa
Lisboa, AML, Portugal
miguelandrade1990@gmail.com

Rui Eusébio
Exército Português. Centro de Psicologia Aplicada do Exército (CPAE).
Queluz, AML, Portugal.
Universidade de Lisboa. Faculdade de Psicologia.
Lisboa, AML, Portugal.
eusebio.rmb@exercito.pt

Marcos Santos Silva
Exército Português. Centro de Psicologia Aplicada do Exército (CPAE).
Queluz, AML, Portugal.
marco.sansil@gmail.com

Received: 28 Oct. 2022
Approved: 06 Feb. 2023
COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

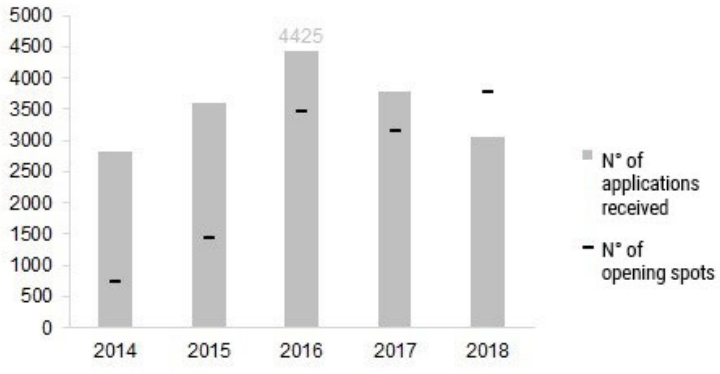
1 INTRODUCTION

In 2004, the Portuguese Army (EP) was faced with the end of compulsory military service and the implementation of a human resources (HR) model based on volunteering (Coelho *et al.*, 2019). With this transformation, the EP was faced with the need to resort to hiring young people for the ranks, thus being dependent on their attraction and competitiveness compared to the rest of the available labor market, requiring new efforts in recruiting and managing the human capital necessary to fulfill the assigned missions. The adaptation of the EP to the new paradigm has revealed challenges that have resulted in an increasing difficulty in attracting and retaining young people for military functions (Silva *et al.,* 2019). This phenomenon is not restricted exclusively to the Portuguese context and has been the subject of studies (Lievens, 2007; Marrone, 2020; North Atlantic Treaty Organization; Research And Technology Organization, 2007), largely due to the financial and operational costs that the difficult regeneration of HR entails, essentially in the category of Private (Lievens, 2007; Marrone, 2020; North Atlantic Treaty Organization; Research And Technology Organization, 2007).

The low adherence of young people, especially to the Private rank, currently represents one of the great challenges facing the EP. Chart 1 shows the evolution of the annual figures for open vacancies and their applications. The growing need to increase the military force and a concomitant decrease in young candidates have resulted in a negative trend in the number of candidates per vacancy, with values that can be considered critical reported in 2018 (Silva *et al.,* 2019). The difficulty of attraction has been verified in the data collected, during the attraction that occurs throughout the selection and training process of the new military, in the voluntary departure (of the active military) and in the mandatory departure (of the military that reaches the maximum limit of contractual renewals). The relationship between the phenomena triggered the notion of a vulnerability at the level of the Army'S HR, which motivated the development and application of intervention measures, among which the following stand out: the decrease in waiting time from the application to the call for the selection process, the elimination of minimum physical fitness requirements, greater geographical distribution of military training courses, the increase in salary during training and the flexibility of tattoos (Silva *et al.,* 2019). In the same sense, the regulation on incentives for the provision of military service was also updated (Decreto-Lei nº 76/2018), however, the set of measures implemented did not prevent the lack of adherence to military service and a voluntary exit that represents amorphous models for the system itself.

Faced with the problem and considering its similarities with the challenges also felt in the international military context (for example, in the USA and Belgium, among others) (Bertonha, 2008), the following analysis intends to know and differentiate the young people who are incorporated into the Army and, thus, contribute to the improvement of the recruitment system.

Chart 1 – Annual number of open places and applications received for the category of Private



Source: adapted from Silva et al. (2019).

Research on the topic suggests the need to investigate the different factors, individual and organizational, that can contribute to a greater attractiveness of military personnel (Lievens, 2007; Marrone, 2020; North Atlantic Treaty Organization; Research And Technology organization, 2007). The present study aims to analyze the profiles of young people incorporated in the category of squares of the EP. The analysis is based on data collected at the time of incorporation, when individuals do not yet have a tacit knowledge of the institution and distinguishes profiles based on the individual characteristics of the trainees, but also their perception of organizational characteristics, attractiveness factors and the level of information of the institution. The results obtained allow us to have a greater knowledge of the young people who have been recruited by the organization and to formulate contributions to new recruitment strategies.

2 METHODOLOGY

The investigation carried out is intended to provide information to support the decision of the Army Command. Thus, a questionnaire was constructed to monitor and measure a set of variables about young people who are starting military life in the EP. This questionnaire is carried out online through the LimeSurvey platform and its application takes place during the incorporation process. The moment of incorporation refers to the day on which candidates, determined in the selection tests, begin the military training necessary for the provision of military service on a voluntary or contract basis. The data collection carried out at this time has as main objective to know the HR that are in the process of integration in the organization, in order to improve internal processes, promote the institutional image and intervene in the investment without return associated with the early exit of the organization (Lomascolo, 2008; North Atlantic Treaty Organization; Research and Technology Organization, 2007; Lomascolo Strand; Berdndtsson, 2015). In total, 2,082 young people participated in the Army's Common General Training Course for enlisted men, held between 2018 and 2020 and, for the purposes of the study, data on gender, area of residence, school and professional path, motivations and perceptions about the institution were used. It should be noted that to carry out this study in the

Portuguese Army, there is no need to submit a research protocol to an ethics committee, it is only necessary to obtain the superior authorization of the Command. It is also added that it was the Army Command itself that assigned responsibility to the Army Center of Applied Psychology for the continuation of the analysis of the phenomenon.

2.1 Statistical Analysis

Multiple correspondence analysis (MCA) is an exploratory method that aims to verify and study the interrelationships between the categories of variables under analysis. Being a method of investigation, the interpretability of the plan of the categories is undoubtedly the essential element for the study. The graphical analysis of the MCA allows, in a representative way, to visualize the relationship of the distribution between the variables. The respective categories to the variables under analysis are represented by points and the distance between them allows to interconnect the existence or not of relationships, translating into the construction of profiles.

The graphic construction has preponderance according to the variables that focus on the axes (which represent the dimensions created) and that their categories are strongly correlated between them and the axes, as can be seen in the following table:

Table 1 – Measures of Discrimination and contributions of variables

Variables	Dimension 1		Dimension 2	
	Discrimination	Contribution	Discrimination	Contribution
Area of Residence	**0,241**	13,40%	0,045	2,90%
Qualifications	**0,617**	34,30%	0,009	0,60%
Reason for admission	0,015	0,80%	**0,273**	17,20%
Want to compete in a higher category	0,015	0,90%	**0,251**	15,80%
History of school failure	**0,441**	24,50%	0,022	1,40%
Willingness to follow studies	**0,265**	14,70%	0,015	0,90%
Level of information about the Army	0,011	0,60%	**0,420**	26,50%
Perception of Remuneration	0,055	3,10%	**0,294**	18,60%
Conditions offered in the labor market	0,139	7,70%	**0,255**	16,10%
Inertia	0,200		0,176	
% variance explained	11,50%		10,12%	

Source: Portuguese Army

The software used for the analysis was IBM SPSS.

According to the table presented, it is observed which are the variables that contribute most to the definition of the axes composed of Dimension 1 and Dimension 2, which were called "Area of residence and history of school failure" and "Reasons for admission and perceptions about the institution".

3 PRESENTATION OF RESULTS AND DISCUSSION

3.1 Characteristics of new recruits

To understand the profile of young people who joined the category of Private of the EP, a set of questions about sociodemographic characteristics was analyzed. These data described in Table 2 revealed that most of the graduates have a history of school repetition (64%) and at the level of education, the secondary completed (63.3%), registering, however, a significant percentage of cases (34.3%) that had only the 3rd cycle of basic education, not completing, thus, the 12th year of schooling (in Brazil, the 3rd cycle of Portuguese basic education corresponds to elementary education and the 12th year of schooling corresponds to Brazilian High School), as described in national legislation (Decreto-Lei nº 176/2012). It should be noted that, since the 3rd cycle is the minimum schooling for applying for the Private rank (Portugal, c2021), obtaining HR with low qualification level may negatively influence the professional performance of the recruited workforce (Ng; Feldman, 2009). Table 2 shows that most of the respondents come from the north of the country. These data are grouped by "area of residential " and result from the combination of cases with a better distribution of the sample and a geographical relationship between residential districts. As an example, the districts belonging to the territorial units of Alentejo and Algarve were grouped into "South" residential zone for statistical analysis purposes.

Table 2 – Characteristics of graduates at the time of incorporation

Characteristics of trainees	N	%
Gender		
Male	1736	83%
Female	346	17%
History of school repetition		
Repeated	1339	64%
Never repeated	743	36%
Education		
3rd cycle	714	34%
Secondary education	1317	63%
Higher Education	49	2%
Other	2	0%
Professional status prior to entry		
Unemployed	1401	67%
Employed	681	33%

Characteristics of trainees	N	%
Area of residence		
North	1072	51%
Centre	514	25%
South	307	15%
Autonomous Regions	189	9%

Source: Portuguese Army

3.2 Ingress characteristics

After analyzing the characteristics of the young people incorporated in the EP, it is also important to know their motivations, aspirations and perceptions about the institution. Regarding the motivation for joining, in Table 3, it is possible to observe that the majority of young people (69%) decided to enlist because of the possibility of "serving the homeland and defending the country", contrary to a minority who joined because of the conditions offered and opportunities provided.

To understand the attractiveness of military service, we resorted to the theory of Moskos (1986), which distinguishes occupational values from institutional values. According to the author, the entry motivated by the defense of the country can be classified as an institutional value defined as an intrinsic and differentiating attribute of the military institution that appeals to a cause superior to the individual interest of the young person. In contrast, motivations based on working conditions, among others, can be included in occupational values characterized as personal interests or motivations (Helmus *et al.*, 2020. According to the author, the current voluntary military service would lead the military organization to lose its institutional values in favor of occupational values oriented to salary and other benefits (*idem.*). However, the results obtained reveal that institutional values continue to prevail over occupational values, suggesting the importance of promoting organizational identity as a factor of attractiveness (LIEVENS, 2007).

The analysis described in Table 3 shows that most of the new graduates (62%) felt informed about the institution, however, a significant percentage had a low or moderate level of knowledge. Regardless of the conditions offered at the time of admission, the decision to enter also depends on the path that the institution provides to the young person. In this sense, it was observed that, at the time of incorporation, most recruits aspire to compete for a higher category (77%) and many have the necessary qualifications for this ascent in the military hierarchy (63%, see Table 1). With the increase in the level of education in the Portuguese population (PORDATA, 2021), admission based on academic qualifications tends to increase eligibility for higher categories[1], facilitating upward movements that make it difficult to fill vacancies at the

1 As an example, both categories of Privates and Sergeants compete for young people with secondary education and a similar age range.

base of the pyramid. It is also added, in references to future aspirations, that the majority of respondents expressed a desire to continue their studies (70%). The data reinforce the relevance of disseminating and ensuring access to incentives related to professional and academic training provided for in regulation (Decreto-Lei nº 76/2018).

Table 3 – Ingress characteristics of graduates

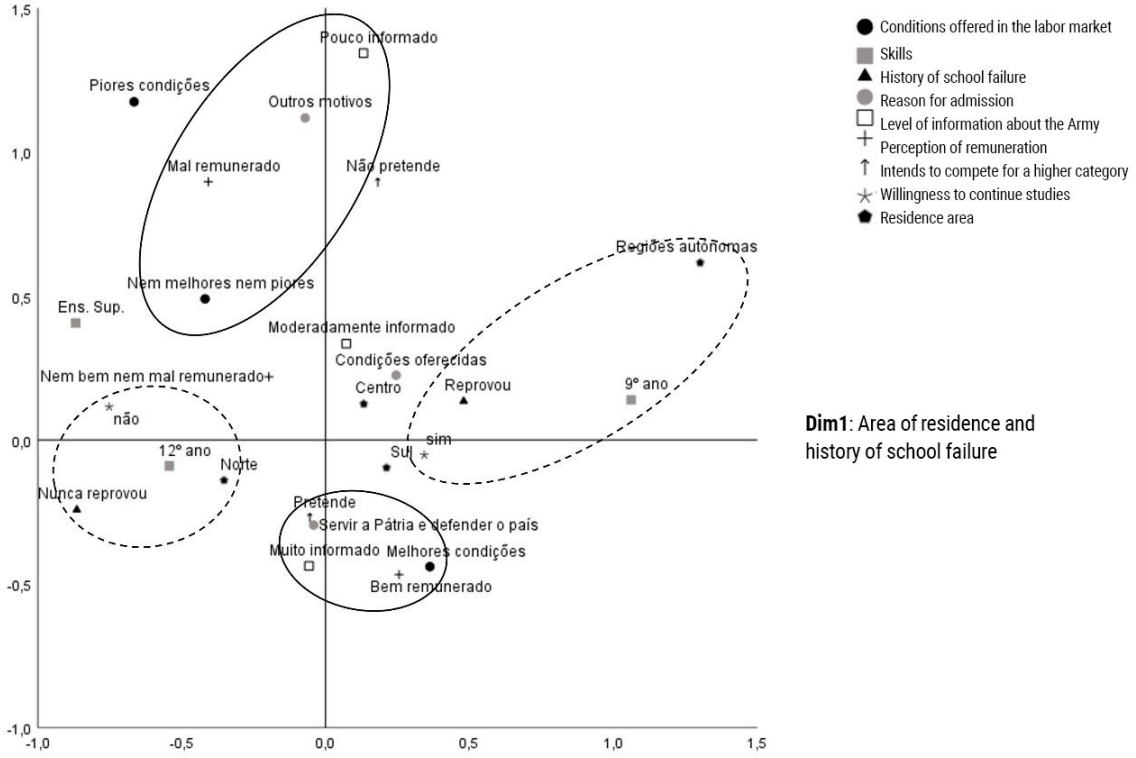
Ingress characteristics	N	%
Reason for ingress		
Serve the motherland and defend the country	1436	69%
Working conditions offered	333	16%
Fitness, action & adventure	117	6%
Be independent	169	8%
Not having another opportunity	27	1%
Market conditions		
Better conditions	1131	54%
Not worse, not better	904	44%
Worst conditions	47	2%
Perception of remuneration		
Well paid	1126	54%
Neither well nor poorly paid	488	23%
Poorly paid	468	23%
Level of information about the Army		
Very informed	1292	62%
Moderately informed	491	24%
Poorly informed	299	14%
Want to appl		
Intends	1599	77%
Not intended	483	23%
Willingness to pursue studies		
Yes	1430	69%
No	652	31%

Source: Portuguese Army

3.3 The Profile of the Military that competes for the Portuguese Army

Based on the variables under analysis and proceeding to a multiple correspondence analysis (MCA) as an exploratory method (Carvalho, 2017), it was possible to materialize the construction of distinct profiles of recruits. Graph 2 shows the representation of the exploratory profiles, supported by a preliminary analysis. The expressed results identify two dimensions that relate the history of school repetition and the area of residence, with the reasons for admission and perceptions about the institution. The first dimension was called "Area of residence and history of school repetition" and allows us to visualize the differences between schooling, academic success and willingness to continue studies among individuals in the north of the country and the autonomous regions. The second dimension was designated as "reasons for entry and perceptions about the institution" which demonstrates the perception of the graduates in relation to the salary they will obtain, the conditions offered, the main reason for entry, their perception of the information they have about the Army and if they intend to apply for a higher category.

Figure 2 – Profiles of reasons for joining



Source: Portuguese Army

The analysis of the first dimension allows identifying different profiles that suggest interesting reflections which discriminating variables are related to the area of residence and school course. Thus, we find the group of subjects who lived in the north and who had associated the attributes of 12th grade of schooling, a school course without failures and without the desire to continue their studies. On the other hand, on the same axis, there is the group of individuals with basic education, resident in the autonomous regions, with a history of school failure and with a desire to continue their studies.

Taking into account the second dimension, a group of recruits is observed, whose main reason for joining was "to serve the motherland and defend the country". These individuals demonstrated an intention to compete for a higher category, felt very informed about the EP at the time of incorporation, considered the military profession well paid and with better conditions compared to other jobs. In contrast, there is also a group of young people who did not intend to apply for a higher category, felt little informed about the institution and perceived unfavorable conditions and opportunities compared to alternatives in the market.

4 CONCLUSION

Knowing the young recruit is essential to rethink the intended candidate profile and outline recruitment strategies aimed at the target audience. The relevance of this theme is unquestionable in view of the HR needs registered in recent years that can compromise the response to institutional missions.

In order to analyze the profiles of young people incorporated into the category of Private of the EP, a sample of 2,082 respondents obtained through a questionnaire applied at the time of incorporation was used. The data analysis made it possible to identify a set of characteristics of the new graduates, namely the prevalence of young men, unemployed and with a history of failing school education. It was found that the vast majority of military personnel have higher qualifications than necessary for entry into the Private rank, a situation that is inseparable from their intention to compete for a higher rank, and the importance of promoting HR management capable of predicting upward movements within the Organization. Different profile patterns were observed, depending on the area of residence, school characteristics and professional perspectives. From a recruitment and dissemination perspective, it should be noted that institutional values remain a main attraction factor for young Portuguese people. The importance of improving information about the institution, the target audience and their influencers was identified. In the patterns identified, it was observed that graduates from the northern region have a successful school career contrary to those from the autonomous regions, who enter less qualified, but with the intention of continuing their studies. In this case, the school and academic incentives of the Armed Forces should play an important role in attracting young islands residents to the EP.

Thus, the data obtained are still in line with other studies that point to a change in the patterns of interests of the new generations and for which there should be great attention, to highlight in young Portuguese the value associated with the military Institution and that should be enhanced and explored.

Finally, this study shows that, given the dimensions raised, there are different profiles of candidates at the level of the country's areas, so this factor can also be taken into account in the dissemination and recruitment strategies of HR.

The continuity of the monitoring implemented by the EP may stimulate studies capable of obtaining new measures to respond to the problem of recruiting young people to the military Institution.

REFERENCE

BERTONHA, J. F. Recrutas ou profissionais? Os dilemas das forças armadas dos EUA na virada do século XXI. **Meridiano 47**, Brasília, DF, v. 9, n. 90, p. 2-4, 2008. Available at: https://periodicos.unb.br/index.php/MED/article/view/2875. Accessed: 8 Feb. 2022.

BRASIL. **Decreto-Lei nº 76 de 11 de outubro de 2018**. Aprova o regulamento de incentivos à prestação de serviço militar nos diferentes regimes de contrato e no regime de voluntariado. **Diário da República**: seção 1, Brasília, DF, n. 196, p. 4936-4945, 11 out. 2018.

BRASIL. **Decreto-Lei nº 176, de 2 de agosto, 2012**. Regula o regime de matrícula e de frequência no âmbito da escolaridade obrigatória das crianças e dos jovens com idades compreendidas entre os 6 e os 18 anos e estabelece medidas que devem ser adotadas no âmbito dos percursos escolares dos alunos para prevenir o insucesso e o abandono escolares. **Diário da República**: seção 1, Brasília, DF, n. 149, p. 4068-4071, 8 fev. 2012.

CARVALHO, H. **Análise multivariada de dados qualitativos**: utilização da análise de correspondências múltiplas com o SPSS. 2. ed. Lisboa: Edições Sílabo, 2017.

COELHO, A. *et al*. Estudo de caracterização sociodemográfica e de satisfação organizacional dos militares do regime de voluntariado e de contrato dos três ramos das forças armadas. *In*: PORTUGUAL. **Militares RV/RC**: caracteristicas e perceções: research brief. Lisboa: Defesa Nacional, 2019. Available at: https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=%3D%3DBAAAAB%2BLCAAAAAAABACzMLAwAACVZvYBBAAAAA%3D%3D. Accessed: 8 Feb. 2023.

HELMUS, T. C. *et al*. **Life as a private**: a study of the motivations and experiences of junior enlisted personnel in the U.S. Army. Santa Monica: RAND Corporation, 2020. Available at: https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2252/RAND_RR2252.pdf. Accessed: 8 Feb. 2022.

LIEVENS, F. Employer branding in the Belgian Army: the importance of instrumental and symbolic beliefs for potential applicants, actual applicants, and military employees. **Human Resource Management**, [*s. l.*], v. 46, n. 1, p. 51-69, 2007.

LOMASCOLO, A. F. **"Do you want excitement? Don't join the Army, be a Nurse!"**: identity work and advantage among men in training for the female professions. 2008. Doctoral (Dissertation) – Virginia Tech, [Blacksburg], 2008.

MARRONE, J. V. **Predicting 36 months attrition in the US Military**: a comparison across service branches. Santa Monica: RAND Corporation, 2020. Available at: https://www.rand.org/pubs/research_reports/RR4258.html. Accessed: 8 Feb. 2022.

MOSKOS, C. C. Tendências institucionais/ocupacionais nas forças armadas: uma atualização. **Forças Armadas e Sociedade**, v. *12*, n. 3, p. 377-382, 1986.

NORTH ATLANTIC TREATY ORGANIZATION; RESEARCH AND TECHNOLOGY ORGANISATION. **Recruiting and retention of military personnel**: final report of research task group HFM-107. Brussels: NATO; RTO, 2007. (RTO Technical report, TR-HFM-107).

NG, T. W.; FELDMAN, D. C. How broadly does education contribute to job performance? **Personnel Psychology**, [*s. l.*], v. 62, n. 1, p. 89-134, 2009.

PORDATA. **Dados estatísticos**. Lisboa: Fundação Francisco Manuel dos Santos, 2021. Available at: https://www.pordata.pt/. Accessed: 12 Feb. 2021.

PORTUGAL. Exército. Regime de contrato/voluntariado. **Como te podes candidatar**. Lisboa: Exército, c2021. Available at: https://www.exercito.pt/pt/junta-te/rc-rv. Accessed: 8 Feb. 2021.

SILVA, M. *et al.* **Employer branding: the army mirrored on it's candidates**. Lisboa: [*s. n.*], 2019. European Research Group on Military and Society. Apresentação em conferência.

STRAND, S.; BERNDTSSON, J. Recruiting the "enterprising soldier": Military recruitment discourses in Sweden and the United Kingdom. **Critical Military Studies**, [London], v. 1, n. 3, p. 233-248, 2015.

ARTICLE DOI 10.52781/cmm.a099

Physiological Responses to 12-Km Loaded March Carrying a Machine Gun or a Rifle: Effect of Weapon Weight in Physically Fit Military Personnel

Respuestas fisiológicas a la marcha equipada de 12 km transportando una ametralladora MAG o un fusil: el efecto del peso del armamento en militares bien acondicionados

Abstract: The objective was to compare physiological responses, during a 12-km march following Brazilian Army protocols, between two groups carrying different loads (personal equipment plus machine gun and personal equipment plus rifle). Additionally, we investigated whether there is a correlation between load weight, in percentage of total body mass (%TBM), and those physiological responses. The following variables were analyzed: mean heart rate, heart rate variation, blood lactate variation and mean rating of perceived exertion. The personal equipment + machine gun group presented significantly higher median values for mean heart rate and heart rate variation. Furthermore, our data showed that load (%TBM) was positively and significantly correlated with all physiological variables assessed, except for blood lactate variation. Performing long-distance load carriage with a machine gun caused greater cardiovascular effort than carrying a rifle.

Keywords: military; weight-bearing; walking; physical exertion; physiological responses.

Resumen: El objetivo fue comparar las respuestas fisiológicas, durante una marcha de 12 km siguiendo los protocolos del Ejército Brasileño, entre dos grupos que transportaban diferentes cargas (equipo personal más ametralladora y equipo personal más fusil). Además, investigamos si existe una correlación entre el peso de la carga, en porcentaje de la masa corporal total (%MCT) y esas respuestas fisiológicas. Se analizaron las siguientes variables: frecuencia cardiaca media, variación de la frecuencia cardiaca, variación del lactato sanguíneo y percepción subjetiva del esfuerzo media. El grupo de equipo personal + ametralladora presentó medianas significativamente más altas para la frecuencia cardíaca media y la variación de la frecuencia cardíaca. Además, nuestros datos mostraron que la carga (%MCT) se correlacionó positiva y significativamente con todas las variables fisiológicas evaluadas, excepto con la variación del lactato sanguíneo. Realizar un transporte de carga de larga distancia con una ametralladora provocó un mayor esfuerzo cardiovascular que llevar un fusil. Además, las cargas más pesadas (% MCT) se correlacionan con una mayor respuesta cardiovascular y una mayor clasificación de percepción subjetiva del esfuerzo.

Palabras clave: militar; soporte de peso; caminata; esfuerzo físico; respuestas fisiológicas.

Lucas Vieira Coelho Dos Santos[1]
lucasvcoelhos@gmail.com

Adriane Mara de Souza Muniz[1]
adriane_muniz@yahoo.com.br

Bruno Trassi Fernandes Silva De Souza[1]
brunotrassi.eb@gmail.com

Ricardo Alexandre Falcão[1]
ricfal9@gmail.com

Verônica Pinto Salerno[2]
vpsalerno@yahoo.com.br

Luis Aureliano Imbiriba[2]
luis_aureliano@hotmail.com

Miriam Raquel Meira Mainenti[1]
miriam.mainenti@hotmail.com

[1]Exército Brasileiro. Escola de Educação Física do (EsEFEx).Rio de Janeiro, Brasil.

[2]Universidade Federal do Rio de Janeiro. Escola de Educação Física e Desportos (EEFD). Rio de Janeiro, Brasil.

Received: 28 Oct. 2022
Approved: 06 Feb. 2023
COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

Military training and operations often depend on personal mobility. In these situations, soldiers carry their own equipment and supplies on their body, usually in backpacks and webbings, thus forming a load-carriage system (BIRREL; HOOPER; HASLAM, 2007; KNAPIK; REYNOLDS; HARMAN, 2004). Service members are thus required to maintain proper physical conditioning, as they may often find themselves in extreme situations where they must endure higher levels of fatigue than usually required from the population in general.

Among military preparation activities, marching training stands out, as it is one of the physical activities most required during military operations, representing about 60-70% of the Australian military tasks, for example (ORR, 2012). Lack of available motorized transport, tactical or terrain impositions and even military instruction or physical training are situations where troops are required to march (BRASIL, 2019). In addition, after marching, the troops must arrive at their stated destination on schedule and able to fight and fulfill the assigned mission.

Although terrain, weather conditions and psychological factors exert a considerable influence on marching (JOVANOVIĆ et al., 2014; MCCORMICK; MEIJEN; MARCORA, 2015; VOLOSHINA, 2013), physiological factors should be given special attention, as physical fitness has a decisive relation to performance (KNAPIK et al., 1990; KRAEMER et al., 1987; SWAIN, 2011), and thus to the fulfillment of the task. Military personnel with platoon marching experience report there are more exhausting roles to be performed, due to the heavy load carried. Therefore, researches are being conducted to assess physiological responses of service members while carrying different loads (FAFUNDES et al., 2017; HOLEWIJN, 1990; PAL et al., 2009; PHILLIPS et al., 2016; QUESADA et al., 2000; STUEMPFLE; DRURY; WILSON, 2004), analyzing heart rate (HR), oxygen consumption (VO_2), rating of perceived exertion (RPE) and other physiological (ventilatory threshold, minute ventilation, respiratory exchange ratio, energy expenditure, inspiratory and expiratory mouth pressures, blood lactate, glucose concentration), biomechanical (electromyography activity, joint rotations and moments, isometric maximal voluntary contraction) and cognitive (correct responses, false alarms, sensitivity) variables (FAFUNDES et al., 2017; FAGHY; BLACKER; BROWN, 2016; GILES, 2019; GRENIER et al., 2012; HOLEWIJN, 1990; PAL et al., 2009; PHILLIPS et al., 2016; QUESADA et al., 2000). However, study results still differ somewhat, with a set of studies not finding any effect of different loads on physiological responses (FAGHY; BLACKER; BROWN, 2016; FAGUNDES et al., 2017; PHILLIPS, 2016) and another set that does (BORGHOLS; DRESEN; HOLLANDER, 1978; GILES, 2019; GRENIER et al., 2012; PAL et al., 2009; PIHLAINEN et al., 2014), as described up below.

One of the first studies on this topic found that during a walk carrying weights of up to 30 kg, each extra kg of weight increased VO_2 by 33.5 milliliters per minute (ml/min), heart rate by 1.1 beats per minute (bpm) and pulmonary ventilation at 0.6 liters per minute (l/min) (BORGHOLS; DRESEN; HOLLANDER, 1978). Another study compared a

50-minute march at an average speed of 5.7 km/h while carrying 5.4 kg of equipment with the first 60 minutes of marching at an average speed of 5.4 km/h while carrying 24.4 kg of equipment, both on terrain with variable inclines (PIHLAINEN et al., 2014). The study results showed significant increases in VO_2, $\%VO_2max$, HR and %HRmax when carrying 24.4 kg (PIHLAINEN et al., 2014). Grenier et al. (2012) also identified a significant variation in mean HR (91 bpm to 139 bpm) depending on the load (23 kg or 47 kg) and the positive elevation change (240 m and 570 m) over the course of the 15-km march. Another study also found that walking speed interferes with HR (modified Harbor protocol), which increases according to speed and load (unloaded: 88.7 bpm at 3.5 km/h, 94.8 bpm at 4.5 km/h; with a 40-kg load: 114.4 bpm at 3.5 km/h, 127 bpm at 4.5 km/h) (PAL et al., 2009). More recently, Giles et al. (2019) found a significant load carriage impact on %HR reserve, with values progressively increasing for load carriage conditions of 47.2 kg and 50.7 kg, compared with 8.8 kg.

Other studies, however, have found different results. Fagundes et al. (2017) found no significant differences in HR and RPE when varying the load from 0% to 15% of body mass both in maximal running tests and in a submaximal test at 90% of the ventilatory threshold. Phillips et al. (2016) also did not find significant HR variations when comparing loaded (25 kg; 189 bpm) and unloaded (187 bpm) maximal stress tests using the modified Balke protocol, despite a reduction in test duration in the loaded condition. Faghy, Blacker and Brown (2016) found no significant differences in blood lactate values when comparing 60-minute submaximal tests performed on a treadmill, with varying loads ranging from 0 to 20 kg.

In addition to this lack of consistency in findings, most studies carried out laboratory tests (FAGHY; BLACKER; BROWN, 2016; FAGUNDES et al., 2017; HOLEWIJN, 1990; PHILLIPS et al., 2016; PAL et al., 2009; QUESADA et al., 2000; STUEMPFLE, DRURY, WILSON, 2004) and did not vary the weight of weaponry, only of backpacks. However, weapons are usually carried during marches, training activities and military operations, and should be considered and assessed. The function which involves carrying a rifle has great importance for platoon tactical organization, as it is the most basic one and performed by most platoon soldiers, as well as carrying a machine gun, due to the firepower of this armament. Knowing the variations in physiological responses involved in each of the platoon duties will help to establish differentiated training activities aimed at developing a level of physical conditioning adequate to the effort required for loaded marching.

Therefore, the aim of this study was to compare physiological responses between a group of individuals carrying personal equipment (PE) plus a machine gun with another group carrying personal equipment plus a rifle during a 12-km march. In addition, we examined whether there is a correlation between the load carried, in percentage of total body mass (%TBM), and the physiological responses measured.

2 METHODS

2.1 Study design

An experimental study was carried out in which military service members were randomly assigned to two groups to perform a 12-km march: carrying either a rifle (lighter, control group) or a machine gun. Physiological responses were measured before, during and after marching.

2.2 Ethical aspects

The study research protocol was approved by the local ethics committee (CAAE: 83493618.1.0000.5235).

2.3 Sample

The sample consisted of 30 volunteer military officers (lieutenants and captains) serving in a Brazilian Army garrison in Rio de Janeiro (convenience sample). Inclusion criteria were as follows: participants should be military volunteers, male, aged between 20 and 32 years old (median: 26.50; 1st quartile: 25.00; 3rd quartile: 28.00 years old), in active service from 7 to 15 years (median: 8; 1st quartile: 7; 3rd quartile: 10 years), have achieved a minimum score of "Good" (B) in the Army Physical Fitness Test (APFT) and have signed the Free and Informed Consent Form (FICF). Were excluded from the study those who had just ended their period of assigned daily duties; with orthopedic, rheumatologic, respiratory or neurological conditions; with acute or chronic musculoskeletal pain; or who used medication that could alter the visual and vestibular systems. Health information was self-reported by participants and confirmed with their military organization's Health Section.

2.4 Test procedures

All participants performed a 12-km march in accordance with the Brazilian Army field manual (BRASIL, 2019). The march was divided into three 4-km stages, with a total duration of three hours. The first stage lasted 45 minutes (average speed of 5.3 km/h), followed by a 15-min rest period. The second and third stages were completed in 50 minutes each (average speed of 4.8 km/h), with a 10-min interval between them (BRASIL, 2019). The 12-km march was performed on a 1-km track, with the start and finish lines at the same place. Two persons at checkpoints located about 500 meters apart were tasked with monitoring the participants' average speed and alerting them to increase or reduce their pace.

All participants marched wearing personal equipment (PE), consisting of belt, suspenders, two 1-liter canteens filled with water, helmet and a large capacity backpack.

However, the sample was randomly divided into two equal groups of 15 participants, each group armed with a different weapon: one used a rifle simulator (4.7 kg) and the other a machine gun simulator (10.8 kg). Both simulators consisted of Mauser Model 1935 rifles with different loads attached to their centers in order to reach the approximate weight of the rifle and the machine gun.

Marching took place in the facilities of the Army's Physical Training Center (CCFEx), Rio de Janeiro. Three volunteers were selected each day between 17:00 and 22:00. Average temperature during marches was of 22.94 ± 1.93ºC and relative humidity was 79.61 ± 4.78%.

Volunteers showed up at the laboratory half an hour before marching for filling the anamnesis form (informing their last APFT score, length of service, age and presence or absence of pain or injury), signing the FICF and having total body mass (TBM, with and without the equipment), pre-effort lactate and resting heart rate measured. They were then randomly assigned to a group by drawing of lots. First we used 10 pieces of paper (10 days of data acquisition) with different sequences of three conditions (we collected data from three military officer per day). The distribution of rifle and machine gun in these sequences was organized in order to ensure a total of 15 individuals for each group. Then, we used simple pieces of paper in a small box with letters F and M, for rifle (F from "fuzil", rifle in Portuguese) and machine gun groups, respectively. After knowing which weapon would be used, we presented instructions on the sequence of activities, the route to be taken and safety rules.

Before marching, all participants ate a cereal bar containing 79 kilocalories and hydrated themselves with at least 200 milliliters of water. Each volunteer marched alone and to this end they started the march at intervals of about 20 minutes. During the rest periods, participants were allowed to remove the backpack and were fed a cereal bar and hydrated.

Heart rate was recorded continuously and perceived exertion was recorded at 0.5 km intervals (while marching) and at the end of the march. After marching, lactate was measured again. The assessments were performed by trained examiners who were working with the main output variables for, at least, six months. Furthermore, the heart rate monitor and the blood analyzer employed in this study are worldwide used and well respected for scientific purposes.

2.5 Instruments

Heart rate (HR) was measured with a V800 heart rate monitor (Polar, Finland), fitted with a Polar H7 strap. After marching, data (HR, distance covered, pace, among others) were transmitted via bluetooth for storage with the Polar Flow software (Polar, Finland). Lactate was measured by analyzing capillary blood with an Accutrend Plus monitor (Roche, Portugal). Perceived exertion was assessed using the modified Borg rating of perceived exertion (RPE), ranging from zero (no exertion) to ten (maximum exertion) (BORG, 1998); participants were given instruction on the scale before marching, which was later reinforced during data collection.

Participants' height was measured with a Professional Sanny stadiometer (American Medical do Brasil Ltda, Brazil) and their Total Body Mass (TBM) with a model 876 digital scale (Seca, Germany). Temperature and relative humidity were measured with a digital thermo-hygrometer (Incoterm, model TTH100, Brazil) at the beginning of each marching stage.

2.6 Data Analysis

Outcome variables were mean heart rate during the 12-km march excluding rest periods (Mean HR); heart rate variation (HR Var), calculated by subtracting the maximum value reached and the rest value; lactate variation (Lac Var = post-march value - pre-march value); and the average of all recorded values of RPE over the 12 km (Mean RPE).

The Shapiro-Wilk test was used to assess the normality of the data set. For descriptive statistics, the median was used [1st quartile; 3rd quartile], because most data have a non-parametric distribution. Statistical comparison of groups was performed using the independent samples Student's T test for Mean HR, age, TBM, height and total load carriage weight (parametric data), and the Mann-Whitney U test for HR Var, Lac Var and Mean RPE (nonparametric data). Categorical data of APFT scores were presented in absolute and relative frequency, and the two groups were compared using the chi-squared test.

Correlation between load (% of total body mass) and outcome variables were assessed using the Pearson test (r) for Mean HR and the Spearman test (rho) for HR Var, Lac Var and Mean RPE. The correlation coefficient (r/rho) was classified as: very strong for r values ≥ 0.90; strong for r between 0.6 (inclusive) and 0.9; regular for r between 0.3 (inclusive) and 0.6; and weak between 0 and 0.3 (CALLEGARI-JACQUES, 2003).

Statistical significance was set at $p < 0.05$, and the analyzes were performed using the SPSS software (version 27.0).

3 RESULTS

Sample characterization data are shown in Table 1. The groups were not different for age, total body mass, height nor Army physical fitness test scores (APFTS). They differed only in the conditions set for the purpose of this study, the total load carriage weight: PE + rifle = 24.7 [24.4; 24.8] kg and PE + machine gun = 30.7 [30.7-30.8] ($p < 0.001$).

Table 1– Characterization of the sample

	Total	PE + rifle	PE + machine gun	p value
Age (years)	26.50 (25.00 - 28.00)	27.00 (25.00 – 28.00)	26.00 (25.00 – 29.00)	1.00[α]
TBM (kg)	79.72 (73.96 - 85.88)	79.05 (74.15 – 85.85)	80.00 (69.55 – 86.00)	0.96[α]
Height (m)	1.77(1.71 - 1.82)	1.79 (1.70 – 1.87)	1.77 (1.71 – 1.81)	0.70[α]
APFTS (%)	E - 46.7% VG - 20.0% G - 33.3%	E - 53.3% VG - 20.0% G - 26.7%	E - 40.0% VG - 20.0% G - 40.0%	0.71[β]

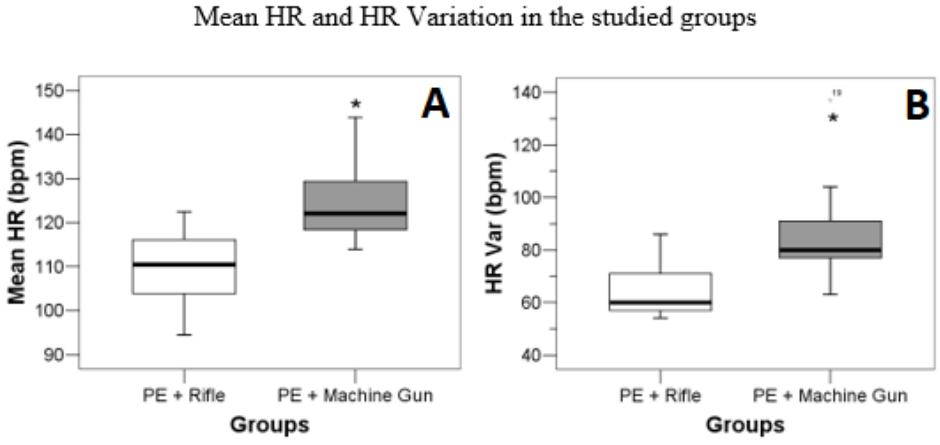
Source: the authors.

Subtitle: PE = Personal equipment, TBM = Total Body Mass, APFTS = Army physical fitness test score, E = Excellent, VG = Very good, G = Good. [α]p value for Student's T test; [β]p value for chi-squared test.

Mean HR and HR Var data for only 26 of the 30 participants were used, due to the loss of data due to operational problems with the frequency meters.

Considering the sample as a whole, the following results were obtained: Mean HR = 117.19 (110.24 - 123.91) bpm; HR Var = 75.00 (59.75 - 81.25) bpm; LacVar = -0.35 (-0.83 - 0.30) mmol/L; Mean RPE = 2.38 (2.03 - 3.21). Comparisons between groups revealed that the PE + Machine Gun group showed higher Mean HR and HR Var (Graphic 1) compared with the PE + Rifle group. No difference was found for Lac Var, with values of PE + rifle = -0.40 [-0.80; 0.60] mmol/L and PE + machine gun: -0.30 [-0.90; 0.10] mmol/L (p = 0.983); and for Mean RPE, with values of 2.25 [2.00; 2.88] and 2.83 [2.33; 3.83], respectively (p = 0.065).

Graphic 1 – Box plot with median, quartiles (1st and 3rd), and minimum and maximum values for Mean HR (mean heart rate) and HR Var (heart rate variation)

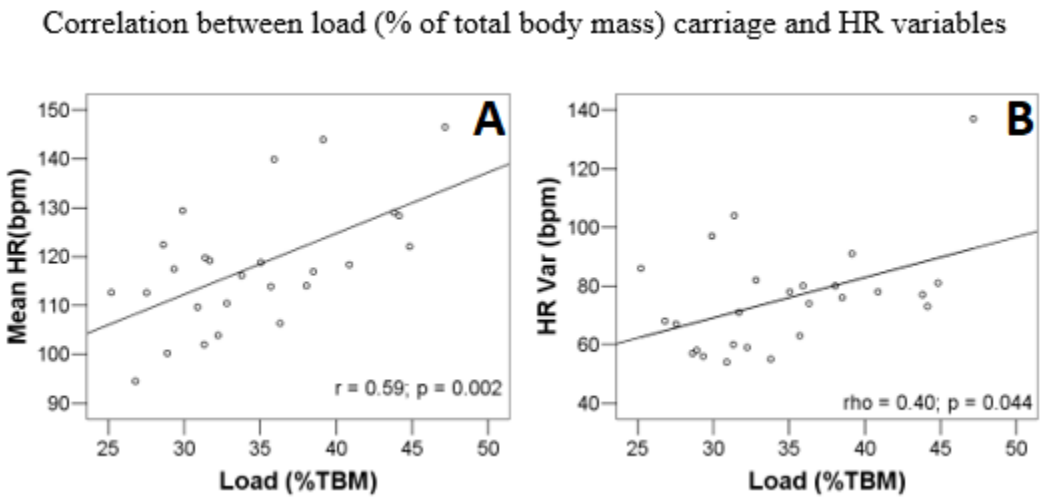


Source: the authors.

Subtitle: A) Mean HR (mean heart rate) and B) HR Var (heart rate variation) for PE (personal equipment) + Rifle and PE + Machine Gun groups. * $p < 0.05$.

Except for Lac Var (rho = 0.15), all variables showed positive, regular and significant correlations with load (% of total body mass) (Graphics 2, 3).

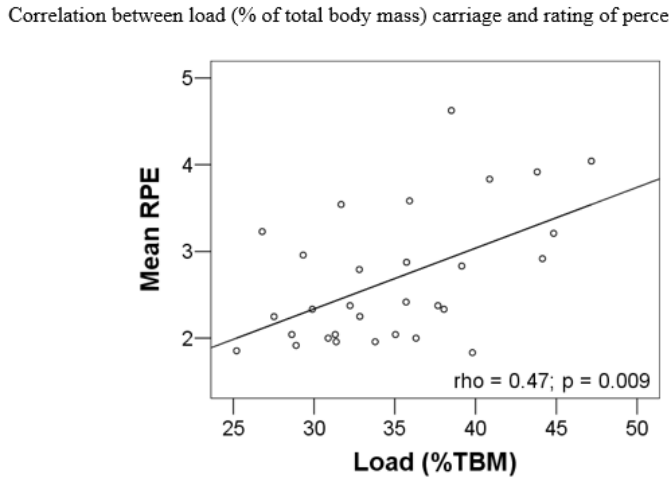
Graphic 2 – Scatter plot for load %TBM (% of total body mass), Mean HR (Mean heart rate) and HR Var (Heart rate variation)



Source: the authors

Subtitle: A) Mean HR (mean heart rate) and B) HR Var (heart rate variation). r = Pearson's correlation coefficient; rho = Spearman's correlation coefficient.

Graphic 3 - Scatter plot for load %TBM (% of total body mass) and Mean RPE (Mean rating of perceived exertion)



Source: the authors.

Subtitle: rho = Spearman's correlation coefficient; RPE = rating of perceived exertion; TBM = total body mass

4 DISCUSSION

This study aimed to compare physiological responses in a 12-km loaded march between two groups of participants: one carrying PE plus a machine gun and the other carrying PE plus a rifle. Additionally, we investigated whether there is a correlation between load carriage weight, in percentage of total body mass (% TBM) and physiological responses. Study results show that carrying the heaviest armament resulted in higher cardiovascular stress, with participants showing higher values for Mean HR and HR Var. With the exception of Lac Var, all variables showed a positive, regular and significant correlation with load carriage weight, as a percentage of total body mass.

The greater cardiovascular demands showed by the group that carried the heaviest load can be explained by the fact that physical activity increases the body's energy requirements, provoking several physiological responses aimed at meeting the increased metabolic demand (BRUM et al., 2004). Cyclical activities such as marching cause an increase in the activity of the sympathetic nervous system (FORJAZ; TINUCCI, 2000), and as a result in heart rate (HR), stroke volume (SV) and cardiac output (CO) (FORJAZ et al., 1998). According to Forjaz and Tinucci (2000), the greater the intensity of the exercise the greater the physiological responses, but these responses do not change during exercises performed at an intensity below the anaerobic threshold. Thus, holding and moving around with the additional weight of the machine gun requires greater CO, which can be achieved through greater HR and SV (MCARDLE; KATCH; KATCH, 2014), explaining the significantly greater values showed by the PE + machine gun group.

These results agree with those of Quesada et al. (2000), who identified that each 15% increase in load weight resulted in an increase in metabolic cost of about 5 to 6% when performing a 40-minute treadmill walk; however, the results differ from those of Fagundes et al. (2017), who found no significant difference in submaximal effort tests performed on a treadmill with loads ranging from 0 to 15% of body mass. Phillips et al. (2016) found no significant difference in Mean HR between groups carrying no load and a 25-kg load in incremental tests on the treadmill.

Grenier et al. (2012) found a variation of 81 bpm in a 4-hour march while carrying a 43-kg load for a simulated military mission, very similar to our results for the PE + machine gun group, which showed a median variation of about 80 bpm.

Unlike our Mean HR and HR Var results, lactate data indicate that differences in the weight carried do not significantly alter blood lactate levels, in agreement with the findings of Faghy, Blacker and Brown (2016), who also did not find significant differences in lactate levels. The likely cause for this result is that both groups performed a long-duration aerobic activity, which leads to a predominance of the oxidative system, resulting in a small concentration of lactate produced by the muscle (MCARDLE; KATCH; KATCH, 2014). The increase in blood lactate concentration is related to an increased lactate production in the muscles, which in turn is directly linked to the use of the lactic anaerobic system to generate enough energy for physical activity (MCARDLE; KATCH; KATCH, 2014).

The lactic anaerobic system is mainly used by the body in more intense physical activities, which require a large amount of energy in a short period of time (MCARDLE; KATCH; KATCH, 2014). Marching, for physically fit individuals, does not have the characteristics of these intense activities, and thus the energy system mostly used by the study participants was the aerobic system. In addition, because it requires greater CO, there is an increase in the blood flow, leading to a faster removal of lactate from the muscles and its transport to the liver to be converted into glucose. Therefore, it is understandable that there have been no major changes in lactate levels.

Perceived exertion data, in turn, showed no significant difference between the groups rifle and machine gun (p=0.065). However, when considering the relative load (a percentage of the individual's total body mass), it could be noted a positive significant correlation between load and RPE values. These results are in agreement with those of Quesada et al. (2000), who found a significant increase in RPE for loads equal to 30% of body mass (BM) in relation to 0%-BM and 15%-BM loads, possibly indicating that RPE increases for loads heavier than 30% of body mass.

A particularity of actual military operations is that, with respect to load carriage, all individuals carry similar absolute weight values, regardless of their body mass. This may cause smaller individuals to expend more energy, possibly generating more fatigue and greater risk of injury. To address this possibility, a correlation analysis was performed to assess the correlation between physiological responses and the weight of the load carried as a percentage of total body mass. Three of the four variables analyzed showed a positive and significant correlation with load (% of total body mass), confirming that a higher BM percentage load generates a greater physiological response.

One of the study limitations is that physiological responses were measured by simpler techniques compared with the direct measurement of oxygen consumption (VO_2) by gas-exchange analysis, which would allow energy expenditure estimation for a given physical activity (MCARDLE; KATCH; KATCH, 2014). This knowledge, however, would not be applicable to combat situations, with military personnel transporting their equipment on a foot march. To this end, heart rate measurement is a tool often used for estimating the intensity level of a physical activity. Another limitation was analyzing the load carried as a percentage of TBM and not of lean body mass. Using the latter in the analysis would allow distinguishing between individuals with the same body mass value but different body compositions. Percentage of body fat and lean body mass assessments should be added in future studies. This will make possible the analysis of load as a percentage of lean body mass or even specifically muscle mass, which will present a better data about muscle quality and function. It should be noted, however, that the troops' lean body mass values would hardly be available, and, on the other hand, TBM measurement is easy to perform, making this study's approach more realistic and applicable to large military contingents. Moreover,

only the armament varied in weight, but machine gun ammunition is known to be heavier, adding to the backpack weight and further impacting the results.

One of the study's strengths was conducting the march outside the laboratory environment, with an uneven route and external climatic conditions, thus improving the study's external validity. Another highlight was using equipment provided by the Brazilian Army's supply chain, which allowed reproducing the same load-carriage conditions that Brazilian troops face in actual military operations, especially with regard to weight distribution, balance and comfort. The only exception was the boots used, which belonged to each participant, in order to ensure greater comfort and avoid possible foot injuries.

It is also worth mentioning that this study aimed to analyze physiological responses in conditions as close as possible to those of actual operations: the load was carried not only in the backpack but also distributed among helmet, armament, belt and suspenders. Finally, marching distance was greater than in most studies (BEEKLEY et al., 2007; QUESADA et al., 2000), so as to observe the behavior of the variables over a longer time period.

5 CONCLUSIONS

Performing long-distance load carriage with a machine gun caused a greater cardiovascular effort than load carriage with a rifle. Moreover, carrying heavier loads (%TBM) is correlated with greater cardiovascular responses and greater RPE values. Military personnel that usually carry a machine gun during operational marching should pay more attention to improving their aerobic training than those that usually carry a rifle. Another practical implication of this fact is that commanders should select soldiers with better aerobic conditioning to carry machine guns, since this weapon demands a greater effort of the cardiovascular system.

ACKNOWLEDGEMENTS

The authors acknowledge CADESM/DECEx (Coordination for Evaluation and Improvement of Military Higher Education / Department of Education and Culture of the Army), that partially supported this work, under Grant "PRÓ-PESQUISA 2019"

AUTHORSHIP AND CONTRIBUTIONS

Author 1 - writing (original draft, revision and edition)
Author 2 – conceptualization, methodology and writing (revision)
Author 3 - writing (original draft and revision)
Author 4 - conceptualization, methodology and writing (revision)
Author 5 - writing (revision)
Author 6 - writing (revision)
Author 7 - conceptualization, methodology and writing (revision and edition)

REFERENCES

BEEKLEY, M. D. *et al*. Effects of heavy load carriage during constant-speed, simulated, road marching. **Military Medicine**, Oxford, v. 172, n. 6, p. 592-595, June 2007.

BIRRELL, S. A.; HOOPER, R. H.; HASLAM, R. A. The effect of military load carriage on ground reaction forces. **Gait Posture**, Oxford, v. 26, n. 4, p. 611-614, Oct. 2007.

BORG, G. **Borg's perceived exertion and pain scales**. [Champaign, IL]: Human Kinetics 1998.

BORGHOLS, E. A.; DRESEN, M. H.; HOLLANDER, A. P. Influence of heavy weight carrying on the cardiorespiratory system during exercise. European Journal of Applied Physiology and Occupational Physiology, Berlin, v. 38, n. 3, p. 161-169, Apr 1978.

BRASIL. Ministério da Defesa. Exército. **Manual de campanha marchas a pé**. 3 ed. Brasilia, DF: Exército, 2019. EB70-MC-10.304. Available at: https://bdex.eb.mil.br/jspui/bitstream/123456789/3470/3/EB70MC10304-Final.pdf. Access on: Feb 13, 2022.

BRUM, P. C. *et al*. Adaptações agudas e crônicas do exercício físico no sistema cardiovascular. Revista Paulista de Educação Física, São Paulo, v. 18, n. 1, p. 21-31, ago. 2004. Available at: http://www.luzimarteixeira.com.br/wp-content/uploads/2009/09/arquivo-adaptacoes-musculares-ao-exercicio-fisico.pdf. Access on: Feb 13, 2022.

CALLEGARI-JACQUES, S. M. Bioestatística: princípios e aplicações. Porto Alegre: Artmed, 2003.

FAGHY, M.; BLACKER, S.; BROWN, P. I. Effects of load mass carried in a backpack upon respiratory muscle fatigue. **European Journal of Sport Science**, Abingdon, v. 16, n. 8, p. 1032-1038, Nov 2016.

FAGUNDES, A. O. *et al*. Effects of load carriage on physiological determinants in adventure racers. **PLoS One**, San Francisco, v. 12, n. 12, e0189516, 2017. Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0189516. Access on: Feb 13, 2022.

FORJAZ, C. L.; TINUCCI, T. A medida da pressão arterial no exercício. **Revista Brasiliera de Hipertensão**, [*s. l.*], v. 7, n. 1, p. 79-87, jan./mar. 2000.

FORJAZ, C. L. *et al*. Post-exercise changes in blood pressure, heart rate and rate pressure product at different exercise intensities in normotensive humans. **Brazilian Journal of Medical and Biological Research**, São Paulo, v. 31, n. 10, p. 1247-1255, 1998.

GILES, G. E. Load carriage and physical exertion influence cognitive control in military scenarios. **Medicine and Science in Sports Exercise**, Hagerstown, v. 51, n. 12, p. 2540-2546, Dec 2019.

GRENIER, J. G. *et al*. Effects of extreme-duration heavy load carriage on neuromuscular function and locomotion: a military-based study. **PLoS One**, San Francisco, v. 7, n. 8, e43586, 2012.

HOLEWIJN, M. Physiological strain due to load carrying. **European Journal of Applied Physiology and Occupational Physiology**, Berlin, v. 61, n. 3-4, p. 237-245, 1990.

JOVANOVIĆ, D. *et al*. Physiological tolerance to uncompensated heat stress in soldiers: effects of various types of body cooling systems. **Vojnosanit Pregl**, Belgrade, v. 71, n. 3, p. 259-264, Mar. 2014.

KNAPIK, J. *et al*. **Frequency of loaded road march training and performance on a loaded road march**. Natick, MA: US Army Research Institute of Environmental Medicine, 1990. (Technical report, n. T13/90).

KNAPIK, J.J.; REYNOLDS, K.L.; HARMAN, E. Soldier load carriage: historical, physiological biomechanical, and medical aspects. **Military Medicine,** Oxford, v.169, n.1, p.45-56, Jan. 2004.

KRAEMER, W. J. *et al*. **The effects of various physical training programs on short duration, high intensity load bearing performance and the Army Physical Fitness Test**. Natick, MA: US Army Research Institute of Environmental Medicine, 1987. (Technical report, n. 30/87). Available at: https://apps.dtic.mil/sti/citations/ADA185473. Access on: Feb 13, 2022.

MCARDLE, W. D.; KATCH, F. I.; KATCH, V. L. Exercise physiology: nutrition, energy, and human performance. 8th ed. [Riverwoods, IL]: Wolters Kluwer Health, 2014.

MCCORMICK, A.; MEIJEN, C.; MARCORA, S. Psychological determinants of whole-body endurance performance. Sports Medicine, Auckland, v. 45, n. 7, p. 997-1015, July 2015.

ORR, R. **The Australian Army load carriage context**: a challenge for defence capability. Brisbane, Australia: Faculty of Health Sciences & Medicine Publications, Oct 2012. Available at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.878.697&rep=rep1&type=pdf. Access on: Jan 10, 2022.

PAL, M. S. *et al*. Optimum load for carriage by soldiers at two walking speeds on level ground. **International Journal of Industrial Ergonomics**, [*s. l.*], v. 39, p. 68-72, 2009.

PHILLIPS, D. B. *et al*. The effects of heavy load carriage on physiological responses to graded exercise. **European Journal of Applied Physiology and Occupational Physiology**, Berlin, v. 116, n. 2, p. 275-280, Feb 2016.

PIHLAINEN, K. *et al*. Cardiorespiratory responses induced by various military field tasks. **Military Medicine**, Oxford, v. 179, n. 2, p. 218-224, Feb 2014.

QUESADA, P. M. *et al*. Biomechanical and metabolic effects of varying backpack loading on simulated marching. **Ergonomics**, London, v. 43, n. 3, p. 293-309, Mar 2000.

STUEMPFLE, K. J.; DRURY, D. G.; WILSON, A. L. Effect of load position on physiological and perceptual responses during load carriage with an internal frame backpack. **Ergonomics**, London, v. 47, n. 7, p. 784-789, June 2004.

SWAIN, D. P. *et al*. Effect of training with and without a load on military fitness tests and marksmanship. **Journal of Strength Conditioning Research**, v. 25, n. 7, p. 1857-1865, July 2011.

VOLOSHINA, A. S. *et al*. Biomechanics and energetics of walking on uneven terrain. The Journal of Experimental Biology, v. 216, pt. 21, p. 3963-3970, Nov 2013.

ARTICLE DOI 10.52781/cmm.a100

Sleep quality, sleepiness level and their connection with obesity indicators in Brazilian military pilots

Calidad del sueño, grado de somnolencia y su relación con indicadores de obesidad en pilotos militares brasileños

Abstract: This article aimed at evaluating sleep quality and sleepiness levels in order to connect them to obesity indicators in Brazilian military pilots. In total, 40 men answered validated questionnaires to evaluate sleep quality and daytime sleepiness, as well as an assessing form. We measured their body mass, height, perimeters (waist and hip), and body composition. We also calculated their Waist-to-height ratio (WTHR), waist-to-hip ratio (WHR), and body mass index (BMI). Visceral adipose tissue was measured by magnetic resonance imaging. We used Stata 14.0 ($p < 0.05$) for statistical analysis. We observed that 47.5% of the pilots presented low sleep quality, 25% slept less than six hours a day, and that there are positive correlations of low magnitude between poor sleep quality with WTHR ($r = 0.3364$; $p = 0.0338$) and fat percentage ($r = 0.3451$; $p = 0.0292$). We concluded that approximately half of the individuals presented poor sleep quality, but almost all of them depicted normal daytime sleepiness.

Keywords: health; sleep disorder; anthropometry; aviators; Armed Forces.

Resumen: Este artículo tuvo como objetivo evaluar la calidad del sueño y el grado de somnolencia y su relación con indicadores de obesidad en pilotos militares brasileños. Los 40 participantes varones respondieron a un cuestionario validado para evaluar la calidad del sueño y somnolencia diurna, y a una anamnesis. Se obtuvieron mediciones de masa corporal, altura, perímetros (cintura y cadera) y composición corporal. Se calcularon la relación cintura/altura (RCA), la razón cintura/cadera (RCC) y el índice de masa corporal (IMC). El tejido adiposo visceral se midió mediante imágenes de resonancia magnética. Para el análisis estadístico se utilizó el programa Stata 14.0 ($p < 0,05$). El 47,5% de los pilotos tenían mala calidad del sueño, el 25% dormían menos de seis horas diarias, y se observaron correlaciones positivas de baja magnitud de mala calidad del sueño con RCA ($r = 0,3364$; $p = 0,0338$) y porcentaje de grasa ($r = 0,3451$; $p = 0,0292$). Se concluyó que cerca de la mitad de la muestra tenía mala calidad del sueño, pero casi todos los individuos presentaban un grado normal de somnolencia diurna.

Palabras clave: salud; trastorno del sueño; antropometría; aviadores; Fuerzas Armadas.

Fabrícia Geralda Ferreira
Força Aérea Brasileira. Programa de Pós-Graduação em Desempenho Humano Operacional.
Rio de Janeiro, RJ, Brasil.
fafege@yahoo.com.br

Leonice Aparecida Doimo
Força Aérea Brasileira. Programa de Pós-Graduação em Desempenho Humano Operacional.
Rio de Janeiro, RJ, Brasil.
ladoimo@gmail.com

Guillermo Brito Portugal
Marinha do Brasil. Programa de Pós-Graduação em Desempenho Humano Operacional.
Rio de Janeiro, RJ, Brasil.
guillermo.portugalmb@yahoo.com.br

José Pedro Rodrigues Ravani
Força Aérea Brasileira. Programa de Pós-Graduação em Desempenho Humano Operacional.
Rio de Janeiro, RJ, Brasil.
josepedrorr@yahoo.com.br

Fábio Angioluci Diniz Campos
Força Aérea Brasileira. Programa de Pós-Graduação em Desempenho Humano Operacional.
Rio de Janeiro, RJ, Brasil.
fabiocampos06@gmail.com

Received: Oct 30, 2022.
Approved: Feb 16, 2023.

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

Sleep is defined as the lowering of the consciousness level characterized by reduced motor activity and decreased response to stimulation (KANDEL; SCHWARTZ; JESSELL, 2014). It is a set of synchronized behavioral and physiological changes originating from two distinct mechanisms responsible for regulating the sleep-wake cycle – a sleep promoter (homeostatic impulse) and the circadian cycle, which promotes awakening (NEVES; MACEDO; GOMES, 2017).

Sleep has restorative and protective functions, thus, alterations in its quantity or quality can negatively interfere with organic functioning, short or long-term reflexes, and various aspects of human life, including social, somatic, psychological, cognitive, and metabolic (CHATTU *et al.*, 2018).

Although the required number of sleep hours varies individually, on average, seven to nine hours of sleep per night is considered satisfactory (HIRSHKOWITZ *et al.*, 2015). However, short sleepers (those who sleep less than seven hours per night), as well as long sleepers (those who sleep more than nine hours per night), have a higher risk of disease and mortality (GALLICCHIO; KALESAN, 2009).

Among the biggest impacts on health, influenced by inadequate sleep hours, is the increase in body mass, especially regarding the fat component. Meta-analyses conducted with prospective studies have shown that short sleep is associated with elevated body mass index (BMI) and risk of developing obesity (ITANI *et al.*, 2017; WU; ZHAI; ZHANG, 2014).

The mechanisms involved in the relationship between sleep and obesity, as well as the meaning of this chain, are yet not fully elucidated. Nevertheless, changes in the circadian cycle influence appetite, satiety, and, therefore, food consumption, favoring weight gain and obesity. Interferences in the biological clock impact the length and quality of sleep, bringing negative consequences for the control of food intake, as they modify the hormonal release linked to homeostasis in the composition both of the body (CRISPIM *et al.*, 2007) and the sleep (PEYRON *et al.*, 1998).

Literature has long evidenced the close relationship between the short duration of sleep time and an increase in BMI in different populations (SEKINE *et al.*, 2002), and, in this sense, the military is not immune to the harms of this relationship. Corroborating this fact, a study conducted with 27,034 active-duty military workers, to evaluate the relationships between demographic characteristics, self-reported health behaviors, and reported medical conditions, found that, of the 17 assessed health behaviors, shorter sleep time was the practice most associated with overweight/obesity (HRUBY; LIEBERMAN; SMITH, 2018).

Military professional occupations, including pilots, regardless of the aircraft type, can be compromised when proper rest does not occur. It is an activity that requires concentration, emotional control, the ability to work under pressure, the ability to quickly adapt to

operational changes, quick reasoning, and spatial orientation, among others (PALMEIRA, 2016). Therefore, the absence of restful sleep can compromise the safety conditions of the flight, whose professional failure can cause irreparable damages.

Inappropriate sleep can also lead to excessive sleepiness, defined as an increased propensity to sleep with a subjective compulsion to sleep and take involuntary naps (BITTENCOURT *et al.*, 2005). Under this condition, the pilot tends to be less careful and more prone to not identifying emergencies in a timely manner, as well as being unable to efficiently respond to adversities in due time (LYZNICKI, 1998).

In addition, poor sleep can lead to worsening physical performance, evidenced by decreased muscle strength (HALSON, 2014), and a greater likelihood of facing barriers to adopting a healthy diet and appropriate exercise behaviors (BARON *et al.*, 2017).

During work, quality sleep is key to maintaining productivity. For pilots, performing tasks sleepy can lead to errors or accidents, since they are often subjected to gravitational loads on the Z axis (+Gz load) that promote physical and mental wear and tear, including flight fatigue (CUNHA, 2007). This condition can be aggravated in pilots whose sleep quality is considered poor, especially if associated with overweight or obesity.

Thus, verifying the relationships between sleep quality, sleepiness level and obesity indicators in military pilots is important to elaborate future care protocols for these professionals, with a view to promoting physical and mental health to ensure flight safety.

Given the above, this article aimed at evaluating the quality of sleep, level of sleepiness and its connections with obesity indicators in Brazilian military pilots.

2 METHODOLOGY

This was a cross-sectional observational study, with a convenience sample, which evaluated the sleep habits of 40 active pilots of the Brazilian Air Force (FAB). The military personnel were all male and worked at the air bases in Rio de Janeiro, Brazil, in 2021.

The study was approved by the Human Research Ethics Committee (CAAE: 53174321.7.0000.5256, Opinion Nr: 5.202.697), with participation by informed consent.

2.1 Instruments and Measurements

We applied the Pittsburgh questionnaire (Pittsburgh Sleep Quality Index - PSQI*)* online, via Google Forms, in April 2021, as well as the Epworth Sleepiness Scale and an assessment form for sample characterization. After that, we performed anthropometric and body composition assessments, including an evaluation of visceral adiposity.

2.1.1 Pittsburgh Sleep Quality Index (PSQI)

The PSQI (BUYSSE *et al.*, 1989) is a self-administered questionnaire already validated in Brazil (Cronbach's alpha: 0.82; BERTOLAZI *et al.,* 2011). This instrument evaluates the subjective quality of sleep over the last month, from seven perspectives: subjective quality of sleep; sleep latency; sleep duration; sleep efficiency; sleep disorders; use of sleep medications, and daytime dysfunction. Its score ranges from zero to 21, with each component having weight distributed on a scale of zero to three points. In the final questionnaire points sum, values of up to five points indicate good sleep quality, from six to ten poor quality, and higher than ten indicate possible sleep disturbance.

2.1.2 Epworth Sleepiness Scale

The *Epworth* Sleepiness Scale (JOHNS, 1991), validated in Brazil (Cronbach's alpha of 0.83; BERTOLAZI *et al.*, 2009), evaluates sleepiness through eight questions that verify the probability of the respondent napping in different daily situations, whether active or passive. The individual answers what their chance of napping is in each of the situations presented, scoring zero, one, two, or three, respectively, for the situations: (I) never napping; (ii) small probability of napping; (iii) average probability of napping; and (iv) high probability of napping. The overall score ranges from zero to 24 points. Values lower than or equal to ten indicate normal sleepiness, between 11 and 15 indicate excessive daytime sleepiness, and higher than or equal to 16, severe excessive daytime sleepiness.

2.1.3 Anthropometric Assessment

After answering the questionnaires, the military workers underwent an anthropometric assessment, and their body mass was measured using the InBody ® bioimpedance device, model 230 (Biospace Corp. Ltd., Seoul, Korea), their height was measured using a wall-mounted tape measure and their waist and hip perimeters were also measured.

2.1.3.1 Body Mass Index

BMI was calculated using body mass in kilograms (Kg) divided by the square of height in meters (m).

2.1.3.2 Waist-to-height Ratio (WTHR) and Waist-to-hip Ratio (WHR)

The perimeters were measured with a Sanny® flexible and inelastic metallic measuring tape (American Medical do Brasil, São Paulo, Brazil), with a two-meter extension and accuracy of 0.1 centimeters (cm), three times, by a single evaluator, being considered the average of the values. The waist measurement point was the one with the smallest perimeter, between the last rib and the iliac crest, at the end of a normal exhalation. Hip circumference was measured in the largest gluteal protuberance. With the waist, height, and hip values, the waist/height ratio (WTHR) and waist/hip ratio (WHR) were calculated.

2.1.4 Body Composition

The fat percentage was the considered variable regarding the body composition, being evaluated through InBody® tetrapolar bioimpedance, model 230 (Biospace Corp. Ltd., Seoul, Korea). The pilots were evaluated only once, without carrying metallic objects, ingesting alcoholic or caffeinated beverages, and without performing intense physical activity in the 24 hours before the test. We requested that they emptied their bladder 30 minutes before evaluation.

2.1.5 Visceral Adipose Tissue

Visceral adipose tissue (VAT) was measured by magnetic resonance imaging, and images were obtained with GE Signa HDxt 1.5 T (General Electric Healthcare, Waukesha, United States). Weighted images were acquired in gradient T1 (in phase and out of phase) in the axial plane, for the measurement of VAT at the umbilical level (not including intestinal loops), and these areas were defined with the *grow region* function of Osirix, being measured in square centimeters (PARENTE *et al.*, 2018).

2.2 Data Analysis

The data analysis was developed in Stata version 14.0. Descriptive analysis was performed, and the results were presented in frequencies (%), means, and standard deviations. The normality of the data was verified by the Shapiro-Wilk test, and deviation was observed in the PSQI score. *The* Pearson correlation was used to assess the relationship between obesity indicators and Epworth questionnaire score *(*level of sleepiness), while Spearman's correlation was used to evaluate the same relationship, but with the PSQI (sleep quality) score, since this variable did not present a normal distribution. The correlation classification was made according to Margotto's analysis (2012) in 1 or -1 = perfect; $0.80 < r < 1$ or $-1 < r < -0.80$ = very high; $0.60 < r < 0.80$ or $-0.80 < r < -0.60$ = high; $0.40 < r < 0.60$ or $-0.60 < r < -0.40$ = moderate; $0.20 < r < 0.40$ or $-0.40 < R < -0.20$ = low; $0 < r < 0.20$ or $-0.20 < r < 0$ = very low and 0 = null. Values of $p < 0.05$ were considered significant.

3 RESULTS

The characteristics of the sample are presented in Table 1, and it should be noted that, on average, they are young, in addition, most belong to transport aviation and have prolonged sleep latency.

Regarding sleep characteristics, it was observed that 47.5% of the pilots had low sleep quality, distributed among poor sleep quality with a higher percentage, followed by possible sleep disturbance in a lower proportion. More than a third of the military personnel had reduced sleep efficiency. Although 25% of the military personnel slept less than six hours a day, most of the sample had normal daytime sleepiness (Table 2).

The results of the correlations can be seen in Table 3. A low magnitude positive correlation was observed between poor sleep quality and WTHR, and between poor sleep quality and fat percentage (both $p<0.05$). For the other variables, no significant relationships were observed in the correlations.

Table 1 – Characteristics of the evaluated Brazilian Air Force pilots

Variable	N	%	Mean	SD
Age (years)	-	-	29.33	3.52
Marital status				
Single	15	37.50%	-	-
Married / In a stable relationship	25	62.50%		
Aircraft (specialty)				
Rotary wings	10	25.00%	-	-
Transport	22	55.00%		
In-flight inspection	8	20.00%		
BMI	-	-	25.64	2.11
Waist circumference (cm)	-	-	83.95	6.12
Waist/height Ratio	-	-	0.48	0.04
Waist/hip Ratio	-	-	0.84	0.05
Body Fat (%)	-	-	20.90	6.15
Visceral adiposity (cm2)	-	-	60.13	45.15
Sleep latency (min)			25.04	22.54

Abbreviations: BMI= body mass index. Source: prepared by the authors, 2022

Table 2 – Sleep characteristics of the evaluated Brazilian Air Force pilots

Variable	N	%
Quality of sleep		
Good	21	52.50
Bad	17	42.50
Possible sleep disturbance	2	5.00
Sleep efficiency		
Good	26	65.00
Reduced	14	35.00
Daytime sleepiness		
Normal	33	82.50
Excessive sleepiness	06	15.00
Severe sleepiness	01	2.50
Hours of sleep		
> 7 hours	12	30.00
Between > 6 and ≤ 7 hours	18	45.00
Between > 5 and ≤ 6 hours	08	20.00
≤ 5 hours	02	05.00
Sleep latency (min)		
≤ 15 min	09	22.50
16 to 30 min	17	42.50
31 to 60 min	11	27.50
> 60 min	03	07.50

Source: prepared by the authors, 2022

Table 3 – Correlation between anthropometric and body composition variables with sleep quality and level of sleepiness.

Variable	Quality of sleep (PSQI Score)		Sleepiness Level (*Epworth* score)	
	r	p	r	p
BMI	0.2616	0.1030	0.0881	0.5888
WC	0.2803	0.0758	0.1156	0.4774
WTHR	0.3364	**0.0338***	0.0688	0.6732
WHR	0.2282	0.1568	0.1720	0.2886
Fat %	0.3451	**0.0292***	0.0558	0.7323
VAT	0.3053	0.0554	0.1525	0.3476

Abbreviations: PSQI = Pittsburgh Sleep Quality Index; BMI = body mass index.
WC = Waist Circumference; WTHR = Waist / Height Ratio WHR = Waist / Hip Ratio;
Fat % = Fat Percentage; VAT = Visceral Adipose Tissue.
* Spearman $p < 0.05$.
Source: prepared by the authors, 2022

4 DISCUSSION

This study aimed at evaluating the quality of sleep, levels of sleepiness, and connections with obesity indicators in Brazilian military pilots, since this can provide the development of more assertive care protocols for these professionals, thus ensuring the stability of flight safety. We observed that 42.5% of the pilots presented poor sleep quality, 82.5% normal daytime sleepiness level and there was a low magnitude positive correlation between poor sleep quality and WTHR, and between poor sleep quality and fat percentage.

The prevalence of poor sleep quality found in this analysis is similar to that described by Morais (2019) who probabilistically evaluated 129 military firefighters in southern Brazil. However, that study showed a high prevalence of individuals with possible sleep disorders (34.9%) when compared to ours, in which only 5% of the sample presented the outcome found by Morais.

On the other hand, Bernardo *et al.* (2018) evaluating 438 military police officers from Florianópolis, found a prevalence of 79.2% of poor sleep quality. Also, in southern Brazil, a study conducted with 22 elite military workers (PINTO *et al.*, 2018) showed that 100% of the military had at least some type of sleep-related disorder or complaint. In addition, 63.6% of the sample had poor sleep quality. It is important to note that in Pinto's study *et al.*, (2018) all military workers underwent polysomnography, clinical evaluation, and answered the Pittsburgh Sleep Quality Assessment Questionnaire and the Epworth Sleepiness Scale. A survey conducted with 68 soldiers of the Brazilian army, however, showed that 66.2% of participants had poor sleep quality (IAHNKE; MORAES, 2022).

We can attribute as a possible explanation for the difference found between the studies, the higher imminent risk faced daily by these professionals, such as military police officers

and firefighters, when compared to the pilots and army personnel. We must draw attention to the fact that military police officers, especially elite ones, and firefighters work in high-risk situations, with a high load of physical and mental stress, which can negatively affect the sleep quality of these professionals.

Regarding sleep efficiency, we observed that in 65% of pilots it was classified as good, that is, when the ratio between the time the pilot remains asleep and the time, he remains in bed is taken into account, this is higher than 85%, a cutoff point to consider good efficiency (BUYSSE *et al.*, 1989). Nevertheless, 35% of military pilots show reduced sleep efficiency, indicating the need for more detailed medical monitoring. A study conducted with 156 active military workers of the US Air Force (PETERSON *et al.*, 2008) who were supporting Enduring Freedom Operation in Southwest Asia, showed that 40% of military personnel had reduced sleep efficiency (<85%). Although it is not possible to directly compare the two situations (military personnel employed in real mission vs. military personnel who were not in operation), in both studies the percentage of military personnel with reduced sleep efficiency is worrisome and needs to be further investigated.

Excessive daytime sleepiness was observed in 15% of the pilots and severe sleepiness in 2.5%. Even though these indices are low, both should not be neglected, since piloting requires concentration and constant decision-making, which can endanger flight safety. Excessive daytime sleepiness contributes to impaired cognitive function and a decrease in alertness (DE PINHO *et al.*, 2006), fundamental activities for perfect flight performance.

Akter *et al.* (2021), while evaluating 175 servicemen of the Norwegian Air Force, observed a 41% prevalence of excessive daytime sleepiness. On the other hand, Pinto *et al.* (2018) and Bernardo *et al.* (2018) found, respectively, 22.7% and 35.8% of individuals with excessive daytime sleepiness. We should note that in Pinto's study *et al.* (2018), the prevalence of excessive daytime sleepiness was associated with obstructive sleep apnea syndrome, work accidents, and worse quality of life. The results of these studies showed that investigations related to daytime sleepiness in military personnel should be carried out, as well as seeking to identify the factors that are associated with this condition so that, with this information, strategies can be developed to mitigate this occurrence.

The recommended number of sleep hours for an adult individual varies between seven to nine hours (HIRSHKOWITZ *et al.*, 2015). Most pilots reported sleeping seven hours or less (70%) with 25% of them sleeping a maximum of six hours per night. Other studies in the literature corroborate our results, as they also showed that the military routinely sleeps less than recommended (BULMER *et al.*, 2022; HARRIS *et al.*, 2015). Thus, it is necessary to expand studies related to sleep in military populations, to better understand the dynamics of this profession and, consequently, optimize the health and performance of these individuals.

It is important to highlight that, throughout the life cycle, there is a great interindividual variability in the need for sleep, and there is no ideal standard value of sleep hours for all individuals. However, it is important to promote adequate hours of sleep, according to individual characteristics, so that it does not cause, in the medium or long term, damage to the health of the military. In this context, a study conducted in 2011 in the United States showed that

short sleep duration was closely related to medical problems, including overweight and obesity (HRUBY; LIEBERMAN; SMITH, 2018).

Sleep latency consists of the total time (in minutes) that the individual takes between turning off the lights and effectively starting to sleep (SHRIVASTAVA *et al.*, 2014). This measure can contribute to the evaluation of sleepiness and sleep restriction/deprivation since values below five minutes indicate severe sleep restriction/deprivation; from five to ten minutes, a problematic case; from ten to 15 minutes, a mild case and from 15 to 20 minutes, little or no sleep debt (JUNG *et al.*, 2013). Conversely, an inability to sleep within 30 minutes can mean prolonged sleep latency (KIRSCH *et al.*, 2020). In this study, the mean sleep latency was 25.02 ± 22.54 minutes, with a minimum latency of five and a maximum of 120 minutes. These data show military personnel in a situation of severe sleep restriction and with prolonged sleep latency. The study conducted by Peterson *et al.* showed a sleep latency of 32.15 ± 35.20, with 41.7 % of the military having latency > 30 minutes (PETERSON *et al.*, 2008). On the other hand, Harris *et al.*, (2015) reported a latency of 25.8 ± 15.85 minutes. Both results are close to those presented in our study, showing that there is a wide variety of sleep latency in military personnel.

In terms of the relationship between sleep variables and obesity indicators, we found a low-magnitude positive correlation between WTHR and poor sleep quality ($r = 0.3364$; $p = 0.0338$) and between fat percentage and poor sleep quality ($r = 0.3451$; $p = 0.0292$). Despite that, because this is a cross-sectional study, it is not possible to infer causality. One of the possibilities of not finding significant data with high magnitude is the fact that the sample was composed of young military personnel (aged 29 ± 4). It is well known that among military personnel, the ability to adapt to difficult situations or significant sources of stress is somewhat common (COTIAN *et al.*, 2014), including inadequate sleep during these adversities. This probably stems from the culture among military personnel, in which depriving oneself of sleep is a demonstration of physical and mental endurance. In addition, because they are pilots – the most important and representative specialty of the FAB, they must present anthropometric standards and a body composition profile compatible with the function and organic hygiene, aspects required of all military personnel. Future research will be able to more accurately elucidate the relationship between the military, obesity, sleep quality, and resilience.

Although these correlations are classified as low (MARGOTTO, 2012), we emphasize that there is evidence in the literature that sleep-related problems may lead to morbidities due to changes in energy metabolism, for example, obesity (KERVEZEE; KOSMADOPOULOS; BOIVIN, 2020). In this regard, Ferreira *et al.* (2022), in a study with 80 urban bus drivers, found a correlation between sleep quality and the variables fat percentage ($r = 0.343$, $p = 0.002$) and abdominal circumference ($r = 0.261$, $p = 0.019$).

Lentino *et al.* (2013), through questionnaires with 14,148 American military personnel, evaluated various health behaviors and habits and their relationship with poor sleep quality. Their results indicated significant associations between sleep quality and physical performance, nutritional habits, measurements of obesity, lifestyle behaviors, and of psychosocial state. The authors found that military personnel who slept poorly were significantly ($p < 0.001$)

less likely to have adequate BMI and waist circumference. In our study, the fact that we did not find relationship between poor sleep quality and waist circumference is probably due to the small sample size, when compared with the aforementioned study.

Hasler *et al.*, (2004) had already pointed out that a sleep duration of less than six hours was associated with increased BMI and obesity. A possible explanation for this is that sleep shortening alters the Ghrelin/Leptin ratio, increasing appetite and the feeling of hunger (ROMERO; ZANESCO, 2006) and causing the individual to increase their caloric intake. In addition, there may be lower caloric expenditure due to fatigue promoted by lack of sleep, which decreases the practice of physical activity (PATEL *et al.*, 2006). As the quality of sleep involves different aspects, among them the number of sleep hours, attention should be drawn to this relationship.

This study presents a limitation in the sample size, which does not allow extrapolation to the entire universe of FAB pilots. However, it was not possible to recruit a larger number of participants due to the cost of magnetic resonance imaging and the need to perform the tests with strict prevention protocols during the covid-19 pandemic. Another limitation concerns the lack of access to the equation used by the Inbody® device to calculate the percentage of fat. This made it impossible to verify possible errors in the choice of the equation, as well as its specificity for the studied sample.

As strengths, we can highlight the use of a gold standard imaging method to measure visceral adiposity; the use of validated questionnaires and scales that minimize biases and enable reliable results; and the methodological rigor of data collection, which included trained interviewers, standardized protocols and anthropometric measurements performed by a single Examiner, thus ensuring the accuracy of the results.

5 CONCLUSION

The data obtained in this article indicated that, about sleep quality, approximately half of the individuals presents poor sleep quality, but despite that, for almost all of them, the level of daytime sleepiness was normal. Regarding obesity indicators, only WTHR and fat percentage showed positive correlations, but of low magnitude, with poor sleep quality.

AUTHORSHIP AND COLLABORATIONS

All authors participated equally in elaborating the article.

REFERENCES

AKTER, R. *et al*. Excessive Daytime Sleepiness and Associated Factors in Military Search and Rescue Personnel. **Aerospace Medicine and Human Performance**, Bethesda, v. 92, n. 12, p. 975–979, 2021. Available from: https://pubmed.ncbi.nlm.nih.gov/34986937/. Access: March 24, 2023.

BARON, K. G. *et al*. Circadian timing and alignment in healthy adults: associations with BMI, body fat, caloric intake and physical activity. **International Journal of Obesity**, Bethesda, v. 41, n. 2, p. 203–209, 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/27795550/. Access: March 24, 2023.

BERNARDO, V. M. *et al*. Atividade física e qualidade de sono em policiais militares. **Revista Brasileira de Ciências do Esporte**, Brasília, DF, v. 40, n. 2, p. 131–137, 2018. Available from: https://www.scielo.br/j/rbce/a/gYBT7Z6hTjhn95khWzcSfSh/?lang=pt. Access: March 24, 2023.

BERTOLAZI, A. N. *et al*. Portuguese-language version of the Epworth sleepiness scale: validation for use in Brazil. **Jornal Brasileiro de Pneumologia**, Brasília, DF, v. 35, n. 9, p. 877–883, 2009. Available from: https://www.scielo.br/j/jbpneu/a/rTpHBbQf6Jbz4QwZNsQDYnh/. Access: March 24, 2023.

BERTOLAZI, A. N. *et al*. Validation of the Brazilian Portuguese version of the Pittsburgh Sleep Quality Index. **Sleep Medicine**, Bethesda, v. 12, n. 1, p. 70–75, 2011. Available from: https://pubmed.ncbi.nlm.nih.gov/21145786/. Access: March 24, 2023.

BITTENCOURT, L. R. A. *et al*. Sonolência excessiva. **Revista Brasileira de Psiquiatria**, São Paulo, v. 27, n. 1, p. 16–21, 2005. Available from: https://www.scielo.br/j/rbce/a/gYBT7Z6hTjhn95khWzcSfSh/?lang=pt. Access: March 24, 2023.

BULMER, S. *et al*. Sleep of recruits throughout basic military training and its relationships with stress, recovery, and fatigue. **International Archives of Occupational and Environmental Health**, Bethesda, v. 95, n. 6, p. 1331–1342, 2022. Available from: https://pubmed.ncbi.nlm.nih.gov/35226165/. Access: March 24, 2023.

BUYSSE, D. J. *et al*. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. **Psychiatry Research**, Bethesda, v. 28, n. 2, p. 193–213, 1989. Available from: https://pubmed.ncbi.nlm.nih.gov/2748771/. Access: March 24, 2023.

CHATTU, V. *et al*. The Global Problem of Insufficient Sleep and Its Serious Public Health Implications. **Healthcare**, Bethesda, v. 7, n. 1, p. 1, 2018. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6473877/. Access: March 24, 2023.

COTIAN, M. *et al*. Revisão sistemática dos aspectos psicossociais, neurobiológicos, preditores e promotores de resiliência em militares. **Jornal Brasileiro de Psiquiatria**, Rio de Janeiro, v. 63, p. 72–85, 2014. Available from: https://www.scielo.br/j/rbce/a/gYBT7Z6hTjhn95khWzcSfSh/?lang=pt. Access: March 24, 2023.

CRISPIM, C. A. *et al*. Relação entre sono e obesidade: uma revisão da literatura. **Arquivos Brasileiros de Endocrinologia & Metabologia**, São Paulo, v. 51, n. 7, p. 1041–1049, 2007. Available from: https://www.scielo.br/j/rbce/a/gYBT7Z6hTjhn95khWzcSfSh/?lang=pt. Access: March 24, 2023.

CUNHA, C. E. D. O voo com o NVG e a fadiga. **Revista da UNIFA**, Rio de Janeiro, v. 19, n. 22, p. 30–42, 2007.

DE PINHO, R. S. N. *et al*. Hypersomnolence and Accidents in Truck Drivers: A Cross-Sectional Study. **Chronobiology International**, Bethesda, v. 23, n. 5, p. 963–971, 2006. Available from: https://pubmed.ncbi.nlm.nih.gov/17050211/. Access: March 24, 2023.

FERREIRA, R. T. *et al*. Sleep quality of urban public transport drivers in a city in the Western Amazon, Brazil. **Journal of Human Growth and Development**, Marília, v. 32, n. 1, p. 43–54, 2022. Available from: https://revistas.marilia.unesp.br/index.php/jhgd/article/view/12613. Access: March 24, 2023.

GALLICCHIO, L.; KALESAN, B. I. Sleep duration and mortality: a systematic review and meta-analysis. **Journal of Sleep Research**, New Jersey, v. 18, n. 2, p. 148–158, 2009.

HALSON, S. L. Sleep in Elite Athletes and Nutritional Interventions to Enhance Sleep. **Sports Medicine**, Bethesda, v. 44, n. S1, p. 13–23, 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/24791913/. Access: March 24, 2023.

HARRIS, E. *et al*. Assessment of Sleep Disruption and Sleep Quality in Naval Special Warfare Operators. **Military Medicine**, Bethesda, v. 180, n. 7, p. 803–808, 2015. Available from: https://pubmed.ncbi.nlm.nih.gov/26126252/. Access: March 24, 2023.

HASLER, G. *et al*. The association between short sleep duration and obesity in young adults: a 13-year prospective study. **Sleep**, Bethesda, v. 27, n. 4, p. 661–666, 2004. Available from: https://pubmed.ncbi.nlm.nih.gov/15283000/. Access: March 24, 2023.

HIRSHKOWITZ, M. *et al*. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. **Sleep Health**, Bethesda, v. 1, n. 1, p. 40–43, 2015. Available from: https://pubmed.ncbi.nlm.nih.gov/29073412/. Access: March 24, 2023.

HRUBY, A.; LIEBERMAN, H. R.; SMITH, T. J. Self-reported health behaviors, including sleep, correlate with doctor-informed medical conditions: data from the 2011 Health Related Behaviors Survey of U.S. Active Duty Military Personnel. **BMC Public Health**, Bethesda, v. 18, n. 1, p. 853, 2018. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6042384/. Access: March 24, 2023.

IAHNKE, V.; MORAES, C. Associação de atividade física com qualidade do sono de jovens militares: um estudo transversal. **Revista de Educação Física**, Rio de Janeiro, v. 91, n. 1, p. 26–35, 2022.

ITANI, O. *et al*. Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression. **Sleep Medicine**, Bethesda, v. 32, p. 246–256, 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/27743803/. Access: March 24, 2023.

JOHNS, M. W. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. **Sleep**, Bethesda, v. 14, n. 6, p. 540–5, 1991. Available from: https://pubmed.ncbi.nlm.nih.gov/1798888/. Access: March 24, 2023.

JUNG, D. W. *et al*. Estimation of Sleep Onset Latency Based on the Blood Pressure Regulatory Reflex Mechanism. **IEEE Journal of Biomedical and Health Informatics**, Bethesda, v. 17, n. 3, p. 539–544, 2013. Available from: https://pubmed.ncbi.nlm.nih.gov/24592456/. Access: March 24, 2023.

KANDEL, E.; SCHWARTZ, J.; JESSELL, T. **Princípios de neurociências**. 5. ed. Porto Alegre: AMGH, 2014

KERVEZEE, L.; KOSMADOPOULOS, A.; BOIVIN, D. B. Metabolic and cardiovascular consequences of shift work: The role of circadian disruption and sleep disturbances. **European Journal of Neuroscience**, Bethesda, v. 51, n. 1, p. 396–412, 2020. Available from: https://pubmed.ncbi.nlm.nih.gov/30357975/. Access: March 24, 2023.

KIRSCH, J. L. *et al*. Associations Among Sleep Latency, Subjective Pain, and Thermal Pain Sensitivity in Gynecologic Cancer. **Pain Medicine**, v. 21, n. 1, p. 5–12, 2020. Available from: https://pubmed.ncbi.nlm.nih.gov/30481329/. Access: March 24, 2023.

LENTINO, C. V. *et al*. Sleep as a component of the performance triad: the importance of sleep in a military population. **U.S. Army Medical Department Journal**, Bethesda, v. 4, p. 98–108, 2013. Available from: https://pubmed.ncbi.nlm.nih.gov/24146247/. Access: March 24, 2023.

LYZNICKI, J. M. Sleepiness, Driving, and Motor Vehicle Crashes. **JAMA**, Bethesda, v. 279, n. 23, p. 1908–1913, 1998. Available from: https://pubmed.ncbi.nlm.nih.gov/9634264/. Access: March 24, 2023.

MARGOTTO, P. R. **Estatística computacional**. Uso do SPSS (statistical package for the social science): o essencial. Caxias do Sul: Escola Superior de Ciências da Saúde, 2012.

MORAIS, K. C. P. de. **Sonolência diurna excessiva, qualidade do sono e qualidade de vida de bombeiros militares**. 2019. Dissertação (Mestrado em Enfermagem) - Universidade de Santa Maria, Santa Maria, 2019.

NEVES, G. S. M. L.; MACEDO, P.; GOMES, M. M. Transtorno do sono: Atualização (1/2). **Revista Brasileira de Neurologia**, Rio de Janeiro, v. 53, n. 3, p. 19–30, 2017. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/biblio-876873. Access: March 24, 2023.

PALMEIRA, M. L. de S. **Excesso de peso em pilotos da aviação regular associado às características do trabalho e de saúde**. 2016. Dissertação (Mestrado em Saúde Coletiva) – Universidade Católica de Santos, Santos, 2016.

PARENTE, D. B. *et al*. Preperitoneal fat as a non-invasive marker of increased risk of severe non-alcoholic fatty liver disease in patients with type 2 diabetes. **Journal of Gastroenterology and Hepatology**, Bethesda, v. 33, n. 2, p. 511–517, 2018. Available from: https://pubmed.ncbi.nlm.nih.gov/28726335/. Access: March 24, 2023.

PATEL, S. R. *et al*. Association between Reduced Sleep and Weight Gain in Women. **American Journal of Epidemiology**, Bethesda, v. 164, n. 10, p. 947–954, 2006. Available from: https://pubmed.ncbi.nlm.nih.gov/16914506/. Access: March 24, 2023.

PETERSON, A. L. *et al*. Sleep Disturbance during Military Deployment. **Military Medicine**, Oxford, v. 173, n. 3, p. 230–235, 2008. Available from: https://academic.oup.com/milmed/article/173/3/230/4557683. Access: March 24, 2023.

PEYRON, C. *et al*. Neurons Containing Hypocretin (Orexin) Project to Multiple Neuronal Systems. **The Journal of Neuroscience**, Bethesda, v. 18, n. 23, p. 9996–10015, 1998. Available from: https://pubmed.ncbi.nlm.nih.gov/9822755/. Access: March 24, 2023.

PINTO, J. do N. *et al*. Avaliação do Sono em um Grupo de Policiais Militares de Elite. **Acta Paulista de Enfermagem**, São Paulo, v. 31, n. 2, p. 153–161, 2018. Available from: https://www.scielo.br/j/rbce/a/gYBT7Z6hTjhn95khWzcSfSh/?lang=pt. Access: March 24, 2023.

SEKINE, M. *et al*. A dose-response relationship between short sleeping hours and childhood obesity: results of the Toyama Birth Cohort Study. **Child: Care, Health and Development**, Bethesda, v. 28, n. 2, p. 163–170, 2002. Available from: https://pubmed.ncbi.nlm.nih.gov/11952652/. Access: March 24, 2023.

SHRIVASTAVA, D. *et al*. How to interpret the results of a sleep study. **Journal of Community Hospital Internal Medicine Perspectives**, Bethesda, v. 4, n. 5, p. 1-4, 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/25432643/. Access: March 24, 2023.

WU, Y.; ZHAI, L.; ZHANG, D. Sleep duration and obesity among adults: a meta-analysis of prospective studies. **Sleep Medicine**, Bethesda, v. 15, n. 12, p. 1456–1462, 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/25450058/. Access: March 24, 2023.

ZANESCO, A.; ROMERO, C. E. M. O papel dos hormônios leptina e grelina na gênese da obesidade. **Revista de Nutrição**, Campinas, v. 19, n. 1, p. 85–91, 2006. Available from: https://www.scielo.br/j/rn/a/gW5Wght6RbsjFCyZQbmWCSj/?lang=pt. Access: March 24, 2023.


ECEME

ARTICLE DOI 10.52781/cmm.a101

Zoonoses and vector diseases in the Brazilian Army military personnel (2017/2018) and the role of the military veterinarian in disease prevention

Zoonosis y enfermedades vectoriales en militares del Ejército Brasileño (2017/2018) y el papel del veterinario militar en la prevención de enfermedades

Abstract: Several studies worldwide indicate high morbidity and mortality associated with infectious diseases in military personnel. This study aimed to learn the biological risks in activities of the Brazilian Army military personnel and to discuss the role of the military veterinarian in actions of Health Protection of the Force. An ecological study focused on the twelve Military Regions of the Force was carried out, analyzing data on notifiable diseases in military personnel, referring to 2017 and 2018. Notifications and the relative risk for diseases in military personnel were compared to the general population. The results showed that arboviruses transmitted by the *Aedes* spp. had the highest notifications among the military personnel and that the relative risk for various diseases was higher in the military personnel. The main hypothesis is the greater exposure to zoonoses during military activities. The veterinarian is qualified to play the role of health officer in the prevention and control of biological risks.

Keywords: Armed Forces; biological risks; military health.

Resumen: A nivel mundial, varios estudios indican una alta morbilidad y mortalidad asociada a enfermedades infecciosas en el personal militar. El objetivo de este estudio fue conocer los riesgos biológicos en las actividades de los soldados del Ejército Brasileño y discutir el papel del médico veterinario militar en las acciones de Protección de la Salud de la Fuerza. Se realizó un estudio ecológico destacando las 12 Regiones Militares de la Fuerza, analizando datos de enfermedades de declaración obligatoria en el personal militar, referentes a los años 2017 y 2018. Se compararon las notificaciones y el riesgo relativo de afecciones en el personal militar con la población general. Los resultados mostraron que los arbovirus transmitidos por el mosquito Aedes spp. tuvieron las mayores notificaciones entre los militares y se verificó que el riesgo relativo fue mayor en esta categoría en diversas situaciones de afecciones. La principal hipótesis para esto es una mayor exposición a las zoonosis durante las actividades militares. El veterinario, por tanto, está capacitado para desempeñar el papel de funcionario sanitario, actuando en la prevención y control de los riesgos biológicos.

Palabras clave: Fuerzas Armadas; riesgos biológicos; sanidad militar.

Elaine Cristina de Freitas Oliveira
Exército Brasileiro. Escola de Saúde e Formação Complementar do Exército.
elainemedvet@yahoo.com.br

Carlos Roberto Franke
Universidade Federal da Bahia. Escola de Medicina Veterinária e Zootecnia.
frankeufba@gmail.com

José Roberto Pinho de Andrade Lima
Escola Superior de Defesa. Ministério da Defesa. Brasília, DF, Brasil.
jose.roberto@defesa.gov.br

Received: Oct 31, 2022
Approved: Mar 4, 2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

Biological health risk is the probability of exposure to biological agents such as bacteria, viruses, fungi, parasites, protozoa, in addition to vectors (arthropods) and animal bites. Here, this concept can be understood as a risk factor, which is a condition or set of circumstances with potential adverse effect, such as diseases (BRASIL, 2001; BRASIL, 2008). It is worth noting that many of these diseases are vector-borne or zoonotic.

The occurrence of infectious and parasitic diseases depends on the conditions or circumstances in which the work is performed and on the occupational exposure, which favors contact, contagion or transmission. Etiological agents are widespread in the environment, depending on environmental and sanitation conditions, as well as on the prevalence of diseases in the general population. As exposure to biological agents also happens in situations outside the workplace, establishing a causal link is difficult (BRASIL, 2001). Infectious diseases cause many problems for deployed military forces around the world. Historically, those transmitted by vectors were responsible for more casualties than combat (MACEDO; PETERSON; DAVIS, 2007). In low- and middle-income countries, infectious diseases are of great concerning in terms of morbidity and mortality for troops, especially due to the current emergence or re-emergence of vector-borne diseases (PAGES *et al*., 2010).

In the 62 United Nations' peacekeeping missions (UN), between 1947 and 2015, 30% of deaths occurred due to diseases, mostly infectious diseases associated with the environment where the missions were caried out. In the UN peacekeeping missions that Brazil participated in between 1957 and 2015, several diseases affecting the troops were identified, including yellow fever, malaria, leishmaniasis, dengue, chikungunya and rabies. Then, 38 deaths from various causes were confirmed, three of them due to malaria (ANDRADE LIMA, 2016).

In Brazil, there are several reports of military personnel affected by infectious diseases due to their work. Cases of leishmaniasis have already been confirmed in the states of Amazon (GUERRA *et al*., 2003; LORENZI, 2014) and in Pernambuco (ANDRADE, 2004; ANDRADE *et al*., 2009; BRANDÃO-FILHO *et al*., 1998); leptospirosis in Paraná (MARASCHIN; ESTRELA; FERREIRA, 2005), Ceará (BRAZ, 2014) and Rio de Janeiro (DE LORENZI, 2014;); severe acute respiratory syndrome in Rio de Janeiro (DE LORENZI, 2014), in addition to cases of chikungunya in military personnel who returned from the UN peacekeeping mission in Haiti in 2014 (LORENZI, 2014).

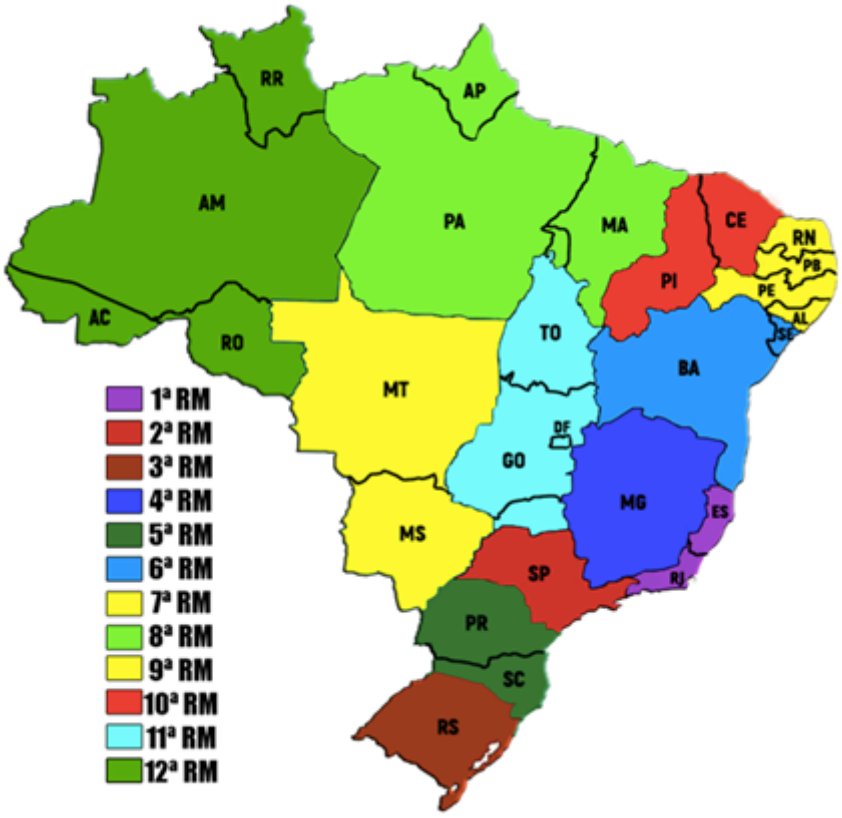
This article aimed to know the biological risks in the activities of military personnel of the Brazilian Army and discuss the role of the military veterinarian in actions of Health Protection of the Force.

2 MATERIALS AND METHODS

An ecological study was carried out adopting the 12 Military Regions (MR) of the Brazilian Army as area analysis units, with their respective federal units of coverage: 1st MR (Rio de Janeiro and Espírito Santo), 2nd MR (São Paulo), 3rd MR (Rio Grande do Sul), 4th MR (Minas Gerais), 5th MR (Paraná and Santa Catarina), 6th MR (Bahia and Sergipe), 7th MR

(Rio Grande do Norte, Paraíba, Pernambuco and Alagoas), 8th MR (Pará, Amapá and Maranhão), 9th MR (Mato Grosso do Sul and Mato Grosso), 10th MR (Ceará and Piauí), 11th MR (Federal District Goiás and Tocantins), and 12th MR (Amazonas, Acre, Rima and Rondônia) (Figure 1). The data considered in the study are comprised in the biennium 2017 and 2018.

Figure 1 – Map of jurisdiction of the Military Regions (MR) of the Brazilian Army



Source: CENTRO ROSA DA FONSECA, 2023

Data on diseases in military personnel were obtained from endemic disease control maps (compulsory notification diseases included) requested from the Army Health Directorate, so to identify the most frequent diseases the military personnel are exposed to in their activities. These maps are sent monthly by all Military Organizations (OM) that have a health section in the MR to which they are subordinated. Finally, the MR send the cartographies to the Army Health Directorate. Some OM, such as military hospitals, also serve reserve military personnel and dependents of military personnel, thus, the number of cases does not necessarily correspond only to occurrences in active-duty military personnel. Only data on diseases that are related to zoonoses and/or those transmitted by vectors were used. The incidences of reported diseases in military organizations were also calculated, using the number of cases divided by the estimate of the number of military personnel of each MR, according to the Army Statistical Yearbook (BRASIL, 2019a), and expressed per 100,000 individuals.

General population data on chikungunya, dengue and Zika were obtained from the epidemiological bulletins about arboviruses of the Brazilian Ministry of Health (MH) (BRAZIL, 2019c; BRAZIL, 2019d); data on Chagas disease, cutaneous leishmaniasis, visceral leishmaniasis were obtained from the website of the National Notifiable Diseases System (Sinan), in which there were no data available for 2018 (BRAZIL, 2019g); data on yellow fever were obtained from the epidemiological bulletin and from the MH reports (BRAZIL, 2017b; BRAZIL, 2018b; BRAZIL, 2019b); data on spotted fever, hantavirosis, leospirosis, plague, and rabies were obtained from the website of the MH (BRAZIL, 2019f), and data on malaria were obtained from the Strategic Management Room of the Ministry of Health (BRAZIL, 2019b). Data on the size of the Brazilian population were obtained from the website of the Brazilian Institute of Geography and Statistics (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2019). Data on yellow fever were made available by seasonal period, which runs from July of one year to June of the following year and, therefore, it was not possible to separate the number of cases for each year; hence, the sum of the cases of 2017 and 2018 was considered. Data used refer to the reported cases confirmed and under investigation, excluding those discarded. The incidence of reported diseases was calculated using the number of cases divided by the estimated population of a given geographical area, according to the Brazilian Institute of Geography and Statistics (IBGE), and expressed per 100,000 inhabitants.

The relative risk for diseases in the military was estimated in relation to the general population, based on the ratio between the incidence of injury in the military and the incidence of injury in the population, to identify if the risk of illness was higher among the military.

3 RESULTS

Table 1 shows data on zoonotic and vector diseases recorded in military personnel.

Table 2 shows data on zoonotic and vector diseases recorded in the general population.

Table 1 – Number of cases notified to the Army Health Directorate of zoonoses and vector diseases of compulsory notification registered in military personnel, by MR, in 2017 and 2018.

MR/Disease		Chikungunya	Dengue	Zika	Chagas Disease	Yellow Fever	Cutaneous Leishmaniasis	Visceral Leishmaniasis	Leptospirosis	Malaria	Total
1st MR (RJ, ES)	2017	3	128	3	0	0	1	0	0	0	135
	2018	39	46	10	0	0	0	0	0	2	97
2nd MR (SP)	2017	0	29	0	0	5	0	0	1	1	36
	2018	0	3	0	0	0	0	0	0	0	3
3rd MR (RS)	2017	0	0	0	2	0	0	1	2	0	5
	2018	0	0	0	0	0	0	1	0	0	1
4th MR (MG)	2017	2	44	0	0	0	0	1	0	0	47
	2018	1	20	0	0	1	2	0	0	0	24
5th MR (PR, SC)	2017	1	2	0	3	0	15	0	0	0	21
	2018	0	3	0	0	0	1	0	3	0	7
6th MR (BA, SE)	2017	0	22	0	0	0	0	0	0	0	22
	2018	11	0	1	1	0	0	0	0	0	13
7th MR (RN, PB, PE, AL)	2017	11	77	0	0	0	10	6	0	2	106
	2018	22	168	2	1	0	16	3	0	6	218
8th MR (PA, AP, MA)	2017	15	120	25	0	10	11	0	1	5	187
	2018	0	15	0	0	0	110	2	0	0	127
9th MR (MS, MT)	2017	1	54	0	0	0	1	3	0	3	62
	2018	52	16	4	0	0	0	1	0	0	73
10th MR (CE, PI)	2017	96	40	3	0	0	0	2	0	0	141
	2018	1	5	0	0	0	0	1	0	0	7
11th MR (DF, GO, TO)	2017	3	72	1	0	0	0	0	0	0	76
	2018	0	85	3	0	0	0	0	0	0	88
12th MR (AM, AC, RR, RO)	2017	85	363	43	0	0	34	2	0	335	862
	2018	6	157	8	0	0	28	1	24	425	649
Total	2017	217	951	75	5	15	72	15	4	346	1,700
	2018	132	518	28	2	1	157	9	27	433	1,307

Source: Prepared by the authors, based on data from the Army Health Directorate (2019).

Table 2 – Number of cases notified to Sinan of zoonoses and vector diseases of compulsory notification recorded in the general population, by MR, in 2017 and 2018.

MR/Disease		Chikungunya	Dengue	Zika	Chagas Disease	Yellow fever*	Spotted Fever	Hantivirus disease	Cutaneous Leishmaniasis	Visceral Leishmaniasis	Leptospirosis	Malaria	Rabies
1st MR (RJ, ES)	2017	5,476	17,514	2,905	0	864	22	0	185	34	236	109	0
	2018	35,342	20,351	2,286	...		7	0	...	...	315	215	0
2nd MR (SP)	2017	934	9,204	309	2	1.000	64	8	254	159	564	127	0
	2018	400	11,465	209	...		104	2	...	...	530	141	1
3rd MR (RS)	2017	63	176	14	0	9	2	6	10	6	494	13	0
	2018	45	93	6	...		3	2	...	...	449	19	0
4th MR (MG)	2017	16,320	25,949	723	0	1.228	33	5	1,520	770	129	69	0
	2018	11,438	23,290	123	...		72	8	...	...	179	46	0
5th MR (PR, SC)	2017	210	2,343	73	0	12	37	21	261	8	575	47	0
	2018	137	1,210	14	...		46	14	...	...	579	79	0
6th MR (BA, SE)	2017	9,412	10,287	2,326	0	27	0	0	2,845	340	109	11	1
	2018	3,412	7,824	679	...		0	0	...	...	93	94	0
7th MR (RN, PB, PE, AL)	2017	5,991	21,838	850	0	13	1	0	399	330	305	26	1
	2018	3,638	40,945	936	...		0	0	...	...	311	22	0
8th MR (PA, AP, MA)	2017	15,251	15,799	1,207	306	28	0	2	4,988	1,182	223	53,354	0
	2018	6,526	5,809	297	...		1	10	...	...	239	62,009	10
9th MR (MS, MT)	2017	3,606	11,523	2,252	2	4	0	10	2,335	148	21	604	0
	2018	13,338	8,273	629	...		1	5	...	...	28	898	0
10th MR (CE, PI)	2017	120,423	44,345	1,527	0	2	1	0	441	642	28	35	0
	2018	1,868	5,286	106	...		2	0	...	...	58	41	0
11th MR (DF, GO, TO)	2017	3,361	72,307	4,614	0	39	5	2	588	333	36	133	1
	2018	354	76,371	1,005	...		1	2	...	...	52	95	0
12th MR (AM, AC, RR, RO)	2017	4,546	8,104	793	10	9	0	0	4,359	35	320	139,900	3
	2018	244	4,874	379	...		0	1	...	...	260	130,854	0
Total	2017	185,593	239,839	17,593	320		165	54	18,185	3,987	3,041	194,428	6
	2018	76,742	205,791	6,669	...	3.235	237	44	...	...	3,093	194,513	11

Source: Prepared by the authors, based on Sinan data. Note: No data available; * aggregate data 2017/18

Table 3 shows data on the incidence of zoonoses and vector diseases recorded in the military personnel and in the general population, as well as relative risk data for zoonoses and vector diseases in the military personnel in relation to the general population.

In 2017, the relative risk was higher in military personnel in the following diseases: chikungunya in the 5th MR (5.61), 7th MR (2.64), 8th MR (1.66), 10th MR (1.82) and 12th MR (7.11); dengue in the 1st MR (3.80), 2nd MR (8.24), 4th MR (4.07), 6th MR (7.50), 7th MR (5.07), 8th MR (12.81), 9th MR (2.05), 10th MR (2.06) and 12th MR (17.03); Zika in the 8th MR (34.93), 10th MR (4.49) and 12th MR (20.62); yellow fever in the 2nd MR (13.12) and 8th MR (613.94); Chagas disease in the 3rd MR and 5th MR (the relative risk value could not be determined since the incidence in the general population was zero); cutaneous leishmaniasis in the 1st MR (2.82), 5th MR (68.22), 7th MR (36.00), 8th MR (3.72) and 12th MR (2.96); visceral leishmaniasis in the 3rd MR (65), 4th MR (3.12), 7th MR (26.13), 9th MR (8.89), 10th MR (7.13) and 12th MR (21.94); leptospirosis in the 2nd MR (4.64), 3rd MR (1.49) and 8th MR (7.56); and malaria in the 2nd MR (20.71), 7th MR (108.54) and 9th MR (2.18). The relative risk in military personnel for dengue in the 5th MR (1.01) presented a value very close to 1, showing no association between exposure to the risk factor and the occurrence of the disease.

In 2018, the relative risk was higher in military personnel for the following diseases: chikungunya in the 6th MR (10.82), 7th MR (8.54), 9th MR (1.64), 10th MR (1.22) and 12th MR (9.03); dengue in the 1st MR (1.17), 4th MR (2.02), 5th MR (2.73), 7th MR (5.80), 8th MR (4.12), 10th MR (2.15) and 12th MR (11.61); Zika in the 1st MR (2.27), 6th MR (4.94), 7th MR (3.02), 9th MR (2.67), 11th MR (1.35) and 12th MR (7.76); yellow fever in the 4th MR (1.92); leptospirosis in the 5th MR (5.72) and 12th (33.90); and malaria in the 1st MR (4.82), 7th MR (379.82) and 12th MR (1.19). The relative risk for Chagas disease, cutaneous leishmaniasis and visceral leishmaniasis in the military personnel could not be estimated in relation to the general population due to the unavailability of data on the incidence in the general population (Table 3).

Table 3 – Incidence of zoonoses and vector diseases of compulsory notification registered in the military personnel (/100 thousand) notified to the Army Health Directorate, incidence of zoonoses and vector diseases of compulsory notification registered in the general population (/100 thousand) notified to Sinan and relative risk (RR) in the military personnel, by MR, in 2017 and 2018. (continued)

MR/Disease Military		Chikungunya			Dengue			Zika			Yellow Fever		
		Military	Population	RR	Military	Population	Military	Military	Population	RR	Population	Population	RR
1st MR (RJ, ES)	2017	7.52	26.41	0.28	320.94	84.46	3.80	7.52	14.01	0.54	0	4.13	0
	2018	95.90	160.24	0.60	113.11	96.30	1.17	24.59	10.82	2.27	0		0
2nd MR (SP)	2017	0	2.07	0	168.19	20.41	8.24	0	0.68	0	29.00	2.21	13.12
	2018	0	0.88	0	16.77	25.18	0.67	0	0.46	0	0		0
3rd MR (RS)	2017	0	0.56	0	0	1.55	0	0	0.12	0	0	0.008	0
	2018	0	0.40	0	0	0.82	0	0	0.05	0	0		0
4th MR (MG)	2017	22.75	77.27	0.29	500.51	122.87	4.07	0	3.42	0	0	5.82	0
	2018	11.16	54.36	0.20	223.11	110.69	2.02	0	0.58	0	11.16		1.92
5th MR (PR, SC)	2017	6.46	1.15	5.61	12.92	12.79	1.01	0	0.40	0	0	0.06	0
	2018	0	0.74	0	17.95	6.57	2.73	0	0.08	0	0		0
6th MR (BA, SE)	2017	0	53.38	0	437.55	58.34	7.50	0	13.19	0	0	0.16	0
	2018	215.90	19.96	10.82	0	45.78	0	19.63	3.97	4.94	0		0
7th MR (RN, PB, PE, AL)	2017	77.61	29.39	2.64	543.25	107.14	5.07	0	4.17	0	0	0.06	0
	2018	153.18	17.93	8.54	1,169.75	201.75	5.80	13.93	4.61	3.02	0		0
8th MR (PA, AP, MA)	2017	156.56	94.35	1.66	1,252.48	97.74	12.81	260.93	7.47	34.93	104.37	0.17	613.94
	2018	0	39.85	0	146.07	35.47	4.12	0	1.81	0	0		0
9th MR (MS, MT)	2017	7.23	59.53	0.12	390.51	190.22	2.05	0	37.18	0	0	0.06	0
	2018	352.30	215.48	1.64	108.40	133.65	0.81	27.10	10.16	2.67	0		0
10th MR (CE, PI)	2017	1,794.39	983.87	1.82	747.66	362.30	2.06	56.08	12.48	4.49	0	0.02	0
	2018	18.45	15.14	1.22	92.25	42.84	2.15	0	0.86	0	0		0
11th MR (DF, GO, TO)	2017	12.11	29.56	0.41	290.54	636.02	0.46	4.04	40.59	0.10	0	0.34	0
	2018	0	3.09	0	335.32	666.93	0.50	11.84	8.78	1.35	0		0
12th MR (AM, AC, RR, RO)	2017	447.51	62.95	7.11	1,911.13	112.22	17.03	226.39	10.98	20.62	0	0.12	0
	2018	30.26	3.35	9.03	776.56	66.91	11.61	40.34	5.20	7.76	0		0

(continua)

Table 3 – Continuation

MR/Disease Military		Chagas Disease			Cutaneous leishmaniasis			Visceral leishmaniasis			Leptospirosis			Malaria		
		Military	Population	RR	Military	Population	RR	Military	Population	RR	Military	Population	RR	Military	Population	RR
1st MR (RJ, ES)	2017	0	0	0	2.51	0.89	2.82	0	0.16	0	0	1.14	0	0	0.53	0
	2018	0	...	...	0	...	...	0	...	...	0	1.49	0	4.92	1.02	4.82
2nd MR (SP)	2017	0	0.004	0	0	0.56	0	0	0.35	0	5.80	1.25	4.64	5.80	0.28	20.71
	2018	0	...	...	0	...	...	0	...	...	0	1.16	0	0	0.31	0
3rd MR (RS)	2017	6.51	0	*	0	0.09	0	3.25	0.05	65	6.51	4.36	1.49	0	0.12	0
	2018	0	...	...	0	...	...	3.01	...	...	0	3.96	0	0	0.17	0
4th MR (MG)	2017	0	0	0	0	7.20	0	11.38	3.65	3.12	0	0.61	0	0	0.33	0
	2018	0	...	...	22.31	...	...	0	...	...	0	0.85	0	0	0.22	0
5th MR (PR, SC)	2017	19.38	0	*	96.87	1.42	68.22	0	0.4	0	0	3.14	0	0	0.26	0
	2018	0	...	...	5.98	...	...	0	...	...	17.95	3.14	5.72	0	0.43	0
6th MR (BA, SE)	2017	0	0	0	0	16.14	0	0	1.93	0	0	0.62	0	0	0.06	0
	2018	19.63	...	...	0	...	...	0	...	...	0	0.54	0	0	0.55	0
7th MR (RN, PB, PE, AL)	2017	0	0	0	70.55	1.96	36.00	42.33	1.62	26.13	0	1.50	0	14.11	0.13	108.54
	2018	6.96	...	...	111.40	...	...	20.89	...	...	0	1.53	0	41.78	0.11	379.82
8th MR (PA, AP, MA)	2017	0	1.89	0	114.81	30.86	3.72	0	7.31	0	10.44	1.38	7.56	52.19	330.07	0.16
	2018	0	...	...	1,071.18	...	...	19.48	...	...	0	1.46	0	0	378.61	0
9th MR (MS, MT)	2017	0	0.03	0	7.23	38.55	0.19	21.70	2.44	8.89	0	0.35	0	21.70	9.97	2.18
	2018	0	...	...	0	...	...	6.78	...	...	0	0.45	0	0	14.51	0
10th MR (CE, PI)	2017	0	0	0	0	3.60	0	37.38	5.24	7.13	0	0.23	0	0	0.29	0
	2018	0	...	...	0	...	...	18.45	...	...	0	0.47	0	0	0.33	0
11th MR (DF, GO, TO)	2017	0	0	0	0	5.17	0	0	2.93	0	0	0.32	0	0	1.17	0
	2018	0	...	..	0	...	...	0	...	...	0	0.45	0	0	0.83	0
12th MR (AM, AC, RR, RO)	2017	0	0.14	0	179.00	60.36	2.96	10.53	0.48	21.94	0	4.43	0	1,763.72	1,937.23	0.91
	2018	0	...	...	126.06	...	...	5.04	...	...	121.02	3.57	33.90	2,143.11	1,796.45	1.19

Source: Prepared by the authors, based on data from the Army Health Directorate, Army Statistical Yearbook, Sinan and INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (2019). Note: [...]: no data available; (*) could not be estimated.

4 DISCUSSION

The results show that urban arboviruses transmitted by the mosquito *Aedes* spp. (chikungunya, dengue and Zika) are the diseases with the most notifications among the military personnel, considering the years 2017 and 2018. With the exception of the 3rd MR, all MRs had reported cases of at least one of them. In general, the cases in the military personnel presented the same pattern of increase or decrease in 2018 relative to 2017 as in the general population.

Studies show that arboviruses are an occupational risk for military personnel in several countries. Gibbons *et al*. (2012) pointed out that dengue is a threat to military troops in endemic areas and that, between 1960 and 1990, dengue occurred frequently in American troops deployed in Asia, Africa and Central America, with an attack rate of up to 80%.

Frickmann and Herchenröder (2019) reviewed the literature on Chikungunya virus infections in troops from several countries on missions abroad and concluded that this disease is a real threat to military personnel deployed in endemic areas due to the mode of vector transmission and in an outbreak scenario. On the other hand, the transmission frequency appears to be low outside the outbreak scenario.

Two cases of Chagas disease were reported in the 3rd MR and three in the 5th MR in 2017, while Sinan data show that there were no cases reported in the same areas and period. Military personnel is constantly transferred and can serve anywhere in Brazil; therefore, these cases can be of professionals who have been transferred from areas with notification to places without notification history. However, the notification of cases of acute Chagas disease must be immediate (within 24 hours of care, by the fastest possible means) to the Municipal Health Department/ State Health Department. The health authority that receives the immediate mandatory notification must notify the other management spheres of the Unified Health System within 24 hours (BRASIL, 2016b). Thus, the differences between the information from the Army Health Directorate and those from the Sinan may result from the failure in the chain of notifications. The cases reported in the military personnel could not be compared to those reported by the general population in 2018, since no data on this condition were available in Sinan.

Of the nine diseases with positive reports in military personnel in 2017 and 2018, yellow fever was the one with the lowest number of reports among MRs (three). This can be explained by the fact that vaccination against yellow fever is mandatory in the military personnel (BRASIL, 2014). However, in MRs that reported it, the incidence was higher than in the general population (although the comparison was impaired because the yellow fever data in the population were not annual but seasonal). Non-compliance with mandatory vaccination, vaccine failure, interference of cases occurring in military dependents may justify the higher incidence in military personnel.

According to researchers Leggat and Frean (2006), the military personnel compose the high-risk group for yellow fever if in endemic areas. However, since there is a vaccine against this disease, the risk will be reduced if the military is vaccinated.

Izurieta *et al*. (2009) published a study with the results of an investigation of an outbreak of hemorrhagic fever in military personnel on a mission in the interior of the Ecuadorian Amazon rainforest. In total, 44 cases of yellow fever and three deaths were identified among the 341 individuals who had not been immunized. The spread of the outbreak was quickly

controlled by vaccination of military personnel who had not been affected. Detachments and outposts within the Amazon rainforest were significantly associated with yellow fever infection due to increased exposure to the transmitting mosquito.

The 8th and the 12th MRs, which cover states in the northern region of the country, showed the highest number of diseases, with the highest incidence. When transferred to one of these MRs, every soldier mandatorily performs the Adaptation Stage to Life in the Jungle, whose objective is to provide adaptation and aggregate military knowledge of combat and survival techniques in the jungle. In these MR there are other internships and operational courses, of a voluntary nature, carried out by military personnel from all over the country. These courses and internships take place in the Amazon operating environment, where there are reservoirs and vectors of leishmaniasis, leptospirosis and malaria. These soldiers usually had no previous contact with these diseases and, therefore, have no immunological memory, which makes them vulnerable. Several military personnel serve in border outposts and patrol the jungle, increasing exposure to these diseases. A study by Dhiman *et al*. (2011) corroborates these claims and points out that the high incidence of malaria in the local population also increases the risk of infection, since it functions as a reservoir for the disease. The studies by Guerra *et al*. (2003) and Lorenzi (2014), which describe outbreaks of cutaneous leishmaniasis in military personnel who participated in operational courses in the Amazon, showed similar findings to those of this research.

The high incidence of cutaneous leishmaniasis in the two years of the study in the 7th MR, which was higher than in the general population in 2017, may be associated with the training that takes place at the Newton Cavalcanti Instruction Center in the state of Pernambuco. In this location, several outbreaks have been reported according to the studies by Brandão-Filho *et al*. (1998), Andrade (2004) and Andrade *et al*. (2009).

Approximately 75% of emerging or re-emerging diseases affecting humans at the beginning of the 21st century are zoonotic diseases (BROWN, 2013). Work environments with animals increase the risk of transmission of zoonotic infections (BIENZ; TOMASZEWSKI; MCDONALD, 2018).

The risk in epidemiological surveillance is shown by the incidence. Incidence measures the risk of becoming ill due to a given disease in a given population in a given period. A high incidence means a high collective risk of getting sick (BRASIL, 2005). The relative risk estimates the magnitude of the association between exposure to the risk factor and the onset of the disease, indicating how often the occurrence of the disease in those exposed is greater than that among those not exposed (WAGNER; CALLEGARI-JACQUES, 1998). The results showed that, in 2017, the risk of military personnel becoming ill due to chikungunya was higher in five MRs; dengue in nine MRs; Zika in three MRs; Chagas disease in two MRs; yellow fever in two MRs; cutaneous leishmaniasis in five MRs; visceral leishmaniasis in six MRs; leptospirosis in three MRs, and malaria in three MRs. In 2018, the risk of the military personnel becoming ill due to chikungunya was higher in five MRs; dengue in seven MRs; Zika in six MRs; yellow fever in one MR; leptospirosis in two MRs and malaria in three MRs; Chagas disease, cutaneous leishmaniasis and visceral leishmaniasis could not be estimated in the general population due to data unavailability.

A review article prepared by Leggat (2010) concluded that even with the advance of measures to prevent tropical diseases, these continue to represent a significant risk for military troops deployed in other countries and in terms of infectious diseases, those transmitted by

vectors, in particular, malaria and arboviruses and, more recently, leishmaniasis, stand out as a major risk for the military personnel.

The causes for the increased risk of these diseases in the military personnel must be investigated. One of the hypotheses is the greater exposure to vectors and reservoirs of diseases during operational activities. Davoust, Marié and Boni (2008) pointed out that the military personnel, by their profession, take risk and constitute a group particularly exposed to zoonotic diseases during operations or training in various environments. In addition, according to these authors, they appear to be more sensitive to exotic zoonoses when they enter a new ecosystem because they do not have immunological memory. Biselli *et al*. (2022) say that the military are exposed to the risk of infectious diseases for a number of reasons, including community life, often in poor environmental conditions regarding hygiene of water and food supply, sanitation, trauma with contaminated wounds and possibility of exposure to extreme temperatures and unknown diseases at their place of origin, for which no natural immunization has therefore been developed.

4.1 Health protection and the role of the military veterinarian

Most of these risks can be mitigated by strict adherence to a comprehensive Force Health Protection plan. Regarding operational health, there is more than one publication that addresses preventive measures.

According to the Health Support in Joint Operations manual of the Ministry of Defense:

> Operational Health is the set of actions related to the conservation of human potential in the best conditions of physical and psychological fitness, aiming to maintain the operational capacity of a Force regarding health aspects; its scope is to mitigate the effects that diseases and injuries can generate on the efficiency, availability and morale of a troop, contributing to the fulfillment of its mission. (BRASIL, 2017a)

While there is a manual from the Ministry of Defense, there is also a Doctrinal Coordination Note (DCN) on 01/2016, prepared by the Department of Education and Culture of the Army. There, the Health Support in the Operations of the Component Ground Force can be found, whose purpose is to present the structuring of operational health in the Brazilian Army and describe the characteristics necessary for the Functional Health Group to support health operations at the Component Ground Force level. Its focus is on operative medicine, whose actions aim to minimize the effects of injuries, diseases and illnesses acquired in military operations, in addition to conducting health actions in peacekeeping missions and in response to disaster situations and humanitarian support in Brazil and abroad, with the objective of safeguarding the physical and mental health of the military and the assisted population (BRASIL, 2016a).

The NCD mentions that, to ensure the health of the military, measures of sanitary and environmental surveillance, zoonosis control, inspection of food and water consumed by the troops and preventive medicine (sanitation, hygiene, disease control, immunization and sanitary education) should be applied. It highlights health intelligence as a vital activity for the planning and success of health support in operations (BRASIL, 2016a).

Health Intelligence "deals with the collection, evaluation, analysis, interpretation and dissemination of health-related knowledge, such as environmental, medical, epidemiological, public health information" (BRASIL, 2018a), among others. It has several purposes, for example, detecting, identifying and minimizing health threats, collaborating in the search for data, contributing to measure the health and environmental risks that troops may be exposed to, with recommendations related to the protection of the health of the Force. It is useful for the development and execution of preventive medicine actions and necessary prophylactic measures (BRASIL, 2016a).

The Ground Military Logistics Field Manual, of the Land Operations Command, says that:

> Health Logistics Function is the set of activities related to the conservation of human capital in the appropriate conditions of physical and psychological fitness, through sanitary measures of prevention and recovery (BRASIL, 2018a).

In addition, it lists measures aimed at disease prevention, water analysis, purification and treatment; environmental management; and, finally, sanitary measures for prevention, sanitary control and food inspection, food safety and biological defense, control of zoonoses and pests. Among the activities of the Health Logistics Function are health protection and health intelligence. Health protection "is related to the conservation and preservation of the general health of contingents, through the prevention of diseases and injuries", through prophylactic measures and adequate sanitary conditions (sanitation, hygiene, disease control, immunization and sanitary education), among others (BRASIL, 2018a).

Prevention of disease is one of the responsibilities of command; however, the importance of health education cannot be underestimated. For the commander to play his primary role, it is necessary that the importance of prevention be emphasized for him, through the communication of environmental risks and infectious diseases for the health of the troops. This awareness has to be made by the health officer, who must assess the risks, specify the prevention and control measures of the diseases, guide the command and the troop and inspect if the measures are being complied with (LYNCH *et al*., 2014). Correct and timely perception of the threat is essential, as protective behavior is linked to risk perception. This can be achieved if the soldier has real knowledge about the risk to which they are exposed, if a health team is available to pass on this knowledge and oversee its execution, if the command is committed to ensuring that protection and control measures are complied with.

Another fundamental factor is the availability of health data for the correct dimensioning of risk and prevention planning by the health team (KUNWAR; PRAKASH, 2015). The awareness of each military is important as disease prevention and control measures are not intuitive, and the risk will not be reduced if not implemented or poorly executed. The importance of prevention must be constantly reinforced by theoretical and practical instructions. The commander should work closely with the health officer and his team (CROFT; BAKER ; VON BERTELE, 2001). Campaign manuals with these guidelines must be published. The military veterinarian, as a health officer, may exercise this function with the commander.

The veterinarian has a wide range of activities such as prevention and treatment of animal diseases, hygiene and inspection of animal products, animal health defense, public

health (control and eradication of zoonotic infections, food safety), environmental and ecological preservation. The veterinarian's training presents a multidisciplinary nature, enabling the professional to work both with humans and with animals, especially when it comes to public health. Moreover, the veterinarian has a fundamental role in the promotion, prevention and assistance to human, animal, and environmental health (POSSAMAI, 2011).

In the military sphere, there are several activities related to the health of the personnel that can be performed by a veterinarian, both in peacetime and in operations. These activities involve food security, prevention of waterborne diseases, control of zoonotic infections, control of pests and vectors, and health intelligence (MARQUES; ANDRADE LIMA, 2016).

According to the Ground Military Logistics Campaign Manual, the

> Veterinary officer acts with the objective of preserving the health of the troop, through sanitary and environmental surveillance measures, water and food inspection and control of zoonotic infections and pests. It also performs clinical and surgical treatment of work animals used in military operations, as well as composes multidisciplinary health teams, in order to evaluate the possible health threats inherent to the operational environment. (BRASIL, 2018a)

To reduce the risk of the troop becoming ill, MRs need to employ the ability of the veterinarian to control the biological risks to the health of the troop: to carry out epidemiological surveillance of the areas in which the OMs are located and where operations occur; depending on the biological risks identified, to propose prevention and control measures for the troop, especially those related to vectors and zoonotic diseases; to carry out sanitary surveillance of the facilities where food is produced and stored, as well as to carry out the inspection of the food itself, including the quality of the water consumed; to control vectors, pests and rodents; to propose measures to avoid and/or reduce environmental damage arising from military activities; to carry out the planning of troop sanitary education, with matters related to protection against vectors, rodents and venomous animals, care with storage and consumption of food and water and the importance of good personal hygiene.

5 CONCLUSION

We found that, for some diseases and in some regions of the country, the risk of getting sick is higher in the military personnel than in the general population, especially concerning vector diseases. According to the data analyzed in this article, the main biological risks to which military personnel were exposed to were those caused by chikungunya, dengue, Zika, Chagas disease, yellow fever, cutaneous leishmaniasis, visceral leishmaniasis, leptospirosis, and malaria.

The main hypothesis for this risk is the greater exposure to reservoirs and vectors of zoonotic infections during the performance of their activities, especially those of operational nature. However, more studies are needed to confirm and deepen these results.

Among the limitations of the research, we can mention the difficulties of obtaining data on diseases in the general population, since for some of them there was no information

regarding 2018. In addition, we face the lack of standardization of elements or provision of seasonal information, such as for the systematization of yellow fever. We also had to deal with the unavailability of data by category of workers, which otherwise would have resulted in a more reliable comparison between populations, since the comparison made in this article was between the military (population of workers aged 18-60 years) and the general population (range 0-90 years). Finally, by surveying the diseases that affect the military personnel, we found data on some compulsory notification diseases; however, it was not possible to identify if all reported cases occurred in active-duty military personnel, since military hospitals also serve reserve military personnel and military dependents.

The military veterinarian is qualified to exercise the role of health officer in the prevention and control of biological risks, as the veterinarian is a professional qualified for this task due to the multidisciplinary nature of the career, conferring knowledge about human, animal and environmental health.

AUTHORSHIP AND COLLABORATIONS

All authors participated equally in elaborating the article.

REFERENCES

ANDRADE, M. S. **Epidemiologia da leishmaniose tegumentar americana em centro de treinamento militar na Zona da Mata de Pernambuco, Brasil**. 2004. Dissertação (Mestrado em Saúde Pública) – Departamento de Saúde Coletiva, Fundação Osvaldo Cruz, Recife, 2004. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/lil-398490. Access: March 27, 2023.

ANDRADE, M. S. *et al*. Novo surto de leishmaniose tegumentar americana em área de treinamento militar na Zona da Mata norte do Estado de Pernambuco. **Revista da Sociedade Brasileira de Medicina Tropical**, Uberaba, v. 42, n. 5. p. 594-596, 2009. Available from: https://www.scielo.br/j/rsbmt/a/cx9CS4dDFJ3y6XRw5GfzsrH/abstract/?lang=pt. Access: March 27, 2023.

BIENZ, M.; TOMASZEWSKI, M.; MCDONALD, E. G. Severe pet-transmitted zoonosis in a patient with a compromised immune system. **Canadian Medical Association Journal**, Ottawa, v. 190, n. 45, p. 1332–1336, 2018. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6232001/. Access: March 27, 2023.

BISELLI, R. *et al*. A historical review of military medical strategies for fighting infectious diseases: from battlefields to global healths. **Biomedicines**, Bethesda, v. 10, n. 8, p. 2050, 2022. Available from: https://pubmed.ncbi.nlm.nih.gov/36009598/. Access: March 27, 2023.

BRANDÃO-FILHO, S. P. *et al*. Leishmaniose tegumentar americana em centro de treinamento militar localizado na Zona da Mata de Pernambuco, Brasil. **Revista da Sociedade Brasileira de Medicina Tropical**, Uberaba, v. 31, n. 6, p. 575-578, 1998. Available from: https://www.scielo.br/j/rsbmt/a/SGdhxZYj5hSfZzGByp475Nj/?lang=pt. Access: March 27, 2023.

BRASIL. Ministério da Saúde. Organização Pan-Americana de Saúde. **Doenças relacionadas ao trabalho**: manual de procedimentos para os serviços de saúde. Brasília, DF: Ministério da Saúde, 2001. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/doencas_relacionadas_trabalho_manual_procedimentos.pdf. Access: March 27, 2023.

BRASIL. Ministério da Saúde. **Curso Básico de Vigilância Epidemiológica**. Brasília, DF: Ministério da Saúde, 2005. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/Curso_vigilancia_epidemio.pdf. Access: March 27, 2023.

BRASIL. Ministério do Trabalho. **Riscos Biológicos – Guia Técnico: os riscos biológicos no âmbito da Norma Regulamentadora no** 32. Brasília, DF: Ministério do Trabalho, 2008.

BRASIL. Ministério da Defesa. **Portaria Normativa no 1.631 – Ministério da Defesa, de 27 de junho de 2014**. Institui o Calendário de Vacinação Militar. Brasília, DF: Ministério da Defesa, 2014. Available from: https://mdlegis.defesa.gov.br/norma_pdf/?NUM=1631&ANO=2014&SER=A. Access: March 27, 2023.

BRASIL. Ministério da Defesa. Brazilian Army. **Portaria no 206 – Departamento de Educação e Cultura do Exército, de 28 de novembro de 2016**. Nota de Coordenação Doutrinária nº 01/2016-DECEx, o Apoio de Saúde nas Operações da Força Terrestre Componente. Brasília, DF: Ministério da Defesa, 2016a. Available from: http://www.sgex.eb.mil.br/sg8/006_outras_publicacoes/07_publicacoes_diversas/08_departamento_de_educacao_e_cultura_do_exercito/port_n_206_decex_28nov2016.html. Access: March 27, 2023.

BRASIL. Ministério da Saúde. **Portaria n° 204, de 17 de fevereiro de 2016**. Define a Lista Nacional de Notificação Compulsória de doenças, agravos e eventos de saúde pública nos serviços de saúde públicos e privados em todo território nacional, nos termos do anexo, e dá outras providências. Brasília, DF: Ministério da Saúde, 2016b. Available from: https://bvsms.saude.gov.br/bvs/saudelegis/gm/2016/prt0204_17_02_2016.html. Access: March 27, 2023.

BRASIL. Ministério da Defesa. Estado-Maior Conjunto das Forças Armadas. **Instrução Normativa nº 2/EMCFA, de 10 de agosto de 2017**. Aprova o Manual Apoio de Saúde em Operações Conjuntas – MD42-M-04 (1ª Edição/2017). Brasília, DF: Ministério da Defesa, 2017a. Available from: https://www.gov.br/defesa/pt-br/arquivos/legislacao/emcfa/publicacoes/logistica_mobilizacao/md42a_ma_04a_apoioa_dea_saudea_opa_cja_1a_eda_2017.pdf. Access: March 27, 2023.

BRASIL. Ministério da Saúde. **Emergência epidemiológica de febre amarela no Brasil, no período de dezembro de 2016 a julho de 2017**. Boletim Epidemiológico, v. 48, n. 28. Brasília, DF: Ministério da Saúde, 2017b.

BRASIL. Ministério da Defesa. Brazilian Army. **Portaria no 131 – Comando de Operações Terrestres, de 8 de novembro de 2018**. Aprova o Manual de Campanha EB70-MC 10.238 Logística Militar Terrestre. Brasília, DF: Ministério da Defesa, 2018a. Available from: http://www.sgex.eb.mil.br/sg8/003_manuais_carater_doutrinario/01_manuais_de_campanha/port_n_131_coter_08nov2018.html. Access: March 27, 2023.

BRASIL. Ministério da Saúde. **Monitoramento do período sazonal de febre amarela Brasil – 2017/2018**. Informe n. 3, outubro de 2018. Brasília, DF: Ministério da Saúde, 2018b.

BRASIL. Ministério da Defesa. Exército. **O Exército em números (Anuário Estatístico do Exército)**. Brasília, DF: Ministério da Defesa, 2019a. Available from: http://sistemaslegado2.eme.eb.mil.br/anuario-estatistico/home/tabelas_por_assunto/25. Access: Sept. 11, 2019.

BRASIL. Ministério da Saúde. **Monitoramento do período sazonal de febre amarela Brasil – 2018/2019**. Informe n. 27, janeiro de 2019. Brasília, DF: Ministério da Saúde, 2019b.

BRASIL. Ministério da Saúde. **Monitoramento dos casos de arboviroses urbanas transmitidas pelos *Aedes* (dengue, chikungunya e Zika), Semanas Epidemiológicas 1 a 34**. Boletim Epidemiológico, v. 50, n. 22. Brasília, DF: Ministério da Saúde, 2019c.

BRASIL. Ministério da Saúde. **Monitoramento dos casos de dengue, febre de chikungunya e doença aguda pelo vírus Zika até a Semana Epidemiológica 52 de 2018**. Boletim Epidemiológico. v. 50, n. 4. Brasília, DF: Ministério da Saúde, 2019d.

BRASIL. Ministério da Saúde. Sala de Apoio à Gestão Estratégica. **gov.br**. Brasília, DF, 2019e. Available from: http://sage.saude.gov.br/#. Access: Sept. 11, 2019.

BRASIL. Ministério da Saúde. Saúde de A a Z. **gov.br**. Brasília, DF, 2019f. Available from: http://www.saude.gov.br/saúde-de-a-z. Access: Sept. 11, 2019.

BRASIL. Ministério da Saúde. Vigilância em Saúde. Doenças e Agravos de Notificação – De 2007 em diante (Sinan). **gov.br**. Brasília, DF, 2019g. Available from: http://www2.datasus.gov.br/DATASUS/index.php?area=0203&id=29878153. Access: Sep. 11,2019.

BRAZ, M. B. M. **O dano endotelial, tubular e de glicocálice na lesão renal aguda da leptospirose**. 2014. Dissertação (Mestrado em Clínica Médica) – Faculdade de Medicina, Universidade Federal do Ceará, Fortaleza, 2014.

BROWN, J. Emerging Pandemic Threats. **United States Agency for International Development**, Washington, DC, 2013. Available from: https://www.usaid.gov/news-information/fact-sheets/emerging-pandemic-threats-program. Access: Sept. 02, 2019.

CENTRO ROSA DA FONSECA. **Centro Rosa da Fonseca**, 2023. Regiões Militares. Available from: https://rosadafonseca.org/regioes-militares/. Access: Sep. 10, 2023

CROFT, A. M.; BAKER, D.; VON BERTELE, M. J. An evidence-based vector control strategy for military deployments: the British Army experience. **Médecine Tropicale**, Bordeaux, v. 61, n. 1, p. 91-98, 2001.Available from: https ://pubmed.ncbi.nlm.nih.gov/11584666/. Access: March 27,2023.

DAVOUST, B.; MARIÉ, J. L.; BONI, M. Pour une approche préventive des zoonoses: la création d'une cellule de détection précoce des infections animales. **Bulletin de l'Académie Nationale de Médecine**, Paris, n. 3, v. 192, p. 541-554, 2008. Available from: https://www.sciencedirect.com/science/article/pii/S0001407919328110. Access: March 27, 2023.

ANDRADE LIMA, J. R. P. Saúde única e operacionalidade nas missões de paz: o papel estratégico do veterinário militar. **Military Review**, Fort Leavenworth, v. 71, n. 1, p. 29-37, 2016.

DE LORENZI, A. G. **Medicina operativa: perspectivas. Defesa Biológica em situações de conflito e em tempos de paz**. 2014. Monografia (Curso de Política e Estratégia Marítimas) – Escola de Guerra Naval, Rio de Janeiro, 2014.

DHIMAN, S. *et al*. Malaria incidence among paramilitary personnel in an endemic area of Tripura. **Indian Journal of Medical Research**, Mumbai, v. 133, n. 6, p. 665-669, 2011. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3135997/. Access: March 27, 2023.

FRICKMANN, H.; HERCHENRÖDER, O. Chikungunya Virus Infections in Military Deployments in Tropical Settings—A Narrative Minireview. **Viruses**, Bethesda, n. 6, v. 11, p. 550, 2019. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6631184/. Access: March 27, 2023.

GIBBONS, R. D. *et al*. Dengue and US Military Operations from the Spanish-American War through today. **Emerging Infectious Diseases**, Bethesda, v. 18, n. 4, p. 623-630, 2012. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3309667/. Access: March 27, 2023.

GUERRA, J. A. O. *et al*. Aspectos clínicos e diagnósticos da leishmaniose tegumentar americana em militares simultaneamente expostos à infecção na Amazônia. **Revista da Sociedade Brasileira de Medicina Tropical**, Uberaba, v. 36, n. 5, p. 587-590, 2003. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/lil-348030. Access: March 27, 2023.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **População residente enviada ao Tribunal de Contas da União Brasil, Grandes Regiões e Unidades da Federação – 2001-2018**. Rio de Janeiro: IBGE, 2019. Available from: https://www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?=&t=resultados. Access: Sept. 10,2019.

IZURIETA, R. O. *et al*. Assessing yellow Fever risk in the Ecuadorian Amazon. **Journal of Global Infectious Diseases**, Bethesda, v. 1, n. 1, p. 7-13, 2009. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2840941/. Access: March 27,2023.

KUNWAR, R.; PRAKASH, R. Dengue outbreak in a large military station: have we learnt any lesson? **Medical Journal Armed Forces India**, Pune, v. 71, n. 1, p. 11-14, 2015. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4297823/. Access: March 27, 2023.

LEGGAT, P. A. Tropical Diseases of Military Importance: A Centennial Perspective. **Journal of Military and Veterans Health**, Melbourne, v. 18, n. 4, p. 25-31, 2010. Available from: https://search.informit.org/doi/abs/10.3316/INFORMIT.894607197197058. Access: March 27,2023.

LEGGAT, P. A.; FREAN, J. Health countermeasures for military deployment. **Occupational Health Southern Africa**, Johannesburg, v. 12, n. 2, p. 4-11, 2006. Available from: https://researchonline.jcu.edu.au/4163/. Access: March 27, 2023.

LYNCH, J. H. *et al*. Bites, stings, and rigors: clinical considerations in African operations. **Journal of Special Operations Medicine**, Petersburg, v. 14, n. 4, p. 113-121, 2014. Available from: https://prolongedfieldcare.org/wp-content/uploads/2016/02/jsom-2014-this-is-africa-bites-stings-and-rigors-clinical-considerations-in-african-operations.pdf. Access: March 27, 2023.

MACEDO, P. A.; PETERSON, R. K.; DAVIS, R. S. Risk assessments for exposure of deployed military personnel to insecticides and personal protective measures used for disease-vector management. **Journal of Toxicology and Environmental Health A**, London, v. 70, n. 20, p. 1758-1771, 2007. Available from: https://pubmed.ncbi.nlm.nih.gov/17885933/. Access: March 27,2023.

MARASCHIN, M. S.; ESTRELA, S. V. B.; FERREIRA, M. F. A. P. L. Ocorrência atípica de casos de leptospirose no município de Cascavel/PR. **In**: SEMINÁRIO NACIONAL ESTADO E POLÍTICAS SOCIAIS NO BRASIL, 2., 2005, Cascavel. **Anais** [...] Cascavel: Universidade Estadual do Oeste do Paraná, 2005.

MARQUES, F. S.; DE ANDRADE LIMA, J. R. P. O veterinário militar como partícipe do processo one health. **Revista Interdisciplinar de Ciências Aplicadas à Atividade Militar**, Salvador, v. 6, n. 1, 2016. Available from: http://www.ebrevistas.eb.mil.br/RICAM/article/view/1190. Access: March 27, 2023.

PAGES, F. *et al*. The past and present threat of vector-borne diseases in deployed troops. **Clinical Microbiology and Infection**, Amsterdam, v. 16, n. 3, 2010. Available from: https://www.clinicalmicrobiologyandinfection.com/article/S1198-743X(14)60825-9/fulltext. Access: March 27,2023.

POSSAMAI, M. H. P. O papel do médico veterinário na educação e formação na vigilância ambiental em saúde. **Revista Electrónica de Investigación y Docencia**, Lagunilla, n. 1, p. 59-73, 2011. Available from: https://revistaselectronicas.ujaen.es/index.php/reid/article/view/1139. Access: March 27, 2023.

WAGNER, M. B.; CALLEGARI-JACQUES, S. M. Medidas de associação em estudos epidemiológicos: risco relativo e odds ratio. **Jornal de Pediatria**, Rio de Janeiro, v. 74, n. 3, p. 247-251, 1998. Available from: https://lume.ufrgs.br/handle/10183/54354. Access: March 27,2023.

ARTICLE DOI 10.52781/cmm.a102

Factors associated with time of permanence in activity of military personnel wearing Personal Protective Equipment against Nuclear, Biological, Chemical and Radiological Agents

Factores asociados al tiempo de permanencia en servicio del personal militar que porta Equipos de Protección Individual contra Agentes Nucleares, Biológicos, Químicos y Radiológicos

Abstract: This study aimed to investigate the factors that can increase or decrease the time in which the military can remain in activity using Personal Protective Equipment (PPE) and provide assistance to decision-makers at the tactical level of what influences can be decisive for the time in the field. fulfillment of the different missions of Nuclear, Biological, Chemical and Radiological Defense (DefNBQR). A review of the literature, where the reviewed articles presented as influencing factors in the tolerance time, to a greater degree the state of hydration prior to the activity, the climate, the physical demand of the task and the type of PPE; and to a lesser extent aerobic condition, sex, body composition and acclimatization. The effectiveness of extra and intracorporeal cooling methods in prolonging time of the permanence was also observed.

Keywords: Personal Protective Equipment; Military Personnel; Work Performance.

Resumen: El objetivo de este artículo fue investigar los factores que pueden aumentar o disminuir el tiempo en que los militares pueden permanecer en actividad utilizando Equipos de Protección Personal (EPP), así como brindar asistencia a los tomadores de decisiones a nivel táctico cuyas influencias pueden ser determinantes para el tiempo en el cumplimiento de las diversas misiones de Defensa Nuclear, Biológica, Química y Radiológica (DefNBQR). Este análisis se trata de una revisión de la literatura cuyos artículos revisados presentaron como factores influenciadores en el tiempo de tolerancia, en mayor grado, el estado de hidratación previo a la actividad, el clima, la demanda física de la tarea y el tipo de EPP; y, en menor grado, la condición aeróbica, el sexo, la composición corporal y la aclimatación. También se observó la efectividad de los métodos de enfriamiento extra e intracorpóreo en la prolongación de la permanencia.

Palabras clave: Equipo de protección personal; militar; desempeño profesional.

Felipe Kohn Martins[1,2]
felipe.kohn@marinha.mil.br

Maria Elisa Koppke[1,3]
maria_koppke@yahoo.com.br

Bruno Ferreira Viana[1,2]
bferreiraviana@gmail

Pedro Moreira Tourinho[1,2]
edromtourinho@gmail.com

Ulisses Tirollo Taddei[1]
utaddei@gmail.com

Priscila dos Santos Bunn[1,2]
priscilabunn@yahoo.com.br

[1]Marinha do Brasil, Centro de Educação Física Almirante Adalberto Nunes, Laboratório de Pesquisa em Ciências do Exercício e Performance. Rio de Janeiro, RJ, Brasil.

[2]Comando da Aeronáutica, Universidade da Força Aérea, Programa de Pós-Graduação em Desempenho Humano Operacional. Rio de Janeiro, RJ, Brasil.

[3]Universidade do Estado do Rio de Janeiro, Programa de Pós-Graduação em Ciências do Esporte e do Exercício. Rio de Janeiro, RJ, Brasil.

Received: Oct 31, 2022
Approved: Mar 14, 2023

http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

The use of Nuclear, Biological, Chemical, and Radiological Agents (NBCR) dates back to the beginnings of warfare, such as the use of Greek fire by the Byzantine Navy in the 7th century. However, the use of chlorine gas during the First World War represented the start of employing chemical elements systematically as combat weapons. Thus, to deal with these various threats, the Brazilian Navy (MB) created, in 2011, the Nuclear, Biological, Chemical, and Radiological Defense System (SisDefNBQR-MB) (BRASIL, 2011).

Three basic requirements are established to deal with NBCR threats: early warning (ability to anticipate threats), protection (ability to protect oneself from the harmful effects of agents), and recovery (ability to mitigate the effects suffered due to the agent) (BRASIL, 2020). Addressing the physical performance of the military in combat with NBCR threats requires observing the protection requirement and seeking to reduce the physiological effects of NBCR agents on the military by using Personal Protective Equipment (PPE) (BRASIL, 2020).

However, combining body protection clothing with respiratory protection equipment reduces the combatant's capacity due to the physical wear and tear resulting from its use and causes a reduction in mobility (BRASIL, 2020). The North Atlantic Treaty Organization (NATO) considers that the use of PPE generates damage to physiological functions and causes other effects on the human body, which may result in an increase in the time to perform tasks and a reduction in the accuracy of their executions, leading to performance degradation (NORTH ATLANTIC TREATY ORGANIZATION, 2004).

MB adopts the classification of PPE for NBCR in four levels: level A is hermetically closed and fully encapsulated (including gloves and boots), presenting positive pressure and total facial protection. Furthermore, the supply of breathable air uses autonomous air cylinders or external air source, as long as it allows the maintenance of positive pressure; level B requires the same level of respiratory protection as level A but with a lower level of skin protection; level C is the average level of protection when less respiratory and skin protection is required; finally, level D is characterized by the lowest level of protection, without respiratory protection equipment (overalls or jackets and pants chemically resistant to partial splashes, with resistant gloves and boots, and goggles) (BRASIL, 2020).

Four main factors are considered when carrying out tasks involving such PPE: the time required to perform the task, level of clothing protection, weather conditions, and workload (NORTH ATLANTIC TREATY ORGANIZATION, 2004). However, there was a gap regarding the factors associated with the time wearing PPE in NBCR activities, particularly those related to the physical demands of the NBCR operator. Therefore, the objective of this article was to investigate the main factors associated with the time that the military can remain working with PPE.

2 METHOD

This article was a narrative review of the literature based on the recommendations of Sanra, with a systematic search carried out in February 2021 in electronic scientific

databases: Scopus, National Library of Medicine (Medline), and Web of Science (BAETHGE; GOLDBECK-WOOD; MERTENS et al., 2019). The factors associated with the time of use of the PPE were defined as independent variables, and the time of permanence or tolerance in activity using PPE as the dependent variable. The search descriptors were obtained from queries in the Health Sciences Descriptors (DeCS) and Medical Subject Headings (MeSH) databases, as shown in Chart 1.

Chart 1 – Descriptors used in the search in the databases.

DESCRIPTOR 1	DESCRIPTOR 2
nuclear, biological, and chemical (NBC) clothing OR NBC protective clothing OR chemical defense clothing OR Protective clothing ensembles OR Biological and chemical protective clothing OR Chemical protective ensemble OR Chemical protective mask OR Chemical protective equipment OR Chemical, Biological, Radiological, and Nuclear OR CBRN OR Hazmat clothing OR Hazmat suit OR CBRN suit OR Encapsulated clothing	Work performance OR Dehydration OR Heat OR Heat stress OR Water stress OR Physiological

Source: Prepared by the authors, 2022

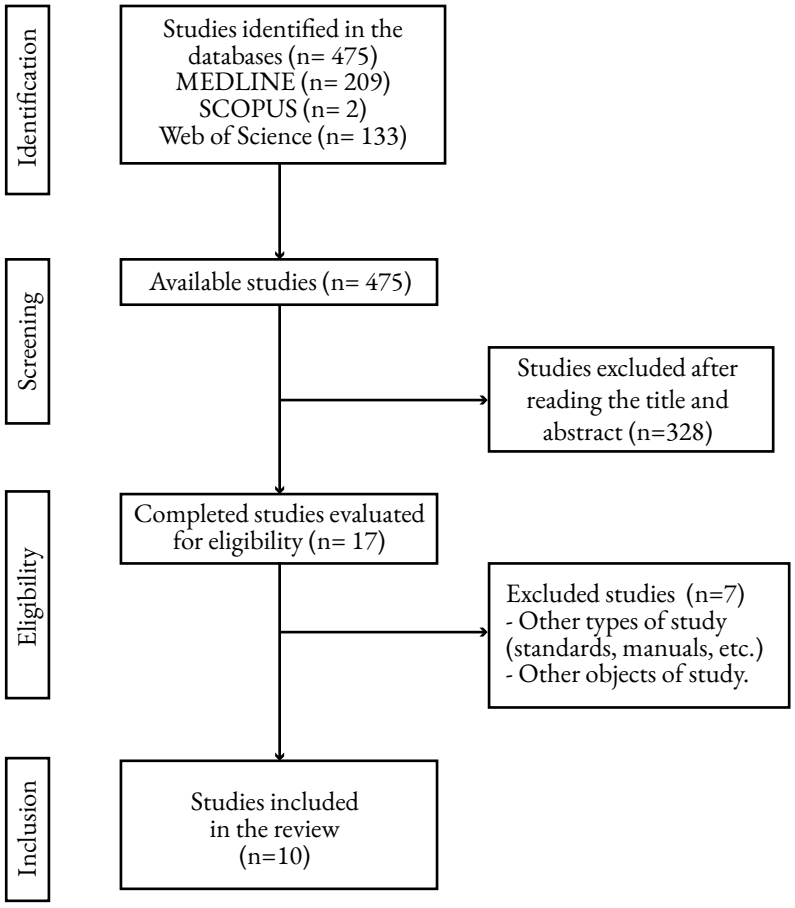
Analyzed articles investigated the length of stay as a study variable, including those assessing PPE levels from C to A of NBCR protection against physical wear and tear. A strategy based on analyses whose population was military and security forces was adopted to establish common parameters for the eligibility of articles, mentioning the exposure of officers to the use of NBCR protective clothing in activities with physical demand and resulted in the time spent in the activity. Studies carried out with a civilian population of a similar age group and body mass were included due to the few articles conducted with military personnel and security force agents. Finally, to standardize the presentation of the results, studies using the PPE classifications of the National Fire Protection Association (NFPA) or the Committee for the

Standardization of Products for the European Common Market had the results described in this article equivalently to the classification of PPE adopted in the MB.

3 RESULTS

Figure 1 presents the results of the search in the databases. We considered the articles that analyzed the use of NBCR PPE from level C to level A during some demanding physical activity and that, among their observations, presented the permanence time, i.e., computing and analyzing the time when the subjects remained using the protective clothing until reaching some physiological or volitional criterion established for the test interruption. The articles analyzed enabled us to obtain their characteristics, presented in Chart 2. Tables 1 and 2 show the tolerance times in minutes according to the Maximum Oxygen Consumption (VO_{2max}), measured in milliliters (mL) per kilo (Kg) per minute (min) reached during the NBCR activity and the PPE used in several studies.

Figure 1 – Literature search flowchart



Source: Prepared by the authors, 2022.

Chart 2 – Characteristics of the studies included in the review.

Author	Type of Protective Clothing	Sample	Condition for test end and final time count	Control group	Investigated factor (independent variable)	Exhibition	Average time of the group exposed to the investigated factor (min)	Average time of Control group (min)
MALEY *et al.* (2020)	Level A	n = 8 men Age: 24.0 ± 4.0 years Height: 180.2 ± 7.5 cm; BM: 77.1 ± 6.8 Kg %G: 13.8 ± 5.9 %	Rectal temperature> 39.0ºC; Heart Rate ≥ 90% of the maximum measured; Working time = 120.0 min Fatigue or nausea.	Use of PPE only	Cooling by outer clothing and/ or intra-body cooling	ICEPEAK Ice vest (P > 0.05)	48.0 (CI 95% = 39.0 to 58.0)	39.0 (CI 95% = 30.0 to 48.0)
						Full body clothing BCS-4 (P < 0.001)	62.0 (CI 95% = 53.0 to 70.0)	
						Cooling vest Kewl-Fit, Model 6626-PEV (P = 0.018)	46.0 (CI 95% = 36.0 to 56.0)	
						ICEPEAK Ice vest associated with prior ingestion of ice slurry (P < 0.001)	56.0 (CI 95% = 46.0 to 67.0)	
BACH *et al.* (2019)	Level C	n = 8 men Age: 23.6 ± 3.9 years; Height: 180.0 ± 7.0 cm; BM: 75.5 ± 6.4 Kg %G: 13.6 ± 5.2 %	Rectal temperature > 39.0 ºC Heart Rate ≥ 90.0% of the maximum measured; Working time = 120.0 min Fatigue or nausea	Use of PPE only	Cooling by outer clothing and/ or intra-body cooling	ICEPEAK Ice vest (p < 0.05)	107.0 ± 16.0	89.0 ± 19.0
						Full body clothing BCS-4 (P = 1.00)	93.0 ± 14.0	
						Cooling vest Kewl-Fit, Model 6626-PEV (P < 0.05)	109.0 ± 13.0	
						ICEPEAK Ice vest associated with prior ingestion of ice slurry (P < 0.005)	110.0 ± 9.0	

continue

Chart 2 – Continuation

Author	Type of Protective Clothing	Sample	Condition for test end and final time count	Control group	Investigated factor (independent variable)	Exhibition	Average time of the group exposed to the investigated factor (min)	Average time of Control group (min)
DENHAR-TOG *et al* (2017)	Level A	n = 40 men Age: 36.7 ± 8.3 years; BM: 84.7 ± 9.5 Kg	Rectal temperature > 39.0ºC Heart Rate > 90% of the maximum measured; Working time = 60 min Fatigue or nausea	Different Uniforms (A-F)	Type of Clothing, Climate, and Nature of the Task	Suit A	55.99	NR
						Suit B*	44.29	
						Suit C	50.98	
						Suit D	56.66	
						Suit E	54.66	
						Suit F**	41.78	
						Moderate climate (24ºC, 50% RH, 20ºC TBU)	53.92	
						Hot and humid (32ºC, 60% RH, 30ºC TBU)	40.44	
						Hot and dry (45ºC, 20% RH, 37ºC TBU)#	26.96	

continue

Chart 2 – Continuation

Author	Type of Protective Clothing	Sample	Condition for test end and final time count	Control group	Investigated factor (independent variable)	Exhibition	Average time of the group exposed to the investigated factor (min)	Average time of Control group (min)
JOVANOVI *et al* (2014a)	Level C	n =10 men (military) Age: 25.8 ± 2.4 years	Rectal temperature > 39,5ºC Measured Heart Rate > 190.0 bpm Working time = 45.0 min Fatigue or nausea	Group with PPE without cooling clothing	Cooling by outerwear	Group wearing cooling clothing	10.0 minutes longer on average than the control group	NR
MCLELLAN *et al*. (2013)	Level C	n = 4 men Age: 26.8 ± 4.4 years; Height: 177.0 ± 5.0 cm; BM: 77.1 ± 8.9 Kg; %G: 13.8 ± 5.9 %	Rectal temperature = 40ºC; Heart Rate > 95% of the maximum measured for 3 minutes; Working time = 190 min; Fatigue or nausea	Group with PPE and camouflaged	PPE embedded in the camouflage and with an opening for cooling	Group wearing PPE embedded in the camouflage and with an opening for cooling (Uniform A) (P < 0.05)	44.3 ± 21.9	33.3 ± 16.1
						Group wearing PPE embedded in the camouflage and with an opening for cooling (Uniform B) (P < 0.05)	47.0 ± 27.7	
CHEUNG and MCLELLAN (1998a)	Level C	n = 8 men Age: 15 to 40 years	Rectal temperature > 39,3ºC Heart Rate > 95% of the maximum measured for 3 minutes Working time = 240.0 min Fatigue or nausea	Moderately trained and pre-acclimatization hydrated subjects	Aerobic Capacity, Hydration Status, and Acclimatization	Moderately trained and post-acclimatization hydrated subjects (P > 0.05)	101.4 ± 11.4	96.6 ± 19.6
						Moderately trained and post-acclimatization hypo-hydrated subjects (P < 0.05)	78.3 ± 16..9	

continue

Chart 2 – Continuation

Author	Type of Protective Clothing	Sample	Condition for test end and final time count	Control group	Investigated factor (independent variable)	Exhibition	Average time of the group exposed to the investigated factor (min)	Average time of Control group (min)
				Highly trained and pre-acclimatization hydrated subjects	Aerobic Capacity, Hydration Status, and Acclimatization	Highly trained and post-acclimatization hydrated subjects (P > 0.05)	115.6 ± 18.4	114.5 ± 27.4
						Highly trained and pre-acclimatization hypo-hydrated subjects (P < 0.05)	100.9 ± 20.4	
MCLELLAN (1998)	Level C	n = 17 women and 13 men Age: 24.0 ± 4.0 years; Height: 180.2 ± 7.5 cm; BM: 77.1 ± 6.8 Kg %G: 13.8 ± 5.9 %	Rectal temperature > 39,3ºC Heart Rate > 95% of the maximum measured for 3 minutes Working time = 300.0 min Fatigue or nausea	Men	Sex	Women	114.4 ± 17.4 (P < 0.05)	142.9 ± 24.4

continue

Chart 2 – Continuation

Author	Type of Protective Clothing	Sample	Condition for test end and final time count	Control group	Investigated factor (independent variable)	Exhibition	Average time of the group exposed to the investigated factor (min)	Average time of Control group (min)
AOYAGI, *et al* (1998a)	Level B	n = 16 men Grupo 1: Age: 29.0 ± 2.0 years; Height: 1.79 ± 0.02 m; BM: 82.6 ± 3.3 Kg; %G: 18.1 ± 1.5% Grupo 2: Age: 28.0 ± 1.0 years; Height: 1.78 ± 0.01 m; BM: 83.8 ± 2.6 Kg; %G: 19.8 ± 1.5%	Rectal temperature > 39,3ºC Heart Rate > 95% of the maximum measured for 3 minutes Working time = 150 min Fatigue or nausea	Group 1	Acclimatization	Group 1 after 6-day Acclimatization	112.0 ± 6.0 (P < 0.05)	97.0 ± 4.0
				Group 2	Acclimatization	Group 2 after 12-day Acclimatization	120.0 ± 10.0 (P < 0.05)	108.0 ± 10.0
AOYAGI, *et al* (1998b)	Level B	n = 16 men Grupo 1: Age: 25.0 ± 1.0; Height: 1.76 ± 0.02 m; BM: 83.6 ± 3.8) Kg; Grupo 2: Age: 31.0 ± 1.0 years; Height: 1.76 ± 0.01 m; BM: 79.3 ± 4.1 Kg	Rectal temperature > 39,3ºC Heart Rate > 95% of the maximum measured for 3 minutes Working time = 120 min Fatigue or nausea	Group 1	Acclimatization and aerobic capacity	Group 1 after Acclimatization (P > 0.10)	49.0 ± 3.0	48.0 ± 2.0
				Group 2	Acclimatization and aerobic capacity	Group 2 after Acclimatization and Aerobic Training Program (P = 0.05 – 0.10)	52.0 ± 3.0	51.0 ± 2.0

continue

Chart 2 – Continuation

Author	Type of Protective Clothing	Sample	Condition for test end and final time count	Control group	Investigated factor (independent variable)	Exhibition	Average time of the group exposed to the investigated factor (min)	Average time of Control group (min)
CHEUNG and MCLELLAN (1998b)	Level C	n =8 men Age: 29.3 ± 6.4 Height: 178.0 ± 7.0 cm; BM: 75.6 ± 9.7 Kg. %G: 12.4 ± 2.8%.	Rectal temperature = 39,3 º C Heart Rate > 95% of the maximum measured for 3 minutes Working time	Previously hypo-hydrated subjects with water replacement during the work period	Hydration status in Light exercise	Previously hydrated group without water replacement during work period (P > 0.05)	93.1 ± 20.8	87.1 ± 14.2
						Previously hydrated group with water replacement during work period (P > 0.05)	106.50 ± 22.1	
				Previously hypo-hydrated subjects with water replacement during the work period	Hydration status	Previously hydrated group without water replacement during work period (P<0.05)	58.3 ± 11.1	53.3 ± 8.9
						Previously hydrated group with water replacement during work period (P > 0.05)	59.7 ± 9.5	

Subtitle: n = sample size; Kg = kilograms; cm = centimeters; PPE = Personal protective equipment; CI 95% = 95% confidence interval; ± = standard deviation; BM = body mass; bpm = beats per minute; %G: body fat percentage; * Significant reduction in PPE length of stay using suit B compared to A (P = 0.002) and E (P = 0.04); ** Significant reduction in PPE length of stay using suit F compared to A (P = 0.019), D (P = 0.014), and E (P = 0.0015). # Reduction in length of stay in hot and dry climates compared to moderate and hot humid climates (P < 0.001); NR = not reported.

Source: Prepared by the authors, 2022

Table 1 – VO_{2max} and tolerance time wearing Level B PPE

VO_{2max} (mL.Kg-1.min-1)		Tolerance time (min)		Author	PPE
Mean	Standard deviation	Mean	Standard deviation		
45.1	1.5	48.0	2.0	AOYAGI, MCLELLAN e SHEPHARD (1998)	Level B
45.7	2.1	49.0	3.0	AOYAGI, MCLELLAN e SHEPHARD (1998)	Level B
46.0	1.9	52.0	3.0	AOYAGI, MCLELLAN e SHEPHARD (1998)	Level B
46.3	2.3	47.0	2.0	AOYAGI, MCLELLAN e SHEPHARD (1998)	Level B
47.2	1.7	120.0	10.0	AOYAGI, MCLELLAN e SHEPHARD (1995)	Level B
48.1	1.8	112.0	6.0	AOYAGI, MCLELLAN e SHEPHARD (1995)	Level B
48.6	2.1	108.0	10.0	AOYAGI, MCLELLAN e SHEPHARD (1995)	Level B
49.5	2.2	97.0	4.0	AOYAGI, MCLELLAN e SHEPHARD (1995)	Level B

VO_{2max} = maximum oxygen consumption; PPE = personal protective equipment.

Source: Prepared by the authors, 2022

Table 2 – VO_{2max} and tolerance time in minutes wearing Level C PPE

VO_{2max} (mL.Kg-1.min-1)		Tolerance time (min)		Author	PPE
Mean	Standard deviation	Mean	Standard deviation		
46.0	2.9	96.6	19.6	CHEUNG e MCLELLAN (1998a)	Level C
48.4	4.9	145.2	26.7	MCLELLAN (1998)	Level C
59.8	2.8	114.5	27.4	CHEUNG e MCLELLAN (1998a)	Level C
51.6	4.0	89.0	19.0	BACH *et al*. (2019)	Level C

VO_{2max} = maximum oxygen consumption; PPE = personal protective equipment.

Source: Prepared by the authors (2022)

4 DISCUSSION

The analyzed results enabled us to relate the time a military person could remain operating in an environment with the presence of NBCR agents. In this case, the combatant's factors (aerobic capacity, sex, and hydration status) and external factors (climate of the

operating environment, type of work to be performed, and the type of PPE required for the task) were observed. In addition, it was also possible to relate this time to factors that can be inserted to prolong the military's ability to remain in military action, such as intra and extracorporeal cooling methods and acclimatization.

4.1 Aerobic Capacity

Aerobic capacity is undoubtedly a preponderant factor when physical exertion is required. However, this perception comes from the analysis of activities in which the subject can exchange heat with the environment, which is not the case when using equipment for protection that aims to contain the exchange of fluids between the person and the external environment. Thus, the analyzed studies sought to understand if this premise would also be valid for this type of activity.

When comparing subjects with a mean VO_{2max} of 46.1 ± 2.9 $mL.Kg^{-1}.min^{-1}$ with subjects with mean VO_{2max} of 59.8 ± 2.8 $mL.Kg^{-1}.min^{-1}$, researchers Cheung e McLellan (1998a) pointed out that, in addition to the more prolonged stay in activity using PPE, subjects had their tests interrupted after reaching the ethical limit of abdominal temperature (39.3ºC), in addition to those who had the test terminated at their request due to the perception of exhaustion.

Aoyagi, McLellan, and Shephard (1998), when analyzing subjects who went through a physical training program based on indoor running or on a treadmill in sessions of 30 to 45 min and three to four days a week, during eight weeks, reaching 60% to 80% of each one's initial VO_{2mas}, resulting in VO_{2max} increased from 39.9 ± 1.7 $mL.Kg^{-1}.min^{-1}$ to 46.3 ± 2.3 $mL.Kg^{-1}.min^{-1}$ found no significant increase in permanence time. However, they noted that the rectal temperature for trained subjects remained lower during the exercise with the PPE, which is a critical determinant in the permanence time. A possible explanation for this significant change in the permanence time of better-conditioned subjects is pointed out by the accumulation of sweat inside the clothes and the impossibility of effective heat exchange with the evaporation of sweat, which ends up overlapping the effect of training on aerobic capacity of subjects, maintaining high heart rate indices, which turns out to be the determining factor for the end of the exercise. Both tests used walking on a treadmill at 4.8 kilometers per hour (km/h) as an exercise, differing in the adopted inclination. Aoyagi, McLellan, and Shephard (1998) used a single inclination of 2%, while Cheung and McLellan (1998b) employed inclinations between 3 and 7%. Possibly, this variation of slopes and a more significant number of tests have led to a slight variation in the permanence time of the more conditioned subjects in the second study.

Jovanović *et al*. (2014a) support the importance of aerobic capacity when developing a test with military personnel and comparing them with results obtained by Nag *et al*. (1997), whose data indicated that men subject to work in which the abdominal temperature is 39º C manage to remain at work for 40 to 45 minutes, while in the tests by Jovanović *et al*. (2014a), a minimum number of military personnel completed the test before 45 minutes, establishing a relationship with the regularity in which the studied military personnel perform strenuous physical activities related to their profession.

While it is well known that better aerobic capacity promotes benefits for performing activities with physical demand (NINDL *et al*., 2017), evidence on how aerobic physiological indices are related to the length of stay is still scarce, therefore requiring further investigations.

4.2 Sex

Faced with the limitation of analyses that investigated differences between the sexes when wearing NBCR protective clothing, the study by McLellan (1998) stands out, founding a thermoregulatory disadvantage for women, which would influence the reduction of the length of stay for women. However, as the thermal advantage presented by men would be based on the amount of sweat they can produce and, consequently, offer greater regulatory efficiency, using PPE insulating evaporation could compensate for such differences, leading to a similar storage capacity of heat between men and women. Therefore, this article divided by the similarity of the percentage of fat associated with VO_{2max} and, with this division, the tolerance times became similar regardless of the sex of the participant.

Therefore, even though sex may influence due to differences in general body composition between female and male averages, such differences are minimized in the case of an exercise with no heat compensation with the PPE. Thus, with aspects related to body composition and aerobic capacity prevailing for the variation in the length of stay, men and women with similar indices of fat percentage and VO_{2max} seem to have identical tolerance times.

4.3 Hydration status

McLellan (1998), Jovanović *et al*. (2014a), and Aoyagi, McLellan, and Shephard (1998) observed an increase in the sweat rate during activity using NBCR PPE, which makes it possible to infer that there is indeed an increase in dehydration during this type of activity. Allied with this, due to the need to isolate, mainly, the airways from the environment, the consumption of water during operation in a contaminated environment is challenging, thus having the NBCR operator as the only opportunity for hydration the moments before starting work and during rest breaks in a decontaminated area.

Cheung and McLellan (1998a) then observed that the state of hypohydration at the beginning of the activity significantly increased the effects of thermal stress, even in acclimatized subjects. Likewise, those who had a normal state of hydration at the beginning of the exercise could remain active with PPE longer than those who were hypo-hydrated, regardless of the benefits of acclimatization and aerobic condition. Therefore, it is essential that when starting operations, subjects are in good hydration conditions. It is also possible to consider if hydration during the execution of the task brings about any effective gain in tolerance time, which, according to another study by Cheung e McLellan

(1998b), there is indeed this correlation when it occurs during the practice of light exercises with PPE. However, there is no determining effect on the lengthening of the permanence time when this hydration during activity occurs when carrying out high-intensity work. This investigation supported, therefore, the evidence that the hydration level before the exercise's beginning affects the operating time.

Thus, the importance of hydration is also highlighted during rest periods so that the person can return to activity with the necessary hydration level. Thus, the tolerance time is not reduced due to the hypohydration process. However, even if less evident, it is essential to avoid hyperhydration during rest. Analyzing several subjects wearing level A PPE in different climates and during other activities, Rubenstein *et al*. (2017) concluded that during rest periods after 60 minutes of activity, hydration with 0.7 liters (L) of water safely rehydrates 90% of operators and prevents under- and over-hydration for the subsequent work cycles. It is worth mentioning that the study also found that excessive rehydration (1.5 L at each rest cycle alternating with a 60-min work cycle) increases the risk of hyperhydration to 39% from the third work/rest cycle onward.

4.4 Operating environment climate and type of work to be performed

DenHartog *et al*. (2017) analyzed different workloads and weather conditions on tolerance time. Considering three climates and work intensities (moderate, hot, and humid, and hot and dry climates; and work – 127 $W.m^{-2}$, 205 $W.m^{-2}$ e 314 $W.m^{-2}$).

Considering that the workload increases when using NBCR PPE (Dorman; Havenith, 2009), predicting an inversely proportional relationship between workload and length of stay is possible. Therefore, DenHartog *et al*. (2017) showed a strong relationship between workload and tolerance time in inverse proportion.

Finally, it is worth confirming that the higher the region's temperature, the shorter the working time. Air humidity is assumed to have no direct influence on time due to the low or no exchange of fluids between the subject and the environment. However, the lack of studies in the literature on this specific relationship prevents confirming this assumption. Thus, according to DenHartog *et al*. (2017), the length of stay is inversely proportional to the work demand within the same climate.

However, due to some limitations in the article by DenHartog *et al*. (2017), age appeared as another possible factor influencing the length of stay. The age/tolerance time relationship was statistically verified, showing a minimal relationship of directly proportional variation, i.e., older subjects would endure longer in operation. However, as this research analyzed professional firefighters, it can be argued if people with more experience operating with PPE over the years have developed some physiological adaptation to withstand more extended periods under conditions of uncompensated thermal stress.

4.5 Type of PPE used

When the Armed Forces require levels C and B of protection, they use the layer system, i.e., when an NBCR threat is detected, the protective clothing, usually made of activated carbon, is placed on top of the combat uniform. From this conception, McLellan *et al*. (2013) compared the current system of layers to a combat uniform capable of filtering NBCR agents and which has ventilation openings (Protective Assault Uniform), requiring only the closure of these openings when detecting an NBCR threat for user's effective protection. When comparing these two protection systems, it was evident that the continuous use of a single combat uniform in activity, which allows a quick transition from a normal condition to an NBCR protection condition, significantly increases the time in the operation of the military personnel in a contaminated environment wearing the PPE. Thus, even if the soldier remains throughout the entire operation in a uniform with less gas exchange with the environment, the open parts of the uniform allow heat exchange with the environment. There is a significant benefit when the military needs NBCR protection. Although this advantage exists, in Brazil, this military technology is not yet available. In the case of a study with the Canadian military, this type of PPE would hardly be applicable in operations of our Armed Forces.

Level A protective clothing used in the armed forces is similar to that employed by fire departments and chemical industry companies, with greater commercial availability. DenHartog *et al*. (2017) investigated whether there are considerable differences between various level A clothing available on the market regarding tolerance time. The only difference noted occurred with one suit compared with the others in a moderately hot climate. Significant differences from this suit are a double layer of chemical protection (against one layer of the others) and its reflective aluminized outer layer. This clothing had reduced permanence time, as DenHartog *et al*. (2017) pointed out, which could result from its two layers increasing thermal stress and/or because it is an average climate, the aluminum layer prevented the exchange of heat from the clothing to the environment. In a hot environment, this suit did not present significant differences compared with the others, indicating the aluminized layer's efficiency in heat reflection.

Reflective clothing is usually used in services where there are fires combined with the release of NBCR agents, being more focused on the use of firefighters. However, concerning the armed forces, there is a latent need to check the importance of the number of protective layers in level A suits, considering that multi-layer clothing will tend to reduce the length of stay of military personnel in operation.

Finally, Xu *et al*. (2019) noted that improving the thermal properties of the fabrics currently used in military PPE can reduce thermal stress and increase the length of stay. However, even so, these advantages depend on the climate of the environment in which the operations are performed.

4.6 Cooling methods

Increasing body temperature is an intrinsic factor to exercise and becomes even more evident when heat exchange with the environment is reduced due to PPE. Thus, body cooling

can be a good alternative to reduce the effects of thermal stress resulting from operations with NBCR threat. Bach *et al*. (2019) and Maley *et al*. (2020) investigated three cooling suits and one associated with the intake of ice slurry by the subjects 30 minutes before the beginning of the exercise. The first study used level C PPE and the second level A PPE, with disagreement between the efficiency of the two suits concerning the length of stay in PPE. While the ice vest showed a significant improvement during tests with level C PPE, the same result was not observed in the test with level A PPE. On the other hand, the whole body suit with water perfusion improved the permanence time only when using the level A clothing.

When discussing this difference, it is essential to note that the ice vest differs from the whole body suit concerning the body surface area covered, area of effective contact with the body, storage temperature, and physical state of the cooling method. Level A clothing encapsulates the subject, isolates them from any gaseous exchange with the environment, limits breathing by the flow of the air valve attached to the cylinder, and restricts the amount of breathable air by the capacity of the cylinder. Thus, it presents, as a rule, a shorter time of permanence compared to level C clothing.

Therefore, for this suit, the water perfusion favors a greater heat exchange surface between the fluid and the body due to its fluid passing through small tubes throughout the body surface. It is more effective in maintaining the entire body refrigerated in a short time. When analyzing the use of level C, the average permanence times compared with level A are much longer, with time available for the entire fluid to have its temperature elevated and balanced with the body's high temperature, causing the subject to lose from then the benefit of external cooling. However, when analyzing the ice vest (stored at -18ºC), even if only the torso is refrigerated, the time the vest will spend absorbing heat from the person until it reaches thermal equilibrium will be much longer than that of the suit with water, thus benefiting the use of level C PPE. Despite these differences, it cannot be said that, in some way, specific cooling clothing is not suitable. Still, these characteristics must be considered when it is necessary to use cooling with different levels of PPE.

The method that demonstrated the most significant increase in tolerance time in both studies was the combination of an ice vest with the ingestion of 7.5 $g.Kg^{-1}$ of ice slurry at -2ºC (2.2% of carbohydrate), at the rate of 1.25 $g.Kg^{-1}$ every five minutes, 30 minutes before the beginning of the exercise. Jovanović *et al*. (2014b) pointed out, when studying cooling suits for PPE of the Serbian Armed Forces, that the use of these implements cooling the torso area causes the abdominal temperature to increase more slowly and the average skin temperature to be significantly lower. Thus, its use under NQBR protective clothing improves the military's physiological stability, contributing to confidence and efficiency in military missions against NBCR threats.

When analyzing the national military reality, it is emphasized that the ingestion of ice slurry can be performed quickly since machines for producing this type of food are available on the market or even using improvised means for its production, maintaining the proportion of ice/weight indicated in the studies. Regarding coolant clothing, even though it is not customary to use them in NBCR missions in the Marine Corps, the Marine Corps

Engineering Battalion currently has water perfusion cooling clothing to perform tasks to deactivate explosive devices with the use of the anti-bomb suit (EOD-9). Therefore, it is adaptable to the service with NBCR PPE.

4.7 Acclimatization

Operating using PPE for NBCR agents requires working at temperatures above average. Therefore, it is worth observing the influence of heat acclimatization by subjects and if there is a relationship with tolerance time. According to the acclimatization protocols specified in the results, three studies observed the relationship between acclimatization and length of stay.

Aoyagi, McLellan, and Shephard (1995) found a significant increase in the tolerance time in acclimatized subjects, contrary to their work (1998), which indicated that there was no variation in the length of stay for acclimatized subjects, similar to Cheung and McLellan (1998a). Analyzing these different perspectives, Cheung and McLellan (1998a) promoted the rehydration of the studied subjects in continuous intervals. Therefore, such continuous hydration may have overcome the beneficial effect of acclimatization. Comparing the two articles by Aoyagi, McLellan, and Shephard, it is clear that acclimatization helps reduce the physiological effects caused by thermal stress due to using PPE. However, there are still certain doubts regarding the direct impact on the length of stay, since in their conclusions, Aoyagi, McLellan, and Shephard (1998) found that the greater the effort required in the exercise, the smaller the effect of acclimatization in the prolongation of the tolerance time. This decrease is likely due to the higher sweating rate in high-intensity activities without heat exchange with the environment, making the temperature increase in the internal microclimate of the PPE sufficiently high to eliminate the physiological differences between acclimatized and non-acclimated subjects. Other investigations point to the advantages of acclimatization in situations of activities that result in thermal stress, helping to reduce heart rate, oxygen consumption, perception of exertion, and thermal sensation (Thake *et al*., 2009)

Thus, the acclimatization time of the study protocols can be assumed as insufficient for a physiological adaptation that effectively promoted the necessary acclimatization. However, Aoyagi, McLellan, and Shephard (1995) noted no significant physiological differences between the groups studied with acclimatizations of six and 12 days, as adaptations to heat occurred in the first days.

Therefore, further analyses would be needed to confirm the actual effectiveness of heat acclimatization in extending the length of stay, despite the already proven benefits. For the reality of the armed forces, it is possible to establish simple acclimatization protocols, similar to those pointed out in studies, to improve the performance of military personnel when there is enough time available preceding a specific mission for NBCR defense.

5 CONCLUSION

From all the data analyzed, it is possible to conclude that several important factors must be considered when the use of NBCR PPE is necessary, some more related to the time

spent in activity (aerobic capacity, sex, hydration status, climate of the operating environment, and type of activity performed) and others prolonging the tolerance time indirectly by acting on the subject's physiological adaptation and their perception of effort (intra and extracorporeal cooling and acclimatization). Thus, it is essential to highlight the initial state of hydration of the subject as a critical condition for the development of tasks since a dehydrated state will significantly reduce their permanence at work, suggesting intakes of 0.7 L of water every 60 minutes of the work cycle.

The type of task and the type of PPE also appear as factors that will influence the working time since the more significant the work intensity and the lower the permeability of the PPE to heat transfer between the subject and the environment, the lesser the influences of other factors will be, since the levels of sweat and its non-evaporation will cause the permanence times to be drastically reduced, regardless of different physiological and perceptual factors. Allied to these two factors is the operating environment, which, as the temperature increases, decreases the ability to remain active without; however, having a significant influence of humidity given the rare exchange of fluids between environment and subject.

Refrigeration methods, either with the help of cooling clothing or through the ingestion of ice slurry, proved to be effective in reducing thermal stress and consequent extension of the time spent in activity with PPE, thus being an efficient tool to increase the time of work of activity specialists, and therefore very important for tasks that require long exposure times to NBCR agents.

Finally, sex does not seem to influence the duration of PPE use. Although incipiently, subjects with better aerobic fitness and a lower fat percentage arguably performed better with PPE and more extended periods of permanence, which can be optimized if acclimatization occurs during activities conducted at high temperatures.

REFERENCES

AOYAGI, Y.; MCLELLAN, T. M.; SHEPHARD, R. J. Effects of 6 versus 12 days of heat acclimation on heat tolerance in lightly exercising men wearing protective clothing. **European Journal of Applied Physiology and Occupational Physiology**, Bethesda, v. 71, n. 2–3, p. 187–196, 1995. Available from: https://pubmed.ncbi.nlm.nih.gov/7588688/. Access: March 28, 2023.

AOYAGI, Y.; MCLELLAN, T. M.; SHEPHARD, R. J. Effects of endurance training and heat acclimation on psychological strain in exercising men wearing protective clothing. **Ergonomics**, Bethesda, v. 41, n. 3, p. 328–357, 1998. Available from: https://pubmed.ncbi.nlm.nih.gov/9520629/. Access: March 28, 2023.

BACH, A. J. E. *et al*. An Evaluation of Personal Cooling Systems for Reducing Thermal Strain Whilst Working in Chemical/Biological Protective Clothing. **Frontiers in Physiology**, Bethesda, v. 10, n. 424, p. 1–11, 2019. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6474400/. Access: March 28, 2023.

BAETHGE, C.; GOLDBECK-WOOD, S.; MERTENS, S. SANRA —a scale for the quality assessment of narrative review articles. **Research Integrity and Peer Review**, London, v. 4, n. 1, p. 2–8, 2019. Available from: https://researchintegrityjournal.biomedcentral.com/articles/10.1186/s41073-019-0064-8. Access: March 28, 2023.

BRASIL. Marinha do Brasil. **Portaria n. 83, de 5 de maio de 2011**. Implanta o Sistema de Defesa Nuclear, Biológica, Química e Radiológica da MB (SisDefNBQR-MB), e dá outras providências. Brasília, DF: Ministério da Defesa, 2011.

BRASIL. Exército Brasileiro. **Manual de Defesa Química, Biológica, Radiológica e Nuclear**. Brasília, DF: Ministério da Defesa, 2017.

BRASIL. Marinha do Brasil. **Manual de Defesa Nuclear, Biológica, Química e Radiológica**. Brasília, DF: Ministério da Defesa, 2020.

CHEUNG, S. S.; MCLELLAN, T. M. Heat acclimation, aerobic fitness, and hydration effects on tolerance during uncompensable heat stress. **Journal of Applied Physiology**, Rockville, v. 84, n. 5, p. 1731–1739, 1998a. Available from: https://journals.physiology.org/doi/full/10.1152/jappl.1998.84.5.1731. Access: March 28, 2023.

CHEUNG, S. S.; MCLELLAN, T. M. Influence of hydration status and fluid replacement on heat tolerance while wearing NBC protective clothing. **European Journal of Applied Physiology and Occupational Physiology**, Bethesda, v. 77, n. 1–2, p. 139–148, 1998b. Available from: https://pubmed.ncbi.nlm.nih.gov/9459534/. Access: March 28, 2023.

DENHARTOG, E. A. *et al*. Variability in Heat Strain in Fully Encapsulated Impermeable Suits in Different Climates and at Different Work Loads. **Annals of Work Exposures and Health**, Oxford, v. 61, n. 2, p. 248–259, 2017. Available from: https://academic.oup.com/annweh/article/61/2/248/2765107. Access: March 28, 2023.

DORMAN, L. E.; HAVENITH, G. The effects of protective clothing on energy consumption during different activities. **European Journal of Applied Physiology**, Oklahoma, v. 105, n. 3, p. 463–470, 2009. Available from: https://link.springer.com/article/10.1007/s00421-008-0924-2. Access: March 28, 2023.

JOVANOVIĆ, D. *et al*. Physiological tolerance to uncompensated heat stress in soldiers: effects of various types of body cooling systems. **Military-Medical and Pharmaceutical Review**, Bethesda, v. 71, n. 3, p. 259–264, 2014a. Available from: https://www.researchgate.net/publication/261368600_Physiological_tolerance_to_uncompensated_heat_stress_in_soldiers_Effects_of_various_types_of_body_cooling_systems. Access: March 28, 2023.

JOVANOVIĆ, D. *et al*. Physiological tolerance to uncompensated heat stress in soldiers: effects of various types of body cooling systems. **Vojnosanitetski Pregled**, Belgrad, v. 71, n. 3, p. 259–264, 2014b. Available from: https://pubmed.ncbi.nlm.nih.gov/24697012/. Access: March 28, 2023.

MALEY, M. J. *et al*. Extending work tolerance time in the heat in protective ensembles with pre- and per-cooling methods. **Applied Ergonomics**, Amsterdam, v. 85, p. 1-6, 2020. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0003687018306379?via%3Dihub. Access: March 28, 2023.

MCLELLAN, T. M. Sex-related differences in thermoregulatory responses while wearing protective clothing. **European Journal of Applied Physiology and Occupational Physiology**, Oklahoma, v. 78, n. 1, p. 28–37, 1998. Available from: https://link.springer.com/article/10.1007/s004210050383. Access: March 28, 2023.

MCLELLAN, T. M.; BOSCARINO, C.; DUNCAN, E. J. S. Physiological strain of next generation combat uniforms with chemical and biological protection: importance of clothing vents. **Ergonomics**, London, v. 56, n. 2, p. 327–337, 2013. Available from: https://www.tandfonline.com/doi/abs/10.1080/00140139.2012.746738. Access: March 28, 2023.

NAG, P.K. *et al*. Human heat tolerance in simulated environment. Indian J Med Res, v. 105, p. 226-234, 1997. Available from: https://pubmed.ncbi.nlm.nih.gov/9183079/. Access: April 04, 2023.

NORTH ATLANTIC TREATY ORGANIZATION. Individual protection equipment on individual and unit performance. **GlobalSpec**, New York, 2004. Available from: https://standards.globalspec.com/std/14362438/ATP-65. Access: March 05, 2023.

NINDL, B. *et al*. Executive Summary From the National Strength and Conditioning Association's Second Blue Ribbon Panel on Military Physical Readiness: Military Physical Performance Testing. **The Journal of Strength and Conditioning Research**, Bethesda, v. 29, n. 11, p. 216-220, 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/26506191/. Access: March 28, 2023.

RUBENSTEIN, C. D. *et al*. Fluid replacement advice during work in fully encapsulated impermeable chemical protective suits. **Journal of Occupational and Environmental Hygiene**, London, v. 14, n. 6, p. 448-455, 2017. Available from: https://www.tandfonline.com/doi/full/10.1080/15459624.2017.1296230. Access: March 28, 2023.

THAKE, C. D. *et al*. The effect of heat acclimation on thermal strain during Explosives Ordnance Disposal (EOD) related activity in moderate and hot conditions. **In**: INTERNATIONAL CONFERENCE ON ENVIRONMENTAL ERGONOMICS, 13., 2009, Boston. **Conference** [...] Boston, 2009. Available from: https://pureportal.coventry.ac.uk/en/publications/the-effect-of-heat-acclimation-on-thermal-strain-during-explosive-3. Access: March 28, 2023.

XU, X. *et al*. Heat strain in chemical protective ensembles: Effects of fabric thermal properties. **Journal of Thermal Biology**, Amsterdam, v. 86, p. 1-7, 2019. Available from: https://www.sciencedirect.com/science/article/abs/pii/S030645651930381X?via%3Dihub. Access: March 28, 2023.


ECEME

ARTICLE DOI 10.52781/cmm.a103

Acceptability and consumption: a study on the perception of the operational rations of the Brazilian Army in the operational environment of jungle

Aceptabilidad y consumo: estudio sobre la percepción de las raciones operativas del Ejército Brasileño en el ambiente operativo de la selva

Abstract: Acceptability and consumption of operational rations are objects of study in several world armed forces, due to the frequent history of underconsumption. In this scope, the present work sought to identify, in an unprecedented way, the perception of military personnel about the menus in the operational environment of the jungle, a strategic region for national defense, through the association of data obtained through an electronic questionnaire and a qualitative instrument of focus groups. The results showed the perception of high technology, but showed opportunities for improvement in terms of monotony, nutritional profile and well-being in consumption. The focus groups emphasized demands for nutritional adaptations and increased menu variety. It was observed that a fraction of the menus present consumption lower than 75% of the volume offered, indicating the need for reformulations, aiming to mitigate underconsumption and impacts on operability. Therefore, it is suggested that complementary studies be carried out, providing opportunities for the development of products that are more adapted to the strategic environment of the jungle.

Keywords: focus group; nutritional profile; monotony; variety.

Resumen: La aceptabilidad y el consumo de raciones operativas son objeto de estudios en varias fuerzas armadas del mundo debido a la frecuente historia de bajo consumo. Dentro de este ámbito, este artículo buscó identificar, de forma inédita, la percepción del personal militar sobre los menús en el ambiente operacional de la selva, región estratégica para la defensa nacional, a través de la asociación de datos obtenidos por cuestionario electrónico e instrumento cualitativo de grupos focales. Los resultados mostraron la percepción de alta tecnología, pero destacaron las oportunidades de mejora en términos de monotonía, perfil nutricional y bienestar en el consumo. Los grupos de discusión destacaron las demandas de adaptaciones nutricionales y mayor variedad de menús. Se observó que una fracción de los menús presenta consumo inferior al 75% del volumen ofrecido, indicando la necesidad de reformulaciones, a fin de mitigar el bajo consumo y los impactos en la operatividad. Así, se sugiere la realización de nuevos estudios, proporcionando oportunidades para el desarrollo de productos mejor adaptados al ambiente estratégico de la selva.

Palabras clave: grupo de discusión; perfil nutricional; monotonía; variedad.

Vitor Luiz Farias de Abreu
Universidade Federal Fluminense.
Faculdade de Veterinária. Departamento de Tecnologia de Alimentos.
Niterói, RJ, Brasil.
Exército Brasileiro. Comando da 12ª Região Militar.
Manaus, AM, Brasil.
vitorvet.mv@gmail.com

Sabrina Sauhier Monteiro
Universidade Federal de Santa Maria (UFSM), Colégio Politécnico.
Santa Maria, RS, Brasil.
sabrinasauthier@hotmail.cm

Wanessa Pires da Silva
Universidade Federal Fluminense.
Faculdade de Veterinária. Departamento de Tecnologia de Alimentos.
Niterói, RJ, Brasil.
wanessapires@id.uff.br

Erick Almeida Esmerino
Universidade Federal Fluminense.
Faculdade de Veterinária. Departamento de Tecnologia de Alimentos.
Niterói, RJ, Brasil.
Instituto Federal de Educação, Ciência e Tecnologia do Rio de Janeiro, Departamento de Alimentos.
Rio de Janeiro, RJ, Brasil.
erick.almeida@hotmail.com

Received: Oct 30, 2022
Approved: Mar 14, 2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

Military work demands high energy expenditures during varied training, such as personnel employment on border strips, engineering missions, actions coordinated with government agencies, and refugee protection, among others. Therefore, appropriate food sources, including operational rations, represent one of the most important conditions for maintaining these professionals' physical and mental health (BOTELHO *et al*., 2014).

With the publication of the Armed Forces Food Manual (MD42-M-03), through Normative Ordinance No. 219/MD, dated February 12, 2010, the Armed Forces now have, in accordance with standardized guidelines, access to safe, balanced, and adequate food for the different operational situations inherent to military life, and it was considered, from that time, a security matter by the Brazilian Armed Forces Food Commission (BRASIL, 2010; SILVA, 2015).

The activities carried out daily in the exercise of the military function are closely dependent on the physical, social, and mental state, hence the importance of food factor, not only in relation to satisfaction with eating, but also in relation to the conditions of elaboration of the food produced within food safety standards. The economic context in which Brazil is inserted demands operability at the lowest cost possible for the country's survival, and the search for lower logistical costs meets the Brazilian society's aspirations (SILVA, 2015).

Military forces often operate far from supply bases and have to be prepared to operate in extreme environments, which can be ultra-cold and low-pressure locations, cold at high altitude, or jungle environment. Food format and nutritional composition should also be varied to meet the military's specific needs and activities in these environments, while preserving food and nutritional quality (STANLEY; FORBES-EWAN; MCLAUGHLIN, 2019).

When these soldiers are on missions or training in hostile environments, such as the jungle biome, energy expenditure may increase, which may impair troop performance. Therefore, to ensure good performance in these activities, it is necessary to have a diet with sufficient energy demand to meet different basal nutritional needs and additional psychological stress (BOTELHO et al., 2014; CARVALHO et al., 2019; MILLET *et al*., 2021).

The determination of energy requirements is, therefore, based on intrinsic factors, such as the soldier's physical state, and also extrinsic ones, such as different types of maneuvers or environmental elements. Demanding military missions often involve activities that lead to lack of sleep and long alertness periods. Thus, providing adequate nutrition is extremely relevant to mitigate stressors and favor physical, cognitive, and immune performance (TASSONE; BAKER, 2017).

In this context, Brazil has continental dimensions, with a territory that covers different geographic regions and operational environments, from the *pampas* of the extreme South to the Amazon region biome, characterized by high electrolyte depletion and a demand for

foods with better digestibility. The different Brazilian Armed Forces have autonomy to outline their technical employment demands, developing products that are more adequate to their strategic objectives.

Thus, the Brazilian Army's combat operational ration (R2) was designed to keep a soldier in operations for a 24-hour period, consisting of a set of main basic foods (thermoprocessed meals in retort pouch packaging, in this case, lunch and dinner), complementary food items (cassava flour, coffee, chocolate milk, sugar, hydroelectrolytes replenisher and snacks, among others), and accessories for cooking, such as stoves and cutlery, which are provided when it is impossible to deploy a field kitchen, and should have a good acceptability by the supported troop (BRASIL, 2022).

The concern with acceptability is not recent and is not only related to the development of new food technologies. Scientifically, it began during World War II, when balanced diets developed by nutritionists had a very low level of acceptability by soldiers. It was in this context that the American Armed Forces began to finance studies with the aim of improving the sensory quality of meals offered to the Army (MINIM, 2006).

When the soldier stops consuming their nutritional and caloric demands effectively, impacts such as weight and basic nutrients losses can interfere with their health and activity maintenance, which is a vulnerability for the deployment of an operation (AHMED *et al*., 2019). Existing historical and experimental data indicate that decreases in physical performance begin in individuals when 10% or more of initial weight is lost (THARION *et al*., 2004).

Thus, research should be continuously developed to map a food type that will better meet demands of a soldier who, in theory, is exposed to extreme stress conditions, seeking in food a way of comfort that can be provided with the help of a safe and palatable meal, reinforcing the food restorative role. Still in this scope, when the operational ration components are not completely consumed, a financial waste is inferred, since the products have a high added value and their acquisitions are expensive for the government.

Therefore, it is important to investigate the consumption profile of operational rations in the Amazon jungle environment, a nationally strategic region, contemplating approximately 22,000 soldiers, and submitted to different profiles of operations, with high consumption of operational rations. Due to the lack of studies in this area, the methodology, at the limit, covered the application of electronic data collection combined with the qualitative focus group technique, allowing also the military's free expression of opinions, therefore bringing reliable results.

The focus group technique was chosen because it is one of the main qualitative tools used to develop the preliminary stages of a piece of research, based on group dynamics whose objective is to stimulate discussion through the exchange of opinions among the participants, enabling the approach of different themes and ideas (WRIGHT, 2015; ELDESOUKY; MESÍAS, 2014; ESMERINO, 2017).

In view of this, this article intends to identify the military's perception of menus in an operational jungle environment, with the help of the association of data obtained through an electronic questionnaire and focus groups, a qualitative instrument, in order to investigate general impressions, consumption and acceptability, and, then, open gaps to propose studies aimed at possible reformulations of existing operational ration menus in the search for food types more adapted to the demands of activities and operations deployed in the Amazon biome.

2 MATERIAL AND METHODS

2.1 Participants

This study was carried out between July and September 2020, in a Military Organization of the Brazilian Army located in the Amazon region, and the participation criteria were being a professional military man and having completed the Jungle Operations Course (COS). The total group of participants consisted of 162 soldiers, aged 24 and 32 years, all male, with an average age of 27 years old. As to the school level, 66% had secondary education, while 34% had tertiary education, and in relation to graduations and ranks, 62% participants were privates and 38% were officers. Most of the participants (59%) came from the Southeast region and the others from the South (19%), Northeast (14%), and North (8%) regions, respectively. There were no participants from the Central-West region.

The research was approved by the Ethics and Research Committee of UFAM (Universidade Federal do Amazonas) under number CAAE 53496121.1.0000.5020.

2.2 Online Survey

After authorization from the Command of the Military Organization, an electronic questionnaire was prepared and made available to the participants on Google Forms platform, aimed at investigating topics in three main themes:

(i) general impressions about menus in the jungle, with answers on a 9-point Likert Scale (1 – totally disagree; 9 – totally agree) (DALMORO; VIEIRA, 2017). The variables in Chart 1 were analyzed;

(ii) acceptability of menu items, with responses on a 9-point hedonic scale (1 – dislike extremely; 9 – like extremely), presented to participants in a balanced complete block design (DALMORO; VIEIRA, 2017);

(iii) consumption of menu items, with responses in five options (0%, 25%, 50%, 75 % and 100%), representing the approximate intake projection of each menu, according to the form developed by the US Army at Natick Center Soldier Center (FOX; WENKAM; HIRSCH, 1988) and associated countries of the North Atlantic Treaty Organization (NORTH ATLANTIC TREATY ORGANIZATION, 2019).

Chart 1 – Variables analyzed on the Brazilian Army soldiers' general impressions about the menus available in the jungle environment

Questions	Description
1. The existing menus in the Brazilian Army are adapted to the jungle environment.	The physiological and nutritional impacts, interfering with performance and operability, may vary based on varied consumption profiles, depending on each region where the personnel have the intake.
2. Menu options are sufficient for jungle operations.	The military are directed to make impressions about the amount of menus offered during operations.
3. I manage to consume the menu options in longer jungle operations without causing a feeling of monotony.	The monotony aspect is related to the impact of repeating menus in situations of prolonged consumption.
4. I notice the feeling of well-being when consuming menus in the jungle environment.	The feeling of well-being is closely related to pleasure in consumption, as well as to impacts on troop morale.

Source: Elaborated by authors, 2022.

2.3 Focus Group

Four Focus Groups were conducted, with the presence of ten military men in each session, totaling 40 participants. The military in the focus groups were selected from a random, non-probabilistic convenience sample, according to interest and availability to participate in the study. The age group was between 24 and 31 years old, with an average age of 26 years old. As to schooling, 72% had secondary education and 28% had tertiary education. The majority (60%) was represented by privates, and 40% by officers.

The total number of sessions was established by the moderator, after the saturation point had been reached. Data saturation is reached when there is information to replicate the study (FUSCH; NESS, 2015), that is, when the ability to obtain additional new information is no longer feasible (GUEST; BUNCE; JOHNSON, 2006).Each session lasted one hour on average, supervised by a moderator and an assistant. In this way, the most significant impressions about general attributes were collected, such as packaging, variety and menu components, ease of preparation, satiety, digestibility, well-being, and waste disposal and quality, following a script of pre-established questions, present in Chart 2, however deepened as needed. The military were given instructions about no right or wrong ideas, and were encouraged to express their opinions freely (ELDESOUKY; MESÍAS, 2014).

The sessions were recorded after participants' authorization and held in an appropriate room, free of external distractions. Data were analyzed by the main researcher after transcription of the recorded files, according to the topics covered.

Chart 2 – Thematic areas and verbal comments of participants from Focus Groups

Themes/Questions	Verbal Comments
1. Are the quality and quantity of operational ration menus satisfactory?	"I think the quantity of menus is good, but they could be a little more tasty" (29 years old, FG* I); "There is little variety in the menus offered" (25 years old, FG III); "I consider it a safe product with good technological quality" (24 years old, FG II).
2. Do you consider the menus suitable for all operational environments? From low mountain temperatures to jungle weather conditions?	"The menus in the Amazon region could have more highly digestible proteins, facilitating jungle operations, fish, for example" (29 years old, FG I); "I experience more digestive difficulties in hot and humid environments, with a lot of intestinal discomfort, interfering negatively with operability" (31 years old, FG III); "Menus are very tasty, I think they are perfectly adapted" (28 years old, FG II).
4. In the case of a longer consumption, would the food still be attractive, that is, is there a perception of fatigue due to the menu monotony?	"I don't see any problems in extending consumption, because I see good quality in general" (28 years old, FG I); "When it's possible, we take supplements, such as straw potatoes, cereal bars and even condensed milk, to improve consumption" (27 years old, FG IV).
5. Is there full component consumption?	"Some items have a good flavor, such as chicken stroganoff, which is well consumed by the majority; rice, for example, is dry, tasteless, and waste is high" (28 years old, FG II); "I open the general packaging and select only the items of interest to me" (27 years old, FG IV); "I don't think I consume 100% of all content, just the items I like the most" (30 years old, FG I).
6. Is there a feeling of pleasure, stress reduction and socialization? Does it generate well-being?	"Some items, such as chicken and beef stroganoff, generate a good feeling, well-being and satiety" (24 years old, FG IV); "I end up repeating the items with the best taste, which is fine for me" (26 years old, FG II); "Items with more carbohydrates, sweeter, give us a lot of pleasure too, but some products should be improved, such as rice, which is dry" (29 years old, FG III);
7. What is the consideration on a possible development of protein pack, and energy?	"It would be awesome to have an alternative to help in situations of fatigue" (24 years old, FG III); "It would be a good option; whenever I can, I take BCAAs and carbo gel" (27 years old, FG IV); "I believe that operability would improve, even with products containing caffeine" (25 years old, FG I).
8. Do you have the impression about being supplied by food? In the proposed interval, for each feeding stage, is there a feeling of satiety?	"Yes, for example, the stroganoffs is very good" (31 years old, FG I); "I feel very hungry between breakfast and lunch" (24 years old, FG III); "Breakfast is too early, and items like crackers don't last until lunch" (25 years old, FG IV).
9. Would you like to propose changes to the menus? Which changes?	"Inclusion of more baked goods, pasta and pizza" (25 years old, FG II); "Increase in the amount of hydroelectrolytes replenishers" (28 years old, FG III); "Inclusion of more fiber in the diet, a lot of constipation [occurs] and poor digestibility (29 years old, FG IV); "I would like more fish and chicken products" (28 years old, FG I);

continue

Chart 2 – Continuation

Themes/Questions	Verbal Comments
10. Is the packaging of adequate volume and easy to handle? Does a tired and exhausted person accept instructions correctly?	"The packaging is easy to handle, but the volume does not help" (27 years old, FG I); "We open the packages beforehand and select the items, we don't even take what will not be consumed to relieve weight and volume" (28 years old, FG IV); "Simple instructions and easy handling" (24 years old, FG III); "Vacuum packaging would help a lot in reducing volume" (30 years old, FG I).
11. Do you consider packaging environmentally appropriate?	"No, but I think it's an important topic" (28 years old, FG III); "The packaging could be biodegradable, causing less environmental impact" (28 years old, FG I).
12. Can you infer benefits from research in this area?	"Yes, because I consider it fundamental that the end of the line be heard" (28 years old, FG III). "It is very important to improve the menu quality and variety" (27 years old, FG II); "The menus do not necessarily need to be regionalized. Simple optimization can be advantageous, such as replacing low-consumption items" (25 years old, FG I).

Note: *Focus Group

Source: Elaborated by authors, 2022.

2.4 Data Analysis

The questionnaire answers on general impressions and acceptability were analyzed based on descriptive interpretation and frequency, with the support of the R Project for Statistical Computing software. A central median axis of answers was identified and categorized by neutrality. The other results were positioned according to acceptability bias, positive or negative. Data interpretation based on the graphic representation makes it possible to measure the intensity degree of positive or negative answers.

Consumption responses were interpreted by frequency analysis, using Microsoft Excel Spreadsheet software, in order to facilitate the consolidation and objective interpretation of data on consumption in the jungle environment operations. The results were expressed in two main Groups: the first one, contemplating consumption greater than or equal to 75%; the second one, with consumption below 75% (NORTH ATLANTIC TREATY ORGANIZATION, 2010).

With regard to the Focus Groups, the collected data, due to the qualitative nature of the research, did not undergo specific statistical treatments, only a thematic organization of ideas that seek the objective expression of the impressions about a certain group on the subject under analysis (VIEIRA *et al*., 2013).

3 RESULTS AND DISCUSSION

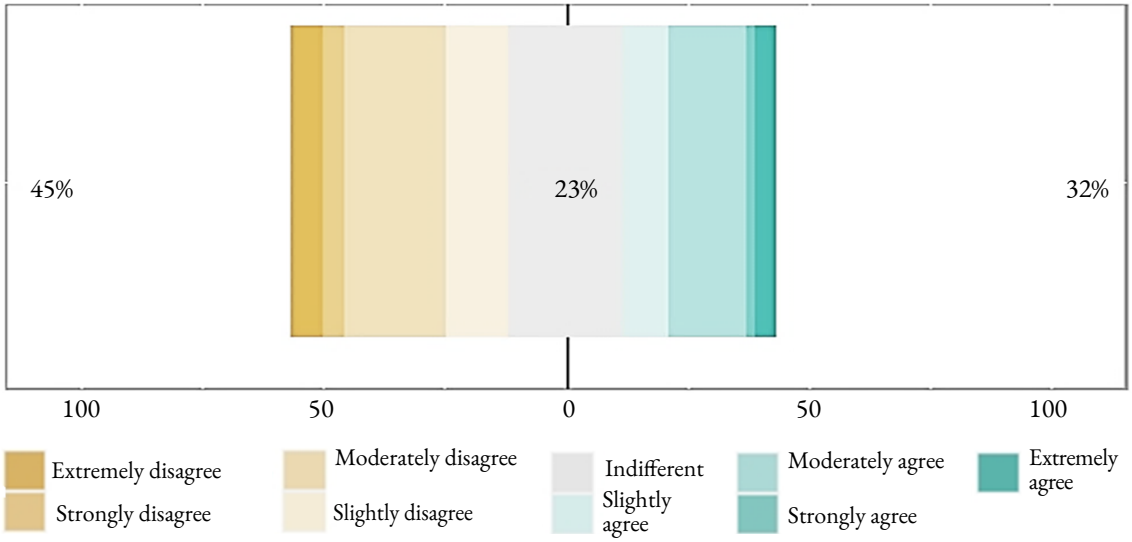
3.1 Online Questionnaire

3.1.1 Adaptation of Menus to the Jungle Environment

Regarding the adaptation of menus to the jungle environment, characterized mainly by high temperatures and high humidity, 45% participants consider that these are not adapted,

and 32% consider them suitable for the jungle environment; however, there is a range of neutrality of approximately 23%, as shown in Figure 1. Thus, it is noted that almost half of the respondents considers this item as a sensitive point for feeding the military on mission in this type of environment.

Figure 1 – Adaptation of operational ration menus to the jungle environment



Source: Elaborated by authors, 2022.

The hot and humid jungle environment already demands a nutritional profile with proteins of better digestibility, reducing the intake postprandial effects, since the military do not have a pre-established rest period, that is, they always have to stay alert. Seeking a nutritional adaptation, the rations used for hot and humid climates should advocate the following adaptations: provide additional energy and contain components less susceptible to degradation by heat; emphasize complex carbohydrates, with adequate protein and moderate fat, and provide additional dry drink mixes to increase fluid intake and help reduce the risk of dehydration due to excessive sweating and consequent loss of body fluids (NORTH ATLANTIC TREATY ORGANIZATION, 2019).

As a result of low adaptation to the environment, a possible underconsumption can be observed, impacting on the body and cognitive score. According to the US Committee on Military Nutrition Research, a gradual loss of body weight between 3% and 10% during military training lasting three to 30 days is unlikely to affect performance, but, a rapid loss of 6.2% weight over a one-week period will lead to worse cognitive outcomes including more tension, depression, anger, fatigue and confusion (TASSONE; BAKER, 2017).

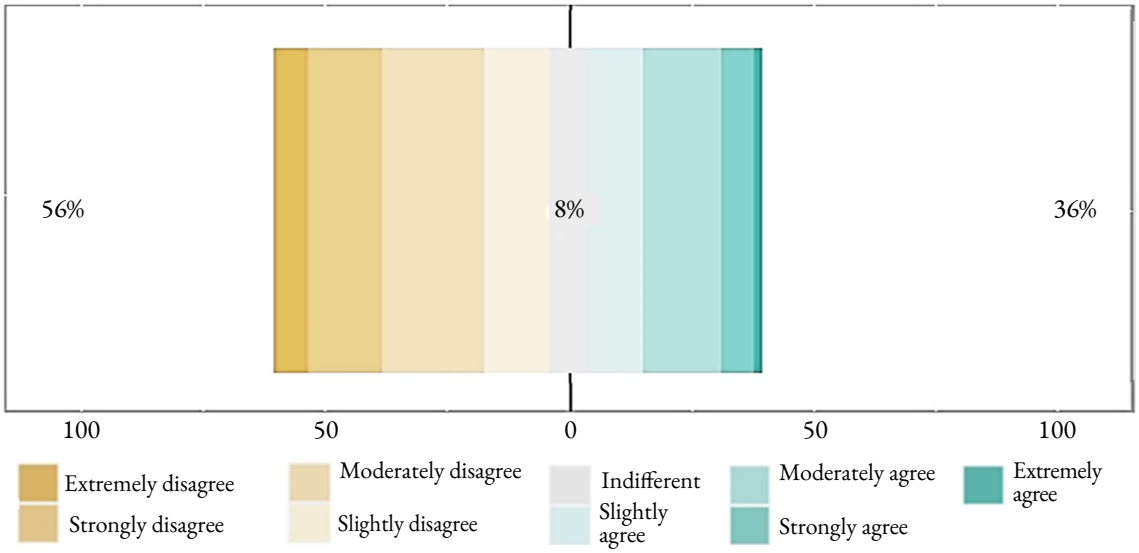
The reduction in menu intake is probably the final result of a combination of factors that include appetite suppression and palatability/variety of feed provided, which is aggravated

in situations of extreme stress, as in the Amazon biome (FALLOWFIELD *et al*., 2014; JOHNSON *et al.*, 2018). In this sense, there is need for improvements that provide more stimuli for ingestion, such as greater food variety, and better palatability and digestibility.

3.1.2 Nutritional Profile in Longer Jungle Environment Operation

It was found that, for 56% military, the rations would not provide energy, proteins, nor macro and micronutrients needed for a longer-lasting activity, impacting the activity operationalization, with possible direct effects on individual performance, as shown in Figure 2:

Figure 2 – Nutritional profile in longer operations



Source: Elaborated by authors, 2022.

However, there is a relevant aspect to be mentioned: the current feeding doctrine does not foresee the use of rations for more than three days. The current menus are doctrinally recommended to maintain health and body score in operational conditions in missions of up to, and only, three days, from preparation activities – such as varied training aimed at combatant qualification – to real employment situations – such as deployments of peacekeeping missions or operations in hostile environments, as the Amazon jungle (BRASIL, 2022).

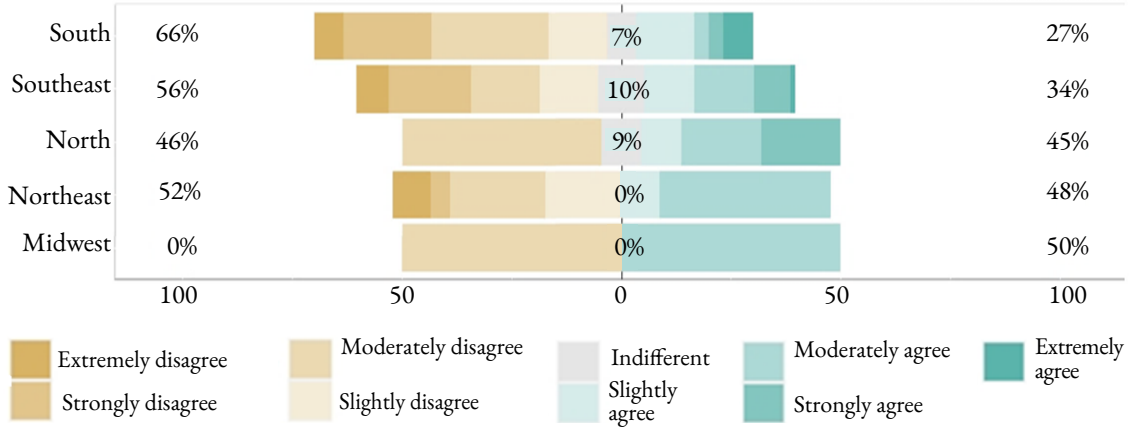
It exposes the relevance of showing that this three-day period was defined by Ordinance nº 721, of December 30, 1999, just citing aspects of monotony and without a technical or physiological basis, besides having been elaborated more than 20 years ago in a logistical and operational context divergent from the current one (BRASIL, 1999).

Military missions have a highly imprecise and variable time of employment, with a tendency to prolonged operation periods. As an illustration, in the North Atlantic Treaty Organization (NORTH ATLANTIC TREATY ORGANIZATION, 2010), the nutritional recommendations allow that the combat ration be used exclusively for a maximum 30-day period, and there may be emergencies in which the military will be obliged to subsist on the ration for a longer duration, until fresh food can be provided.

In the United States Army, the military food policy allows combatants to consume three meals of operational rations for up to 21 consecutive days as their sole source of sustenance (MCCLUNG *et al*., 2020).

Still, 36% military consider that the current rations can supply the combatant in longer periods, maintaining the body score and the adequate nutrient delivery, that is, guaranteeing the macro and micro nutritional balance necessary for their homeostatic maintenance. In order to analyze this population group's profile, answers were also evaluated according to each military man's region of origin, seeking impressions by geographic region, thus obtaining Figure 3:

Figure 3 – Nutritional profile in prolonged operations x military man's region



Source: Elaborated by authors, 2022.

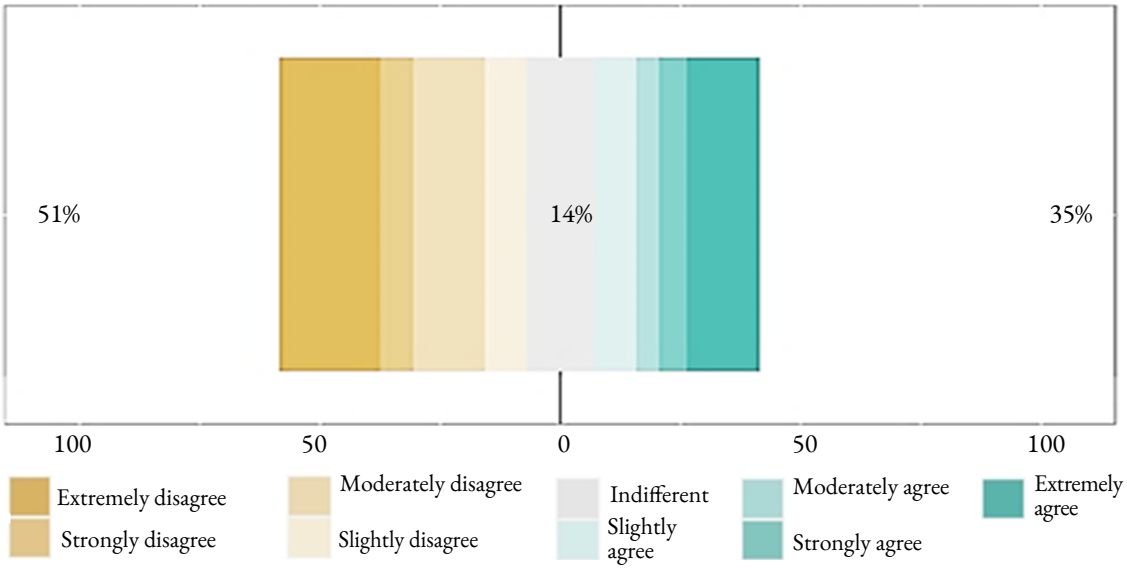
Military men from the Southeast and South regions have a more demanding consumption profile, in which 66% and 56%, respectively, considered the menus adequate for longer-term employment. These characteristics may be in accordance with the profile of the Gross Domestic Product (GDP) of these regions, respectively first and second in Brazil, leading to greater product diversity and, thus, forming a profile of more selective consumers (RESENDE; MAGALHÃES, 2013). Regarding the participants from the North and Northeast regions, 52% and 46% considered the menus unsuitable, respectively.

3.1.3 Menu Monotony in the Operational Jungle Environment

Thermoprocessed foods sterilized in an autoclave form the basis of the operational ration meals (lunch and dinner) and are packaged in long-lasting flexible laminated packaging (retort pouch), without the need for refrigeration, and are represented by chicken stroganoff, beef stroganoff, chopped beef in sauce, beef with goulash sauce, *vaca atolada* (beef ribs with cassava), beef with vegetables, *feijoada*, minced beef with potatoes, pinto beans with sausage, rice with beans and beef. Cassava flour, which does not undergo thermal processing, was also included in this analysis because it is part of the menu options.

It was observed that 51% military consider the menus monotonous, with little variety, not meeting individual demands in possible situations of longer operations, which infers a worrying negative impact on consumption due to the loss of attractiveness and food fatigue. Such a situation can interfere with individual performance due to the nutrient underconsumption that would mitigate the combatant's physical and psychological exhaustion (AHMED, 2019). It should be noted that 35% consider the quantity of menus to be satisfactory, with 14% having a neutral range, forming a balance profile, as shown in Figure 4:

Figure 4 – Menu monotony in the jungle environment



Source: Elaborated by authors, 2022.

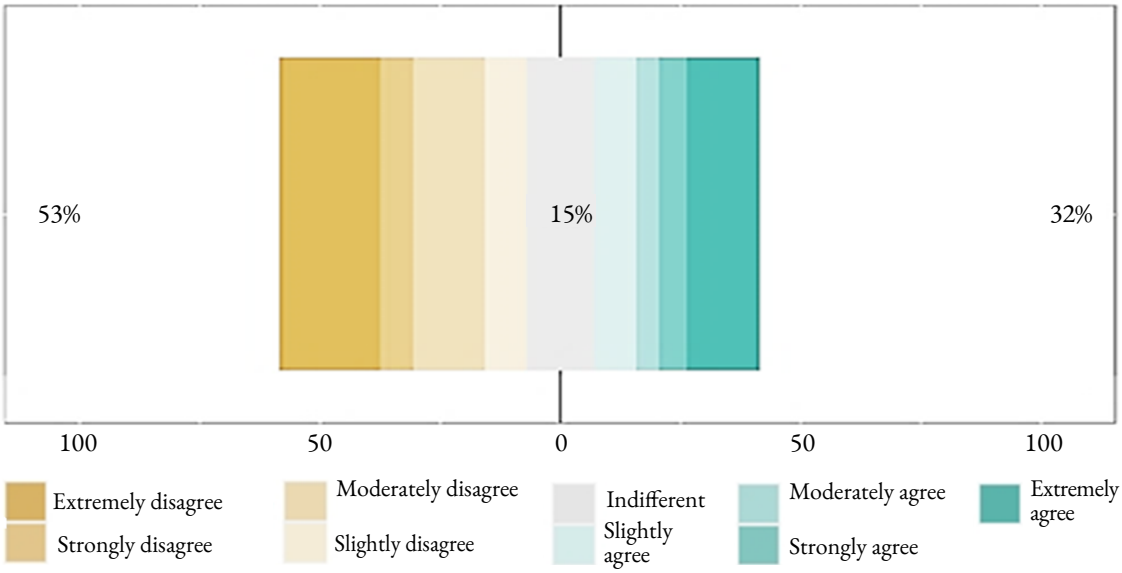
The monotony may be directly related to the quantity of existing menus, but the consolidation of a larger amount and in a rotation system could help improve this aspect. As an example, among NATO member countries, menu options vary from two units (Czech Republic) to 24 items (United States), covering the main meals, given the general requirement to provide a varied diet to combatants that encourages its consumption (NORTH ATLANTIC TREATY ORGANIZATION, 2010).

Crawford (2020) observed, in a study with Canadian rations, that boredom is worrying and refers to the inevitable monotony of eating the same food for a long period. Logistical and resource challenges make it difficult an unlimited rotation of menu items, however maintaining a reasonable variety of menu items is important to reduce menu monotony and fatigue. To avoid boredom, the Canadian Army currently supports a rotation of approximately 20 different main menu items per year, which may be a plausible strategy to implement nationwide.

3.1.4 Well-being in the Operational Jungle Environment

As shown in Figure 5, for 53% military, ration menus do not provide well-being, that is, they do not provide that feeling of pleasure in consumption, in addition to some psychological comfort. Only 32% perceive positive wellness effects from eating. In operations, food should work as an element that raises the combatant's morale and reduces stress, an extreme factor.

Figure 5 – Menu monotony in the jungle environment



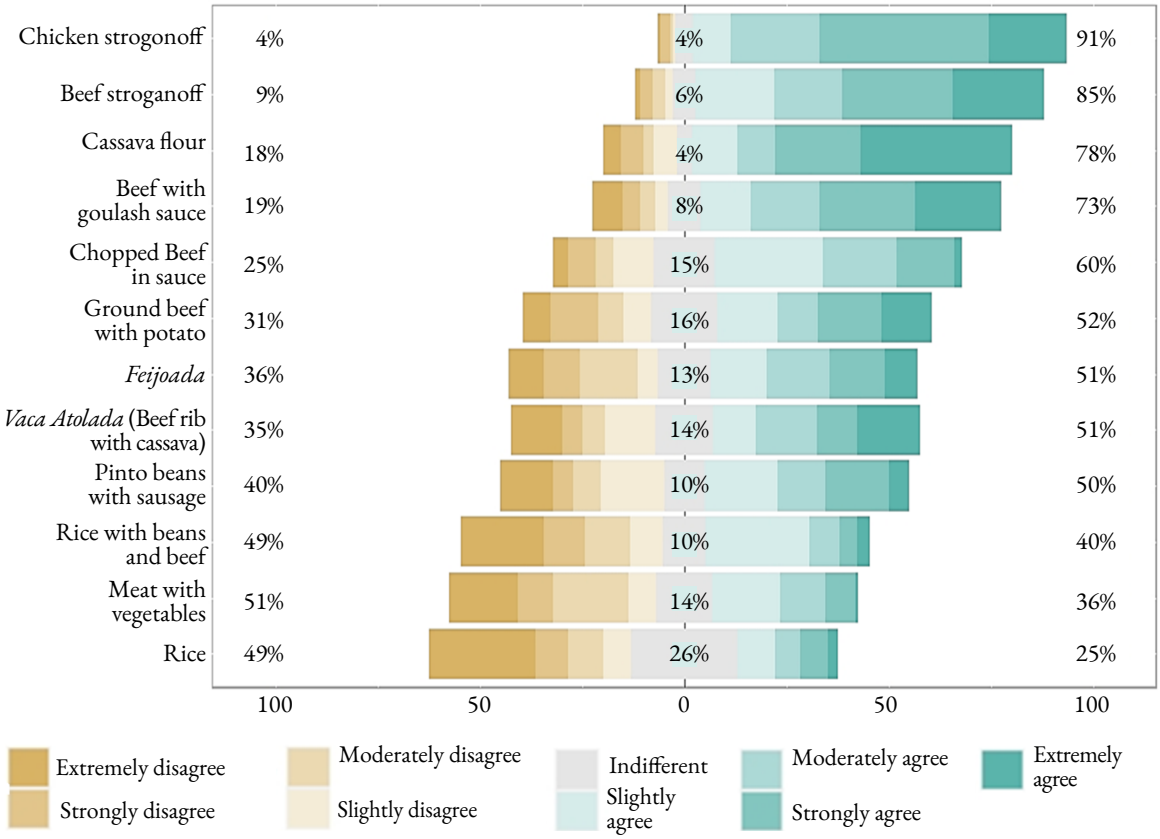
Source: Elaborated by authors, 2022.

There are few variables to mitigate operational stress, sometimes configured by exhaustive actions with few hours of rest and at inappropriate places. A diet that provides comfort and well-being can mitigate individual stress, impacting performance positively. Thus, food, in addition to the primary function of nutritional and physiological support, has to provide a feeling of comfort and pleasure in its ingestion, particularly in real military operations (SPENCE, 2017). The perception of food discomfort can compromise intake and potentially determine a serious weight loss, which will lead to a reduction in operational performance (HIRSCH *et al*., 2005).

3.1.5 Acceptability of Staple Food in the Operational Jungle Environment

In evaluating the acceptability of the operational rations, based on previous experimentation of the items, it was observed that the most accepted menus were the beef and chicken stroganoff, with respectively 91% and 85% positive evaluations. However, on the other hand, beef with vegetables and rice had low acceptability, 36% and 25%, respectively, as shown in Figure 6. Also noteworthy is the high acceptability of the cassava flour, 78%, a product that has little added technology, however, with high consumption throughout the national territory and an excellent source of carbohydrates.

Figure 6 – Acceptability of Staple Food in the Operational Jungle Environment



Source: Elaborated by authors, 2022.

Thus, of the 12 analyzed menus, only three formulations (rice with beans and beef; beef with vegetables; and rice – 25%) presented results with levels below 50% of acceptability. The results obtained raise an alert regarding the sensory quality of the products offered and suggest that, given the evaluated acceptability, there may be an underconsumption of these menus by the military.

Perceptions of the existence of a low sensory acceptance and underconsumption profile in Brazilian operational rations have already been reported. According to researchers Campos and Marques:

> In all evaluated sensory attributes, the results obtained were considered undesirable. Complementary research should be carried out in a controlled environment, with specialized troops, to assess whether the complexity of the theater of operations interferes with the situation and eating behavior of the combatant. (CAMPOS; MARQUES, 2020, p. 13)

According to De Graaf *et al*. (2005), little research on the acceptability of combat rations has been performed, showing the importance of studies that demonstrate the military's real needs in the most divergent profiles of operational environments, optimizing physical and cognitive health.

In the United States, the use of the 9-point hedonic scale (1 – dislike extremely and 9 – like extremely) to assess acceptability, developed by the US Army in the 1950s, is widely disseminated. Most commercial food products intended for the general public average between five and eight (NORTH ATLANTIC TREATY ORGANIZATION, 2010). Based on this methodology, the results obtained can be seen in Table 1:

Table 1 – Acceptability mean and standard deviation of menus in the jungle environment

Menu	Mean	Standard Deviation
Chicken stroganoff	7.4	1.5
Beef stroganoff	7.0	1.9
Cassava flour	7.0	2.4
Beef with goulash sauce	6.5	2.4
Chopped beef in sauce	5.6	1.9
Minced beef with potatoes	5.5	2.5
Vaca Atolada (beef ribs with cassava)	5.5	2.6
Feijoada	5.2	2.5
Pinto beans with sausage	5.1	2.4
Beef with vegetables	4.3	2.3
Rice with beans and beef	4.2	2.4
Rice	4.0	2.4

Source: Elaborated by authors, 2022.

In this context, three menus (beef with vegetables, rice with beans and beef, and rice) also would not potentially be commercially acceptable, corresponding to 25% analyzed items. Also, the results of low acceptability of the items rice, rice with beans and beef, and beef with vegetables, with scores below five points, give rise to a concern with possible impacts on consumption according to a study carried out by De Graaf *et al*. (2005), o who observed that the

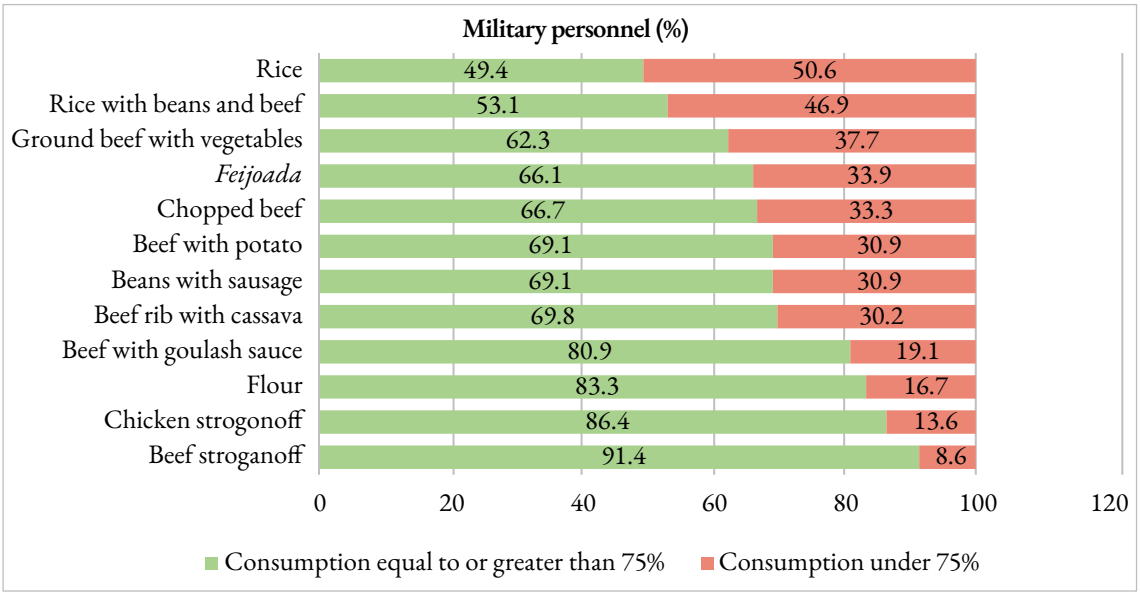
consumption of portions of items with scores below 5 points in the acceptability criterion was below 77% total amount. Thus, there is an additional concern regarding the item rice, since it constitutes the main source of carbohydrates in the diet and is present in all the menu options offered, causing impacts on the balance of calories ingested, which becomes an aggravating factor in high-demand jungle environment.

The Brazilian territory has continental dimensions and diverse biomes and native populations, with regionalized food profiles. Certainly, the Amazon region's impressions may differ from others, but they have to be scientifically based for menu optimization, aiming at increasing consumption, reducing material losses, and mitigating physical, cognitive, and performance deficits.

3.1.6 Acceptability of Staple Food in the Operational Jungle Environment

Of the 12 basic food menu items, two (12.5%) of these (rice with beans and beef; rice) presented consumption below 75% offered portion, by approximately 50% participants, causing a concern about possible impacts on the consumption and, consequently, on the body score. The results are shown in Figure 7:

Figure 7 – Consumption of staple food operational ration in the operational jungle environment



Source: Elaborated by authors, 2022.

Aligning with the good acceptability of beef and chicken stroganoff menus, 91% and 86% participants indicated their consumption equal to or greater than 75% offered portion, respectively. The same trend can be observed with cassava flour and beef with goulash sauce, both with good acceptance and consumption.

However, it was found that 51% participants reported rice consumption below 75% package volume. It is observed that under these circumstances, a caloric deficit of 260 kilocalories (Kcal) occurs according to the Brazilian Table of Food Composition, representing 8% total calories in a dietary demand of 2,800 Kcal indicated for an adult in normal conditions of activity, inferring an interference in the body score (BRASIL, 2010; UNIVERSIDADE DE CAMPINAS, 2011).

The results are in line with reports on inadequate calorie intake and possible impacts on energy deficits during intense periods of operations and field training, which can reach about 40% military's total energy needs (FALLOWFIELD *et al*., 2014; MARGOLIS *et al*., 2014; MARRIOTT; 1995).

Booth, Coad and Roberts (2003), in a study on the exclusive consumption of rations for a 23-day period in the Australian Army, observed that there was a high rate of discarding items, with foods rich in carbohydrates being the most discarded: on average 46% crackers, 72% mushroom bars, 81% baked beans, 93% chocolate, 94% white sugar, 96% candies, 99% potato powder and 100% rice – i.e., 40% energy available.

According to a randomized clinical trial carried out in the US Army, when rations are consumed as intended, for a 21-day period, soldiers are nutritionally adequate in terms of energy and micronutrients (LENFERNA DE LA MOTTE *et al*., 2021; MCCLUNG *et al*., 2020). Nevertheless, several studies report that rations are rarely consumed as should be (BOOTH; COAD; ROBERTS, 2003; FALLOWFIELD *et al*., 2014; HILL *et al*., 2011; MARGOLIS *et al*., 2014; ZINN C *et al*., 2017). Waste, underconsumption, and negative energy balance are commonly reported issues, resulting in weight loss, body fat reduction, protein catabolism, immune suppression, increased perceived fatigue, decreased military performance (reaction time, marksmanship, and decision making), increased risk of injury and decreased resistance (BEALS *et al*., 2019; BOOTH; COAD; ROBERTS, 2003; HILL *et al*., 2011; LENFERNA DE LA MOTTE *et al*., 2021).

With regard to the item rice with beans and beef, consumption below 75% was registered in approximately 47% answers. This means that in a portion of 350 grams (g), at least 87g are not ingested by approximately half of the participants, representing a deficit of 203 Kcal, in addition to micronutrients such as vitamin C, B vitamins, iron, and calcium (UNIVERSIDADE DE CAMPINAS, 2011).

The protein genres are and additional concern: in addition to being a caloric source, proteins participate in complex metabolic activities in the body structure, especially in the health of the body score. For example, a 100g portion of *feijoada* contains 8.7g of protein, 6.5g of lipids, 32 milligrams (mg) of calcium and magnesium, 11g of fiber and 22mg of cholesterol, which participate in several metabolic processes, including the hormonal modulation and neuromuscular functioning (UNIVERSIDADE DE CAMPINAS, 2011).

Despite the results of this work demonstrating compatibility between acceptability and consumption, De Graaf *et al*. (2005) found that acceptability plays an important role in food intake and choice, but this is not the dominant factor at all. In this sense, one verifies that additional research on the factors that determine food intake by the military is necessary and

should analyze the interaction between mission, food, and the environment where the operation will be carried out.

3.2 Focus Groups

According to Gaspar, Escribano and Mesias (2016), the main advantage of using focus groups in relation to other more structured research methods, for example, questionnaires, is that this method allows promoting greater freedom of expression in the discussion of varied topics (CHALOFSKY, 2001; MESÍAS; MARTÍN; HERNÁNDEZ, 2021; STEWART; SHAMDASANI, 2014).

In this way, through discussions and debates in Focus Groups, the most significant impressions were collected about general attributes, such as packaging, variety and menu components, ease of preparation, satiety, digestibility and well-being and disposal of waste, as results expressed in Table 2, with the most relevant participants' comments.

Menus were a widely discussed subject, and they were considered monotonous by the military. Simpler diet solutions were presented, approaching homemade products with greater acceptance, such as grilled/roasted dishes, pasta, *carreteiro* rice, *tropeiro* beans, among others, which already occurs in other countries and which would improve the "well-being" component," favoring pleasure in consumption, as reported by a participant in the Focus Group (FG) II, who describes the desire to see "inclusion of more baked goods, pasta and pizza." Ideas regarding improving product options were also noted, rather than increasing the amount of food offered.

Another fact pointed out by practically everyone refers to satiety. Although breakfast was not the subject of this article, there were significant recurrent reports on the insufficiency of nutrients in this meal, with emphasis on the low caloric amount, as reported by a FG IV participant: "Breakfast is too early, and items like crackers don't last until lunch." Besides the nutritional gap between breakfast and lunch, it is still possible to infer the underconsumption of some basic foods already mentioned, which leads the military to seek alternatives to meet the demands, such as eating food in the environment or carrying personal items, such as assorted crackers or straw potatoes, which unbalances the profile of the food offered by the supply chain, modifying the institutionally proposed diet. It is essential to explain that the periods between meals are usually long and many military men, in a compensatory way, consume breakfast items fractionally, mitigating the feeling of hunger. Also with the same objective, they usually carry commercial supplements, such as high absorption carbohydrates and protein bars, which was expressed in FG IV: "It would be a good option; whenever I can, I take BCAAs and carbo gel".

In the view of McClung *et al*. (2020), designing ration menus that meet numerous military requirements (e.g., weight, volume, shelf life, and nutrient intake), all with similar priority, requires reasoning and skill. Having a higher ration fat content can be a partial solution because it allows for a more energy-dense ration (i.e., energy per unit volume). This characteristic favors the development of products with a smaller volume, meeting the military's desires and reducing individual logistical efforts.

Digestive difficulties aggravated by the profile of the hot and humid environment, causing the sensation of heartburn and indigestion, have also been reported. Due to the military profession profile, the absence of long rest intervals after eating should be considered. That is, after consumption, which is normally carried out in a short period of time, the military will be immediately ready for action, taking into account that the digestibility of the menu should not interfere with its performance. In this sense, the adoption of proteins with high digestibility would have a positive impact on performance and operability aspects, which is in line with the possibility of including fish in the diet.

Fish proteins are easily digestible and have a high biological value. Fats are rich in polyunsaturated fatty acids from the omega three series, which have reducing effects on blood cholesterol levels, decreasing the risk of vascular diseases (BRASIL, 2010). Still on digestibility, the military cited the lack of dietary fiber, as reported by a FG III participant, on the possibility of "inclusion of more fiber in the diet." This finding was already mentioned in a study on the nutritional quality of operational rations, carried out by Barros and Koglin (2022), in which a lack of dietary fiber was found in three of the five menus offered. Adequate fiber intake is essential for the normal maintenance of the gastrointestinal tract and health, and it is important that this be part of the healthy population's diet, reducing the risk of chronic degenerative diseases (CUPPARI, 2005).

It is worth mentioning the high technological quality involved in the product, confirming the testimony of FG II: "I consider it a safe product with good technological quality" in line with the results identified by researchers Avena and Ginani (2009), who concluded that the thermoprocessed meal is microbiologically safe.

As to the preparation for food consumption, the processes were considered adequate, allowing even tired soldiers to be able to correctly manipulate the preparation components. However, the excess of waste generated by packaging was profusely mentioned, in addition to the excess of waste resulting from the underconsumption of some items.

The participants (34.8%) mentioned considerations about the large volume of operational rations, making transportation and packing in backpacks difficult. As a proposal, the vacuum system could facilitate operations. Additionally, some participants (8.2%) mentioned the possibility of using packaging, with less environmental impact. Currently, only one ration component (cutlery) is derived from biodegradable components (BRASIL, 2022).

Thus, depending on the results presented, it is evident that research in the area of military food, with data collected from the assisted troops and their reading at the end of the line, is of great relevance and provide fundamental data for a better understanding of consumption, acceptance, and performance in the various operational and tactical niches, providing opportunities for continuous improvement in the quality of the items offered.

It should also be noted that the combination of electronic questionnaires and interviews in Focus Groups allowed participants to express, objectively and freely, their impressions about the product profile (operational ration) in the jungle environment, providing in-depth understanding and impressions about the entire feeding dynamics in the jungle environment,

and thus helping the design of strategies aimed at the development and/or reformulation of products and processes in the operational environment under study.

Finally, it is noted that this article has limitations due to both the sample size and the sampling used (non-probabilistic), and its results cannot be externalized to the country's entire military population, but, as evidenced, it opens opportunities for investigations in other regions, with more military personnel and other operational environments. In addition, one suggests that studies on the perception and consumption of menus should be performed in the field, for example, with ethnographic approaches.

4 CONCLUSION

The association of the tools employed (electronic questionnaire and focus groups) proved to be efficient to obtain information about general impressions, acceptability, and consumption of operational rations in the jungle environment. Despite all the excellent technology involved in existing products, the results showed profiles of monotony, nutritional deficit, little variety and low well-being in consumption, in addition to underconsumption and low acceptability of the main menus. In this context, the constant evaluation of the acceptability of the menus is suggested, providing opportunities for sensorial, nutritional and digestibility improvements, which guarantee the military's adequate energy and nutritional balance in the jungle environment.

Additionally, the possibility of inserting new processes and food products in the feeding routine was highlighted, and also of materials used in packaging, optimizing the combatant's operability and the military activity sustainability. Finally, given the importance of food for the performance and success of military exercise, it is recommended that similar studies should be reproduced in the most different operational environments, conducted in addition to observational on-site techniques.

ACKNOWLEDGMENTS

This article was carried out supported by the Department of Education and Culture of the Army (DECEx) and the Coordination for the Improvement of Higher Education Personnel (CAPES) – Granting Code 001, as well as by the Brazilian research agencies: CNPq and Carlos Chagas Filho Foundation for Research Support in the State of Rio de Janeiro (Faperj).

AUTHORSHIP AND COLLABORATION

All authors had equal participation in the elaboration of this article.

REFERENCES

AHMED, M.; MANDIC, I.; LOU, W.; GOODMAN, L.; JACOBS, I.; L'ABBÉ, M. R. Comparison of dietary intakes of Canadian Armed Forces personnel consuming field rations in acute hot, cold, and temperate conditions with standardized infantry activities. **Military Medical Research**, Bethesda, v. 6, n. 1, p. 1–16, 2019. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6696676/. Access: February 20, 2020.

AVENA, F.; GINANI, V. **Avaliação nutricional de refeições termoprocessadas**. 2009. Monografia (Especialização em Gastronomia e Defesa Alimentar) – Centro de Excelência em Turismo, Universidade de Brasília, Brasília, DF, 2009. Available from: https://bdm.unb.br/bitstream/10483/992/1/2009_FernandaLimaAvena.pdf. Access: April 10, 2019.

BARROS, P. A. C. Z.; KOGLIN, G. Ração Operacional de Combate do Exército Brasileiro: Uma Análise Nutricional. **Saúde e Desenvolvimento Humano**, Canoas, v. 10, n. 2, p. 1–12, 2022. Available from: https://revistas.unilasalle.edu.br/index.php/saude_desenvolvimento/article/view/7825. Access: September 10, 2022.

BEALS, K. *et al*. Energy deficiency during cold weather mountain training in NSW SEAL qualification students. **International Journal of Sport Nutrition and Exercise Metabolism**, Bethesda, v. 29, n. 3, p. 315-321, 2019. Available from: https://pubmed.ncbi.nlm.nih.gov/30160550/. Access: March 23, 2023.

BOOTH, C. R.; COAD, R; ROBERTS, W. Evaluation of an Australian combat ration pack as a sole nutrition source during 23 days of military adventurous training in the tropics. **Nutrition & Dietetics**, New Jersey, v. 60, n. 4, p. 239-47, 2003. Available from: https://www.researchgate.net/publication/27257094_Evaluation_of_an_Australian_combat_ration_pack_as_a_sole_nutrition_source_during_a_23_day_military_exercise_in_the_tropics. Access: March 23, 2023.

BOTELHO, R. B. A.; AVENA, F.; VERAS, M.; ZANDONADI, R. P. Adequação nutricional de oferta e consumo de refeições por soldados brasileiros. **Revista de Nutrição**, Campinas, v. 27, n. 2, p. 229-239, 2014. Available from: https://www.scielo.br/j/rn/a/TNBX3qHdFXqtxHbmjjg9L6H/?lang=en&format=pdf. Access: February 20, 2020.

BRASIL. Ministério da Defesa. Exército. **Portaria nº 721, de 30 de dezembro de 1999**. Aprova as Instruções Gerais para a Administração das Rações Operacionais no Exército Brasileiro em Tempo de Paz (IG 10-07). Brasília, DF: Ministério da Defesa, 1999. Available from: https://bdex.eb.mil.br/jspui/bitstream/1/836/1/IG%2010-07.pdf. Access: March 23, 2023.

BRASIL. Ministério da Defesa. Exército. **Portaria Normativa Nº 219/MD, de 12 de fevereiro de 2010**. Aprova o Manual de Alimentação das Forças Armadas. Brasília, DF: Ministério da Defesa, 2010. Available from: http://www.1rm.eb.mil.br/images/4.-ANEXO-I--B--Portaria-Normativa-n-219MD-de-12-de-Fevereiro-de-2010-K.pdf. Access: June 13, 2021.

BRASIL. Ministério da Defesa. Exército. **Especificação Técnica de Artigo de Subsistência**: Ração Operacional de Combate. 3. ed. Brasília, DF: Diretoria de Abastecimento, 2022. Available from: http://www.dabst.eb.mil.br/index.php/biblioteca-de-normas-tecnicas/subsist%C3%AAncia/81. Access: June 2, 2021.

CAMPOS, F. M.; MARQUES, L. **Estudo de aceitabilidade da Ração Operacional de Combate no âmbito do Exército Brasileiro**. Brasília, DF: Ministério da Defesa, 2020.

CARVALHO, M.; BOTELHO, R. B. A.; LACERDA, L.; ZANDONADI, R. P. Sensory analysis of ready-to-eat meals in the Brazilian Army. **Journal of Culinary Science and Technology**, São Paulo, v. 17, n. 4, p. 313-325, 2019. Available from: https://www.tandfonline.com/doi/full/10.1080/15428052.2018.1442761. Access: November 28, 2020.

CHALOFSKY, N. **How to conduct focus groups**. Alexandria: American Society for Training and Development, 2001.

CRAWFORD, L. **Sensory Testing of Canadian Armed Forces Individual Meal Packs**. 2020. Tese (Doutorado em Ciência da Alimentação) – University of Guelph, Ontario, 2020. Available from: https://atrium.lib.uoguelph.ca/xmlui/bitstream/handle/10214/21269/Crawford_Laura_202009_MSc.pdf?sequence=4&isAllowed=y. Access: January 12, 2021.

CUPPARI, L. **Guia de Nutrição clínica no adulto**: Guias de Medicina Ambulatorial e Hospitalar da Unifesp – Escola Paulista de Medicina. Barueri: Manole, 2005.

DALMORO, M.; VIEIRA, K. M. Dilemas na construção de escalas Tipo Likert: o número de itens e a disposição influenciam nos resultados? **Revista Gestão Organizacional**, Chapecó, v. 6, n. 3, p. 161-174, 2013 Available from: http://www.spell.org.br/documentos/ver/31731/dilemas-na-construcao-de-escalas-tipo-likert--o-numero-de-itens-e-a-disposicao-influenciam-nos-resultados-. Access: March 23, 2023.

DE GRAAF, C *et al*. Food acceptability in field studies with US army men and women: Relationship with food intake and food choice after repeated exposures. **Appetite**, Amsterdam, v. 44, n. 1, p. 23-31, 2005. Available from: https://www.researchgate.net/publication/8125988_Food_Acceptability_in_Field_Studies_with_US_Army_Men_and_Women_Relationship_with_Food_Intake_and_Food_Choice_After_Repeated_Exposures. Access: March 23, 2023.

ELDESOUKY, A.; MESÍAS, F. An insight into the influence of packaging and presentation format on consumer purchasing attitudes towards cheese: A qualitative study. **Spanish Journal of Agricultural Research**, Madrid, v. 12, n. 2, p. 305-312, 2014. Available from: https://www.researchgate.net/publication/262492437_An_insight_into_the_influence_of_packaging_and_presentation_format_on_consumer_purchasing_attitudes_towards_cheese_A_qualitative_study. Access: November 12, 2021.

ESMERINO, E. A. *et al*. Consumers' perceptions toward 3 different fermented dairy products: Insights from focus groups, word association, and projective mapping. **Journal of Dairy Science**, Bethesda, v. 100, n. 11, p. 8849-8860, 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/28888609/. Access: December 10, 2020.

FALLOWFIELD, J. L. *et al*. Energy expenditure, nutritional status, body composition and physical fitness of Royal Marines during a 6-month operational deployment in Afghanistan. **British Journal of Nutrition**, Cambridge, v. 112, n. 5, p. 821-829, 2014. Available from: https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/energy-expenditure-nutritional-status-body-composition-and-physical-fitness-of-royal-marines-during-a-6month-operational-deployment-in-afghanistan/7320BB9C1A491A4C7CC37BD1885291E0. Access: January 5, 2020.

FOX, M; WENKAM, N; HIRSCH, E. Acceptability studies of military ration: Meal, Ready-to-Eat. **Foodservice Research International**, New Jersey, v. 5, n. 3, p. 189-199, 1988. Available from: https://www.researchgate.net/publication/230530485_ACCEPTABILITY_STUDIES_OF_MILITARY_RATION_MEAL_READY-TO-EAT. Access: March 23, 2023.

FUSCH, P.; NESS, L. R. Are we there yet? Data saturation in qualitative research. **Qualitative Report**, Fort Lauderdale, v. 20, n. 9, p. 1408, 2015. Available from: https://nsuworks.nova.edu/tqr/vol20/iss9/3. Access: March 23, 2023.

GASPAR, P.; ESCRIBANO, M.; MESIAS, F. J. A qualitative approach to study social perceptions and public policies in *dehesa* agroforestry systems. **Land Use Policy**, Amsterdam, v. 58, p. 427-436, 2016. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0264837716300990?via%3Dihub. Access: January 25, 2021.

GUEST, G.; BUNCE, A.; JOHNSON, L. How many interviews are enough? An experiment with data saturation and variability. **Field Methods**, London, v. 18, n. 1, p. 59-82, 2006. Available from: https://journals.sagepub.com/doi/10.1177/1525822X05279903. Access: February 10, 2021.

HILL, N.; FALLOWFIELD, J.; PRICE, S.; WILSON, D. Military nutrition: maintaining health and rebuilding injured tissue. **Philosophical Transactions of the Royal Society B: Biological Sciences**, Bethesda, v. 366, n. 1562, p. 231-240, 2011. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3013424/. Access: March 23, 2023.

HIRSCH, E. S.; KRAMER, F. M.; MEISELMAN, H. L. Effects of food attributes and feeding environment on acceptance, consumption and body weight: Lessons learned in a twenty-year program of military ration research. **Appetite**, Amsterdam, v. 44, n. 1, p. 3–45, 2005. Available from: https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1040&context=usarmyresearch. Access: March 23, 2023.

JOHNSON, C. D. *et al*. Energy expenditure and intake during special operations forces field training in a jungle and glacial environment. **Applied Physiology, Nutrition, and Metabolism**,

Bethesda, v. 43, n. 4, p. 381-386, 2018. Available from: https://pubmed.ncbi.nlm.nih.gov/29144888/. Access: March 23, 2023.

LENFERNA DE LA MOTTE, K-A.; SCHOFIELD, G.; KILDING, H.; ZINN, C. An Alternate Approach to Military Rations for Optimal Health and Performance. **Military Medicine**, Oxford, p. 1-7, 2021. Available from: https://academic.oup.com/milmed/advance-article/doi/10.1093/milmed/usab498/6462370. Access: November 12, 2022.

MARGOLIS, L. M. *et al*. Energy requirements of US Army Special Operation Forces during military training. **Nutrients**, Bethesda, v. 6, n. 5, p. 1945-1955, 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/24824290/. Access: March 23, 2023.

MARRIOTT, B. M. **Not eating enough**: Overcoming Underconsumption of Military Operational Rations. Washington, DC: National Academy Press, 1995.

MCCLUNG, H. L. *et al*. Randomized Trial Comparing Consumption of Military Rations to Usual Intake for 21 Consecutive Days: Nutrient Adequacy And Indicators Of Health Status. **Journal of the Academy of Nutrition and Dietetics**, Bethesda, v. 120, n. 11, p. 1791-1804, 2020. Available from: https://pubmed.ncbi.nlm.nih.gov/32828737/. Access: March 23, 2023.

MESÍAS, F. J.; MARTÍN, A.; HERNÁNDEZ, A. Consumers' growing appetite for natural foods: Perceptions towards the use of natural preservatives in fresh fruit. **Food Research International**, Amsterdam, v. 150, p. 110749, 2021. Available from: https://www.sciencedirect.com/science/article/pii/S0963996921006499. Access: January 10, 2022.

MILLET, J. *et al*. Effects of Acute Heat and Cold Exposures at Rest or during Exercise on Subsequent Energy Intake: A Systematic Review and Meta-Analysis. **Nutrients**, Basel, v. 13, n. 10, p. 3424, 2021. Available from: https://www.mdpi.com/2072-6643/13/10/3424. Access: March 23, 2023.

MINIM, V. P. R. **Análise sensorial**: estudos com consumidores. Viçosa: Editora UFV, 2006.

NORTH ATLANTIC TREATY ORGANIZATION. Nutrition science and food standards for military operations (nutrition et normes d'alimentation pour les operations militaires). TR-HFM-154. North atlantic treaty organisation and research and technology organization. **NATO**, Paris, 2010. Available from: https://www.sto.nato.int/publications/Pages/default3.aspx. Access: April 10, 2021.

NORTH ATLANTIC TREATY ORGANIZATION. Standardization Office. NATO Standard AMedP-1.11. Requirements of Individual Operational Rations for military use. **NATO**, Paris, 2019. Available from: https://nso.nato.int/nso/nsdd/APdetails.html?APNo=2020&LA=EN. Access: January 2, 2021.

RESENDE, G. M.; MAGALHÃES, J. C. R. **Disparidades do produto interno bruto (PIB) per capita no Brasil**: uma análise de convergência em diferentes escalas regionais (1970-2008). Brasília, DF: Instituto de Pesquisa Econômica Aplicada, 2013.

SILVA, D. L. **Caracterização das rações operacionais das três forças armadas brasileiras**. 2015. Trabalho de Conclusão de Curso (Bacharelado em Nutrição) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2015. Available from: https://www.lume.ufrgs.br/bitstream/handle/10183/127114/000973613.pdf?sequence=1. Access: February 10, 2018.

SPENCE, C. Comfort food: A review. **International Journal of Gastronomy and Food Science**, Amsterdam, v. 9, p. 105-109, 2017. Available from: https://www.sciencedirect.com/science/article/pii/S1878450X16300786. Access: November 17, 2019.

STANLEY, R.; FORBES-EWAN, C.; MCLAUGHLIN, T. Foods for the military. **In**: MELTON, L.; SHAHIDI, F.; VARELIS, P. (ed.). **Encyclopedia of Food Chemistry**, Amsterdam: Elsevier, 2019, p. 188-195. v. 3.

STEWART, D. W.; SHAMDASANI, P. N. **Focus groups**: Theory and practice. London: Sage, 2014.

TASSONE, E. C.; BAKER, B. A. Body weight and body composition changes during military training and deployment involving the use of combat rations: A systematic literature review. **British Journal of Nutrition**, Bethesda, v. 117, n. 6, p. 897-910, 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/28452292/. Access: March 23, 2023.

THARION, J. *et al*. Adequacy of garrison feeding for special forces soldiers during training. **Military Medicine**, Bethesda, v. 169, n. 6, p. 483-490, 2004. Available from: https://pubmed.ncbi.nlm.nih.gov/15281681/. Access: March 23, 2023.

UNIVERSIDADE DE CAMPINAS. **Tabela Brasileira de Composição de Alimentos**. 4. ed. Campinas: Núcleo de Estudos e Pesquisas em Alimentação, 2011.

WRIGHT, J. **International Encyclopedia of the Social & Behavioral Sciences**. Oxford: Elsevier, 2015.

ZINN, C. *et al*. A 12-week low-carbohydrate, high-fat diet improves metabolic health outcomes over a control diet in a randomised controlled trial with overweight defence force personnel. **Applied Physiology, Nutrition, and Metabolism**, Bethesda, v. 42, n. 11, p. 1158-1164, 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/28700832/. Access: March 23, 2023.

ARTICLE DOI 10.52781/cmm.a104

Pulmonary function of combat pilots: What are the chronic effects of exposure?

Función pulmonar en pilotos de combate: ¿Cuáles son los efectos crónicos de la exposición?

Abstract: The effects related to work at high altitudes and acceleration force overload can generate physiological compensation mechanisms and eventual short-, medium- and long-term changes in lung function. Therefore, this study aimed to describe the chronic changes in lung function in combat pilots of the Brazilian Air Force. The sample consisted of 19 combat pilots and 20 controls. For pulmonary function measurements, we observed an increase in the mean values of Forced Vital Capacity (FVC) and Forced Expiratory Volume in the First Second ($FEV_{1)}$, a decrease in lung volume, an increase in resistance and work of breathing, in the exposed group compared to the control, with significant modifications to Residual Volume (RV) by Total Lung Capacity (TLC) in liters (L) and percentage (%). Similar behavior when evaluated according to flight hours, with an increase proportional to the increase in exposure time. Discrete changes, such as those observed in this research, may reflect adaptations of the respiratory system, bringing a complementary view to changes in chronic conditions.

Keywords: pilots; military; high altitude; acceleration force; lung function.

Resumen: Los efectos inherentes al trabajo en altitudes elevadas y sobrecarga de la fuerza de aceleración pueden generar mecanismos de compensación fisiológica y eventuales modificaciones de la función pulmonar a corto, mediano y largo plazo. Ante eso, el objetivo de este artículo fue describir las modificaciones crónicas de la función pulmonar en pilotos de combate de la Fuerza Aérea Brasileña (FAB). La muestra estuvo compuesta por 19 pilotos de combate del grupo expuesto y 20 voluntarios del grupo control. Para las medidas de función pulmonar se observó un aumento de los valores medios de Capacidad Vital Forzada (CVF) y Volumen Espiratorio Forzado en el Primer Segundo (VEF_1), disminución del volumen pulmonar, aumento de la resistencia y del trabajo respiratorio. En el grupo expuesto, en comparación con el grupo control, observamos cambios significativos para el Volumen Residual (RV) por Capacidad Pulmonar Total (TLC) en litros (L) y porcentaje (%), es decir, VR/CPT. Comportamientos similares cuando se evalúan según las horas de vuelo, con aumento proporcional a la elevación del tiempo de exposición. Las modificaciones sutiles, según las observadas en esta investigación, pueden ser reflejo de adaptaciones del sistema respiratorio, trayendo una mirada complementaria para los cambios en condiciones crónicas.

Palabras clave: piloto; militar; altitud elevada; fuerza de aceleración; función pulmonar.

Maritza Fabiana Sepulveda Soares
Força Aérea Brasileira. Universidade da Força Aérea Brasileira.
Rio de Janeiro, RJ, Brasil.
mfsepulveda@hotmail.com

Pedro Lopes de Melo
Universidade do Estado do Rio de Janeiro.Instituto de Biologia Roberto Alcantara Gomes.
Rio de Janeiro, RJ, Brasil.
plopes@uerj.br

Paula Morisco de Sá
Força Aérea Brasileira. Universidade da Força Aérea Brasileira.
Rio de Janeiro, RJ, Brasil.
paulamorisco@hotmail.com

Received: Aug 30, 2023
Approved: Mar 14,2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

The pilot is exposed to the adverse effects of working at high altitudes during air activity. Extreme vibrations, dysbarism, hypoxia, the action of acceleration loads (G-Force), and other environmental stressors are frequent, especially in flights above 15,000 feet (GÜL; SALMANOĞLU, 2012). This air segment requires supplemental oxygen, the cabin environment can present controlled pressurization, and the effects of working at altitude may seem more evident (ALVES *et al.*, 2008; GÜL; SALMANOĞLU, 2012; PETRASSI *et al.*, 2012).

The literature describes that reducing air pressure with increasing altitude leads to hypoxia, also known as hypobaric hypoxia (ALVES *et al.*, 2008). Lowering the alveolar partial pressure of oxygen lowers arterial blood pressure. Thus, in an acute ventilatory response, the body works to recover homeostasis of oxygen concentration, causing hypocapnia and respiratory alkalosis (PETRASSI *et al.*, 2012). This compensation causes respiratory muscle fatigue (BUSTAMANTE-SÁNCHEZ; DELGADO-TERÁN; CLEMENTE-SUÁREZ, 2019; POLLARD *et al.*, 1997), with possible psychomotor impairment in acute hypobaric patients, which may affect the postural control of the crew. Therefore, it increases proportional postural sway as altitude increases (NORDAHL *et al.*, 1998).

In addition, acceleration force tolerance in the aerospace context is considered a particular factor and may have physiological effects related to the respiratory system, vision (commonly called blackout – complete loss of vision), and the level of consciousness (with loss of consciousness, known as Induced Loss of Consciousness – G-LOC) (RUSSOMANO; CASTRO, 2012).

In addition to these, with the G-Force overload acting on the thorax, the airways in the lower third of the lung may collapse, evolving up to 50% of the lung as the acceleration force progresses, generating consequent changes in the distribution of lung blood flow (WEST, 2013). Pulmonary capillaries must be thin and exposed directly to the alveolar space for efficient gas exchange. Thus, changes in ambient pressure are transmitted to the alveolar capillaries, impacting pulmonary circulation both by lung deformation and by changes in the distribution of hydrostatic pressure in the lung (PRISK, 2011).

Additionally, individual biopsychological factors can be decisive when engaging in aerial combat. Aviation troops must be able to deal with these conditions, whether in routine situations or a high workload (GINDHART, 1999; GÜL; SALMANOĞLU, 2012; SAUVET *et al.*, 2009). The acclimatized subject may experience less deleterious effects on the body, which makes it possible to carry out daily work even at very high altitudes (4400 to 5500 meters), with efficiency close to that of the subject working at sea level. However, the possibility of developing diseases or adaptations due to continuous exposure should be considered (ARISTIZABAL *et al.*, 2019; DUISHOBAEV *et al.*, 2018).

External offsets can be used in high-performance military aviation to reduce the deleterious effects of exposure during flight. In addition to personalized training and acclimatization, oxygen supplementation between 70 and 100% can occur to solve the effects of hypoxia, which can occur from 15,000 feet of altitude or 4,572 meters (BUSTAMANTE-SÁNCHEZ;

DELGADO-TERÁN; CLEMENTE-SUÁREZ, 2019). Mechanical assistance measures are used to maintain adequate venous return. Anti-G suits, positive breathing pressure, and anti-G effort maneuvers, such as the Anti-G Strain Maneuver (AGSM), are seen as fundamental means to tolerate acceleration (ÖZTÜRK; İLBASMIŞ; AKIN, 2012).

Some instruments are commercially available to estimate pulmonary function assessment indices, among which spirometry and plethysmography are the most established (MUNGOGE *et al.*, 2016; SOCIEDADE BRASILEIRA DE PNEUMOLOGIA E TISIOLOGIA, 2009; TRINDADE; SOUSA; ALBUQUERQUE, 2015). In addition, the Forced Oscillation Technique (FOT), described by DuBois *et al.* in 1956, stands out for being complementary to traditional instruments and has the advantage of being a method performed in spontaneous ventilation (OOSTVEEN *et al.*, 2003).

A more detailed analysis of lung function under exposure conditions described above may contribute to better coping and improvement of human performance and the man-machine relationship in the Brazilian armed forces, providing parameters for diagnostic evaluation and longitudinal follow-up of these subjects.

Thus, this article aimed to (1) compare changes in lung function between volunteers in the control group and fighter pilots of the Brazilian Air Force (FAB); (2) analyze the effects of the flight exposure period on the lung function of combat pilots; (3) analyze the effects of work at high altitudes considering the particularities of exposure with low and high exposure to the G-load.

2 MATERIAL AND METHODS

The proposed protocol was carried out at the Biomedical Instrumentation Laboratory of the State University of Rio de Janeiro (UERJ), based on applying a sociodemographic questionnaire and pulmonary function tests performed by duly trained technicians. The sequence in which the tests were carried out was FOT in the multifrequency version, spirometry, and full-body plethysmography.

The sample was selected for convenience. The group of exposed subjects enrolled volunteer fighter pilots from the First Group of Fighter Aviation (1st GavCa) and pilots from Transport Squadrons from Santa Cruz Air Force Base and Galeão Air Force Base. All could fly according to the criteria proposed by the current military legislation – ICA 160-6/2016 (BRASIL, 2016) and identified for this research according to the abbreviations: GFighter and GTransport, respectively. For the control group, the subjects were: non-flying personnel, military or not, non-sedentary, and similar to the exposed group in age, weight, and height. The exclusion criteria for all groups were respiratory infections in the last 30 days, chest diseases, and smoking.

Lung flow and volume were measured using the BPd full-body plethysmograph (nSpire Health, Inc., 1830 Lefthand Circle, Longmont, CO 80501). The tests followed the guidelines for pulmonary function tests (GRAHAM, 2019; NEDER *et al.*, 1999; PEREIRA; MOREIRA, 2002; SOCIEDADE BRASILEIRA DE PNEUMOLOGIA E TISIOLOGIA, 2009). The FOT was previously described in detail (MELO; WERNECK;

GIANNELLA-NETO, 2000) and follows international standards (NAVAJAS e FARRÉ, 2001; OOSTVEEN *et al.*, 2003; SÁ *et al.*, 2013).

Results were presented using mean and standard deviation. Commercial software was employed to compare group differences (STATISTICA for Windows, release 5.0). The analysis between the two groups used the independent t-test for samples with normal distribution and Mann-Whitney for non-parametric samples. The comparisons between the three groups used the Analysis of Variance (ANOVA), followed by Tukey's test when the distribution presented a parametric characteristic, and Kruskal Wallis ANOVA, followed by Mann Whitney when non-parametric. Results with $p < 0.05$ were considered statistically significant. Finally, Pearson and/or Spearman correlation coefficients determined correlation analyses.

3 RESULTS

The study involved 37 volunteers, 18 from GControl and 19 from GPilots (6 from GTransport; 13 from GFighter). The analysis based on the biometric parameters showed a homogeneous distribution (Table 1).

Table 1 – Anthropometric data of the analyzed volunteers – GControl × GTransport × GFighter

Parameters	GControl N = 18	GTransport N = 6	GFighter N = 13	p
Age (years)	33.27 ± 5.63	30.16 ± 2.31	31.46 ± 1.98	ns*
Weight (kg)	80.22 ± 8. 62	82.61 ± 6.19	82.6 ± 8.32	ns*
Height (cm)	175.16 ± 5.28	178.16 ± 7.67	177.25 ± 5.71	ns*
BMI (kg/m^2)	26.06 ± 2.13	26.60 ± 1.95	26.01 ± 2.14	ns*

Note: Results presented as mean ± standard deviation. *Anova/Tukey test, **Kruskal Wallis Anova/and Mann Whitney. $P < 0.05$. Ns = not significant.

Source: Prepared by the authors, Soares *et al.* (2022).

In the evaluation of pulmonary function based on spirometry, in the comparison between the GControl, GTransport, and GFighter, we observed slightly higher mean values in the Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV_1), and Forced Expiratory Flow ($FEF_{25-75\%}$) in the groups of fighter pilots compared with the other groups, although without significant changes (Table 2).

Table 3 presents the pulmonary function results from the plethysmographic parameters, in which Residual Volume (RV), Total Lung Capacity (TLC), and RV/TLC showed lower mean values in the group of fighter pilots compared with the other groups. Significant RV and RV/TLC modifications were observed in the analysis between the control and fighter groups. Resistance, whether measured using plethysmography or FOT (Table 4), showed progressively higher mean values, with a proportional drop in conductance.

In addition, we also saw an increase in ventilatory workload measured through Z4Hz, although without statistically significant changes.

Table 2 – Spirometric measurements of the studied groups – GControl × GTransport × GFighter

Parameters	GControl	GTransport	GFighter	p
FVC L	4.97 ± 0.22	5.11 ± 0.34	5.47 ± 0.61	ns*
FVC %	98.39 ± 7.24	96.46 ± 7.35	102.52 ± 7.44	ns*
FEV_1 L	3.97 ± 0.49	4.36 ± 0.47	4.32 ± 0.55	ns*
FEV_1 %	95.59 ± 10.70	98.76 ± 8.10	97.91 ± 9.55	ns*
FEV_1/FVC L	80.8 ± 5.87	85.48 ± 8.72	79.11 ± 5.39	ns*
FEV_1/FVC%	96.95 ± 7.37	102.46 ± 10. 70	95.23 ± 6.70	ns*
FEF_{25-75} % L	4.02 ± 1.20	4.69 ± 25. 47	4.1 ± 0.97	ns*
FEF_{25-75} %	86.84 ± 23.99	95.07 ± 25. 47	85.96 ± 20.25	ns*
FEF_{25-75}/FVC L	0.82 ± 0.24	0.92 ± 0.27	0.75 ± 0.17	ns*
FEF_{25-75}/FVC %	88.27 ± 23.58	99.85 ± 31. 30	84.17 ± 20.94	ns *

Subtitle: FVC – Forced Vital Capacity; FEV_1 – Forced Expiratory Volume in One Second; FEF – Forced Expiratory Flow. Results presented as mean ± standard deviation.
*Anova/Tukey test, **Kruskal Wallis Anova/and Mann Whitney. P < 0.05. Ns = not significant.
Source: Prepared by the authors, Soares *et al*. (2022).

Table 3 – Plethysmography measurements of the studied groups – GControl × GTransport × GFighter

Parameters	GControl (0)	GTransport (1)	GFighter (2)	p
RV L	2.63 ± 0.98	1.91 ± 1.05	1.79 ± 0.82	ns*
RV %	147.3 ± 53.36	105.46 ± 61. 81	100.16 ± 46. 101	0-2 *
TLC L	7.49 ± 1.29	6.65 ± 0.88	7.23 ± 0.99	ns*
TLC %	110.25 ± 15.79	93.46 ± 13. 65	100.71 ± 12. 55	ns**
RV/TLC L	33.96 ± 9.28	27.57 ± 11. 42	24.2 ± 9.05	0-2*
RV/TLC %	130.2 ± 37.08	108.56 ± 46. 75	93.96 ± 35. 64	0-2*
Raw L	2.54 ± 1.25	2.61 ± 1.93	3.08 ± 1.27	ns*
Raw %	186.7 ± 94.28	190.4 ± 132. 30	229.63 ± 93. 70	ns*
Sgaw L	0.15 ± 0.08	0.14 ± 0.05	0.1 ± 0.03	ns**
Sgaw %	68.33 ± 39.30	64.05 ± 26. 98	46.89 ± 14. 81	ns**

Subtitle: RV – Residual Volume; TLC – Total Lung Capacity; Raw, Resistance of the respiratory system; Sgaw, Conductance of the respiratory system. Results presented as mean ± standard deviation.
*Anova/Tukey test. **Kruskal Wallis Anova/and Mann Whitney. P < 0.05. Ns = not significant.
Source: Prepared by the authors, Soares *et al*. (2022).

Table 4 – FOT measurements of the studied groups – GControl × GTransport × GFighter

Parameters	GControl (0)	GTransport (1)	GFighter (2)	p
fr	12.80 ± 3. 62	10.69 ± 2.91	11.13 ± 3.43	ns **
Xm	0.38 ± 0.33	0.53 ± 0.31	0.54 ± 0.36	ns *
R0	2.86 ± 0.74	2.33 ± 0.75	3.08 ± 0.82	ns *
S	2.83 ± 16.73	3.23 ± 18.41	10.44 ± 16. 59	ns **
Rm	2.89 ± 0.77	2.37 ± 0.64	3.18 ± 0.81	ns*
Cdyn	0.02 ± 0.00549	0.025 ± 0.009	0.02 ± 0.005	ns*
Z4Hz	3.57 ± 0.99	2.93 ± 1.10	3.72 ± 0.98	ns*

Subtitle: fr, Resonance Frequency; Xm, Mean Reactance; R0, Total Respiratory System Resistance; S, Slope Coefficient of the Resistance Curve; Rm, Mean Resistance; Cdyn, Dynamic Compliance of the Respiratory System; Z4Hz, Impedance Module of the Respiratory System. Results presented as mean ± standard deviation. *Anova/Tukey test, **Kruskal Wallis Anova/and Mann Whitney. P < 0.05. Ns = not significant.

Source: Prepared by the authors, Soares *et al*. (2022).

We analyzed the subjects based on subgroups of flight hours to clarify whether the changes found would be related to exposure to the G-load alone or to the time of exposure to altitude. For this characterization, the sample lost homogeneity for anthropometric parameters, with a significant change for age (Table 5). Furthermore, we identified a significant inverse correlation in comparing flight hours and the spirometric parameters FEV_1/FVC and $FEF_{25-75\%}$ in their absolute values (Table 6). For correlations between plethysmography and FOT parameters, there were no significant changes.

Table 5 – Anthropometric data from characterization by flight hours

Parameters	GControl	GPilots			P
	(N = 18) (0)	Up to 1000 h (N = 4) (1)	1000 to 1500 h (N = 10) (2)	> 1500 h (N = 5) (3)	
Age (years)	33.27 ± 5.63	28.75 ± 0.5	30.77 ± 1.56	33 ± 1.78	1-2, 1-3, 2-3**
Weight (kg)	80.22 ± 8. 62	80 ± 5.58	85.96 ± 7.10	79.31 ± 8.14	ns*
Height (cm)	175.16 ± 5.28	178 ± 9.20	178.36 ± 5.46	176 ± 5.93	ns*
BMI (kg/m^2)	26.06 ± 2.13	25.94 ± 2. 13	26.98 ± 1.40	25.2 ± 2.62	ns*

Note: Results presented as mean ± standard deviation. *Anova/Tukey test. **Kruskal Wallis Anova/and Mann Whitney. P < 0.05. Ns = not significant.

Source: Prepared by the authors, Soares *et al*. (2022).

In Tables 7, 8, and 9, we observe the behavior of lung function with the progression of time of exposure to air activity given the results of spirometric, plethysmographic, and FOT parameters, respectively.

Overall, we observed a slight increase in the average values of FVC in liters (L) and percentage (%) and FEV_1 (L and %) with increasing flight hours. We also noted increased mean values of FEV_1/FVC (L and %), $FEF_{25-75\%}$ (L and %), and FEF/FVC (L and %) when comparing the GControl and subjects with up to 1000 flight hours, with a subsequent decrease in the subjects with 1000 to 1500 and those with more than 1500 flight hours. However, values were within normal limits. The plethysmographic parameters RV, TLC, and RV/TLC (L and %) decreased when comparing GControl with GPilots, with increasing exposure in flight hours. The resistance progressively increased compared with the GControl, with a slight decrease in conductance observed only in the groups with more than 1000 flight hours. The increase in the work of breathing was seen when comparing GControl with Pilots, with increased mean values with increasing exposure in flight hours.

Table 6 – Correlation between flight hours and spirometric parameters

Horas de voo	FVC L	FEV_1	FEV/FVC	$FEF_{25-75\%}$	FEF/ FVC
R	.042	-.318	-.498	-.468	-.476
p	.865*	.184*	.030*	.044*	.039*

Note: Results presented in correlation. P < 0.05 was considered significant.

* Pearson correlation, **Sperman correlation.

Source: Prepared by the authors, Soares *et al*. (2022).

Table 7 – Spirometric results with the characterization by flight hours

Parameters	G Control		GPilots		P
	(N = 18) (0)	Up to 1000 h (N = 4) (1)	1000 to 1500 h (N = 10) (2)	> 1500 h (N = 5) (3)	
FVC L	**4.97 ± 0.22**	5.08 ± 0.21	5.46 ± 0.62	5.37 ± 0.62	ns*
FVC %	98.39 ± 7.24	95.95 ± 8.58	102.08 ± 8.25	101.4 ± 5.91	ns*
FEV_1 L	3.97 ± 0.49	4.53 ± 0.47	4.32 ± 0.57	4.21 ± 0.49	ns*
FEV_1 %	95.59 ± 10.70	102.07 ± 7.85	97.47 ± 9.93	96.5 ± 8.28	ns*
FEV_1/FVC L	80.8 ± 5.87	89.20 ± 8.17	79.12 ± 5.22	78.67 ± 5.45	ns*
FEV_1/FVC %	96.95 ± 7.37	106.45 ± 11.17	95.25 ± 6.63	94.9 ± 6.17	ns*
FEF_{25-75} % L	4.02 ± 1.20	5.275 ± 1.34	4.095 ± 0.97	3.89 ± 0.92	ns*
FEF_{25-75} %	86.84 ± 23.99	104.25 ± 27.24	84.78 ± 19.99	84.64 ± 19.21	ns*
FEF_{25-75}/FVC L	0.82 ± 0.24	1.03 ± 0.25	0.75 ± 0.16	0.73 ± 0.18	ns*
FEF_{25-75}/FVC %	88.27 ± 23.58	110.32 ± 34.26	83.36 ± 20.78	83.7 ± 19.29	ns*

Subtitle: FVC, Forced Vital Capacity; FEV_1, Forced Expiratory Volume in One Second; FEF, Forced Expiratory Flow. Results presented as mean ± standard deviation. *Anova/Tukey test, **Kruskal Wallis Anova/and Mann Whitney. P < 0.05. Ns = not significant.

Source: Prepared by the authors, Soares *et al*. (2022).

Table 8 – Plethysmographic results with the characterization by flight hours

Parameters	G Control		GPilots		P
	(N = 18) (0)	Up to 1000 h (N = 4) (1)	1000 to 1500 h (N = 10) (2)	> 1500 h (N = 5) (3)	
RV L	2.63 ± 0.98	2.23 ± 1.19	1.76 ± 0.67	1.6 ± 1.07	ns*
RV %	147.39 ± 53.36	124.77 ± 69. 20	97.94 ± 33.82	91.3 ± 65.66	ns*
TLC L	7.49 ± 1.29	6.85 ± 1. 06	7.2 ± 0.98	6.91 ± 1.07	ns*
TLC %	110.25 ± 15.79	96.75 ± 16.31	99.71 ± 10.17	97.2 ± 17.84	ns**
RV/TLC L	33.96 ± 9.28	31.26 ± 12. 54	24.22 ± 7.13	22.57 ± 11.84	0-2, 0-3**
RV/TLC %	130.22 ± 37.08	124.47 ± 50. 38	93.88 ± 28.04	87.24 ± 46.95	0-2, 0-3**
Raw L	2.54 ± 1.25	2.60 ± 2. 32	3.01 ± 1.31	3.06 ± 1.32	ns*
Raw %	186.78 ± 94.28	183.65 ± 151. 24	223.92 ± 93.06	230.76 ± 108.12	ns*
Sgaw L	0.15 ± 0.08	0.15 ± 0.06	0.10 ± 0.03	0.10 ± 0.03	ns**
Sgaw %	68.33 ± 39.30	70.12 ± 31.34	46.86 ± 14.38	48.96 ± 16.08	ns**

Subtitle: RV, Residual Volume; TLC, Total Lung Capacity; Raw, Resistance of the respiratory system; Sgaw, Conductance of the respiratory system. Results presented as mean ± standard deviation. *Anova/Tukey test. **Kruskal Wallis Anova/and Mann Whitney. P < 0.05. Ns = not significant.

Source: Prepared by the authors, Soares *et al*. (2022).

Table 9 – FOT results with the characterization by flight hours

Parameters	G Control (0)	Up to 1000 h (1)	1000 to 1500 h (2)	> 1500 h (3)	P
fr	12.80 ± 3. 62	10.32 ± 2.48	11.45 ± 3. 96	10.74 ± 2.70	ns**
Xm	0.38 ± 0.33	0.56 ± 0.24	0.45 ± 0.36	0.65 ± 0.37	ns*
R0	2.86 ± 0.74	2.18 ± 0.92	2.98 ± 0. 76	2.96 ± 0.68	ns*
S	2.83 ± 16.73	0.97 ± 22. 70	11.57 ± 17.57	7.84 ± 13.29	ns**
Rm	2.89 ± 0.77	2.19 ± 0.75	3.09 ± 0.75	3.05 ± 0.61	ns*
Cdyn	0.02 ± 0.00549	0.029 ± 0.009	0.02 ± 0.003	0.01 ± 0007	ns*
Z4Hz	3.57 ± 0.99	2.75 ± 1. 12	3.62 ± 0.87	3.73 ± 1.23	ns*

Subtitle: fr, Resonance Frequency; Xm, Mean Reactance; R0, Total Respiratory System Resistance; S, Slope Coefficient of the Resistance Curve; Rm, Mean Resistance; Cdyn, Dynamic Compliance of the Respiratory System; Z4Hz, Impedance Module of the Respiratory System. Results presented as mean ± standard deviation. *Anova/Tukey test, **Kruskal Wallis Anova/and Mann Whitney. P < 0.05. Ns = not significant.

Source: Prepared by the authors, Soares *et al*. (2022).

4 DISCUSSION

We will begin the discussion by considering the first and second objectives of this article, in which we seek to compare changes in lung function between GControl and GPilots volunteers and analyze exposure to flying in its different spheres, i.e., the transport pilot with low exposure to G-load, and the fighter pilot with high exposure.

Initially, we believed that exposure of the respiratory system to all the undesirable effects of aviation could trigger some process of lung damage. However, this was not identified in this study.

Despite the non-significant results, we must consider that all the subjects analyzed are healthy and practitioners of regular activity, with physical fitness for flying regulated by ICA 54-1 (BRASIL, 2011) and inherent to military readiness. With these characteristics, our results showed parameters with a predicted cutoff point for pulmonary function behavior within normal limits, as described in the literature (GRAHAM, 2002; NEDER *et al.*, 1999; SOCIEDADE BRASILEIRA DE PNEUMOLOGIA E TISIOLOGIA, 2009).

In the sample studied, the specificity of physical training was not monitored. Aptitude for work was based on previously established norms for military service (BRASIL, 2011). However, Bateman *et al.* (2006) report in a review article that the effects of muscle strength training, aerobic fitness, and resistance to fatigue on G-force tolerance are still a complex subject to be discussed and without evident results. Previous analyses describe that neither aerobic training can be considered always harmful nor strength training can be regarded as universally effective in improving tolerance to the G force (BULBULIAN, 1986). For the respiratory system, there is an improvement in lung capacity and oxygen consumption rates by increasing the pulmonary vascular network with the practice of regular physical activity (MCKENZIE, 2012).

Subtle modifications such as those observed in this research, with a slight progressive increase in lung function in the comparison between GControl, GTransport, and GFighter, expressed with the help of spirometric parameters, may be a reflection of adaptations of the respiratory system to exposure in small doses and over many years of work and therefore must be considered. The reduction in RV for the same comparisons may be associated with an increase in FVC, optimizing the air volume available for ventilatory exchanges. Despite this, the mean values of TLC also decreased, countering this analogy.

Contradicting our results, other authors analyzed pulmonary function in athletes of different sports. They observed more significant static pulmonary volumes and greater pulmonary diffusion capacity in elite swimmers compared to runner athletes. These authors credited their findings to possible age differences between the combined controls in addition to genetic characteristics, suggesting further studies for clarification (CORDAIN; STAGER, 1988).

Aerial activity and swimming practice can be similar, especially regarding the combination of labor gestures, as the swimmer combines periods of immersion in water, exercises, and apnea, with evidence of subtle changes in the permeability of the lungs (DROBNIC *et al.*, 2018). For such high-performance swimming athletes, physical training at high altitudes is often used to increase physiological adaptations and, consequently,

improve activity performance (LUNDBY; ROBACH, 2016; RODRIGUEZ *et al.*, 2015). These reflections, ultimately, shed light on the understanding that exposure to high altitudes can act as a modifying factor in lung performance even in the presence of adequate physical conditioning, that is, analyses aligned with the results presented in our study since GControl and GPilots differ only in the criterion of exposure to the flight, with physical fitness being common to both.

There are no reports in the literature about late adaptations of the respiratory system in exposure to high altitudes and G-force overload in combat pilots. In high-performance athletes, previously documented adaptations consider the pulmonary response to exercise much greater than the cardiovascular or peripheral muscular system (WARBURTON, SHEEL; MCKENZIE, 2008). Under conditions of acclimatization to work at high altitudes and G overload, the result may be similar.

In studies with elite athletes, minute ventilation can increase about 20 times compared with resting values, showing that the lung can handle heavy work demands (WARBURTON; SHEEL; MCKENZIE, 2008), despite suffering the consequences relating to such action.

However, in the air work environment, connotations of glory do not coexist, and the literature shows that flying in high G-load environments imposes strong cardiometabolic wear on the body (TESCH, HJORT; BALLDIN, 1983).

Bustamante-Sánchez; Delgado-Terán; Clemente-Suárez (2019) conducted a study with 23 male airmen in a hypobaric chamber, including pre- and post-exposure measurements. The sample comprised seven transport aviation crew members, three transport pilots, ten helicopter pilots, and three F-18 fighter pilots from the Spanish Air Force. The authors report that exposure to hypoxia increased the perception of stress and exertion and decreased respiratory muscle function regardless of the crew group. Transport pilots were more negatively affected than helicopter pilots and transport aircrew (BUSTAMANTE-SÁNCHEZ; DELGADO-TERÁN; CLEMENTE-SUÁREZ, 2019). Since the fighter pilot is led to experience moments of low oxygen, such as routine aerial activity, possibly, acclimatization conditions are established, which causes a better physiological response when the pilot is exposed to it again.

In that same study by Bustamante-Sánchez; Delgado-Terán; Clemente-Suárez (2018), FEV_1 and PEF were reduced in the studied population, with this drop being significant in PEF for helicopter pilots and in PEF and FEV_1, for transport crew members, suggesting that these may be associated with symptoms of muscle fatigue respiratory effects after hypoxic exposure (BUSTAMANTE-SÁNCHEZ; DELGADO-TERÁN; CLEMENTE-SUÁREZ, 2019; POLLARD *et al.*, 1997). Comparing the groups, the transport pilots had significantly lower FEV_1 values in the post-tests. FVC increased, and FEV_1 and PEF decreased for the group of fighter pilots, but with no significant changes for the pre- and post-test. The authors associate the result with the different profiles of physical training and technical preparation of these populations (BUSTAMANTE-SÁNCHEZ; DELGADO-TERÁN; CLEMENTE-SUÁREZ, 2019).

Aligned with these authors, Beer *et al.* (2017) observed a significant reduction in mean values of flows and lung capacities measured with the help of spirometry in ten US Air Force fighter pilots under conditions of confinement and high loads of oxygen supplementation. Measurements were made in the pre-flight and post-test 12 hours after the end of the flight.

Hormeño-Holgado; Clemente-Suárez (2019) evaluated 29 Spanish Air Force pilots' psychophysiological responses under combat and air defense exercise conditions lasting approximately 30 minutes each. Combat maneuvers were performed at altitudes between 8,000 and 18,000 feet (with oxygen supplementation) and with G-force between 0.5 and 5.9. Spirometry measurements were taken two hours before and 30 minutes after the flights. The results presented by the authors showed a slight reduction in FVC and an increase in FEV_1 and PEF, without significant changes, in the attack exercise condition. A similar result was seen for the defense exercise but with a significant modification for the FVC (HORMEÑO-HOLGADO; CLEMENTE-SUÁREZ, 2019).

The reduction in lung flows and volumes in acute situations such as those narrated by the studies mentioned above, under conditions of immediate post-flight assessment, conditions of fatigue of the respiratory muscles are plausible. Öztürk; Ilbasmiş; Akin (2012) describe that evidence of respiratory muscle fatigue may be associated with vigorous muscle maneuvers performed throughout the flight to provide mechanical assistance to minimize the effect of thoracic distortion and maintain adequate venous return (ÖZTÜRK; İLBASMIŞ; AKIN, 2012). However, in chronic situations, such as those evaluated in this research, long-term low-dose exposure seems to trigger an increase in respiratory performance.

The strength and resistance of the respiratory muscles improve with training, similar to what happens to the peripheral skeletal muscle. However, cellular changes in humans (WARBURTON; SHEEL; MCKENZIE, 2008) – or even the impact of this response on the pulmonary function of combat pilots – are not yet documented.

It is admissible that continuous exposure to thoracic deformations, pulmonary vascular alterations, airway closures, and other repercussions peculiar to the combat aviation environment lead to the reproduction of tissue, airway, and lung parenchyma adaptations. These facts were observed in this research through the increase in the mean values of respiratory system resistance measured with plethysmography and FOT, either for comparison between GControl and GPilots, or for the progressive mean increase in the Control, Transport, and Fighter groups, proportionally to the decrease in conductance, providing a measure of lung gas transfer.

Additionally, the Xm measured using FOT reflects changes in lung homogeneity based on the elastic characteristics of the system (MELO; WERNECK; GIANNELLA-NETO, 2000; OOSTVEEN *et al.*, 2003). More positive mean values were observed in this research, in the analysis between the Control and Pilots groups, and comparing GControl, GTransport, and GFighter. Despite the increase in resistance and decrease in conductance, a possible improvement in lung elasticity may be associated with long-term muscle gain, with better pressure variation and, thus, better ventilatory use.

While the effects described in previous studies with combat pilots have been observed in acute conditions and with fewer subjects, it is possible to infer that the singularity of each aviation profile can create different patterns of physiological responses.

In addition, our study highlights the late changes in exposure to the deleterious effects of aviation, bringing a complementary look to the behavior of the respiratory system in chronic conditions. Considering that it is part of the fighter's routine to use anti-G protection maneuvers and against the effects of G-LOC throughout the occupational flight journey (ÖZTÜRK; İLBASMIŞ; AKIN, 2012), it would be relevant to associate the improvement of lung function observed by our study in GFighter compared with the other groups to this specificity.

Healthy individuals living in these high-altitude regions have slightly better lung function than subjects residing at lower altitudes or sea levels (ARISTIZABAL *et al.*, 2019; DUISHOBAEV *et al.*, 2018).

Seeking to clarify whether the changes found would be related to the time of exposure to altitude or exposure to the G-load alone, we analyzed the subjects considering subgroups of flight hours, our third objective.

The change in sample homogeneity based on anthropometric parameters, with a significant difference in the age of the subgroups analyzed, was expected since subjects who recently joined the FAB have yet to have the opportunity to experience more significant moments of exposure to flying. However, the group with the longest flight time has an average age equivalent to that of the control group.

The inverse correlation between flight hours and FEV_1/FVC and $FEF_{25-75\%}$ parameters may clarify the possible occurrence of small airway dysfunction with increased exposure to flight. These results may reflect areas of entrapment and limitation of expiratory flow (AZEVEDO; SANTOS, 2018), which may be associated with changes in the pulmonary vascular network. Results are in line with the behavior of higher mean values of resistance and decreased conductance of the respiratory system, also observed in this article. However, parameters such as RV/TLC (L and %) showed reduced values, contradicting these findings (AZEVEDO; SANTOS, 2018). Thus, it is plausible that we are facing initial changes and that not all dysfunction markers are altered.

For this sample, exposure to work at high altitudes, based on the characterization of accumulated flight hours, seems to bring more harmful effects to the respiratory system in the analyzed combat pilots. Such occurrence is independent of the presence of G overload.

The literature lacks articles describing changes in lung function in populations similar to the one analyzed in this study. There are previous reports of populations residing in high-altitude environments, considering the temporary effects or long-term acclimatization (TALAMINOS-BARROSO *et al.*, 2020). The adaptation matches changes in respiratory control mechanisms (WEITZ; GARRUTO; CHIN, 2016), genetic adaptations that are transferred through generations, such as the development of larger lung volumes; changes in arterio-alveolar oxygen gradients; and increased uterine artery blood flow during pregnancy, thus suggesting a better efficiency in oxygen transport and consumption (TALAMINOS-BARROSO *et al.*, 2020). The increase in RV is also reported and justified by the improvement in the alveolar area and a moderate increase in the number of red blood

cells (FRISANCHO, 2013). However, in this study, we observed a reduction in the mean RV values with the progression of exposure to flying.

While the changes in the respiratory system of subjects living in high-altitude regions aim to improve the efficiency of oxygen consumption and transport, these seem to follow different adaptation pathways among people (EICHSTAEDT *et al.*, 2014; LORENZO *et al.*, 2014).

Therefore, it is possible to infer that there is a sum of actions that influence the adaptations of the respiratory system of combat pilots in the face of the aerial activities that they carry out, from certain factors, such as exposure to high altitudes to the demands related to an overload of G-Force.

Indeed, more studies are needed to clarify the chronic changes in lung function in the population of combat pilots and if these changes remain after the exposure ends.

5 STUDY LIMITATIONS

During the data collection period, the volunteers who applied for this study were relocated to other bases in Brazil, given the renovation of the airstrip at Santa Cruz Air Base in Rio de Janeiro, where most of the pilots in this sample were. Subsequently, in resuming the collection flow, the lockdown began due to the COVID-19 pandemic, remaining for almost two years. These facts hindered data collection with these individuals, reducing the number of subjects per group.

Furthermore, it is necessary to point out the complexity of the scheduling and collection scale for this group of professionals since they belong to an elite group of aviators among the other FAB military personnel and, therefore, have an overloaded agenda of commitments and missions inherent to such a function.

While the possible characterization of the practice of physical activity carried out as a routine by each subject in the sample could provide further clarification about the results, it was not the object of study of this research.

Future studies should consider these issues and the possibility of reassessing these groups in situations at the beginning, middle, and end of a military career, such as for combat pilots, with the possibility of bringing up additional information for analysis.

6 CONCLUSION

We observed a slight increase in lung function in transport and fighter pilots compared with the control group. For this analysis, no changes indicative of abnormalities or obstructive and restrictive disorders were observed.

Concerning the period of exposure in flight, we noticed a slight increase in lung function as exposure progressed, with possible initial damage to the small airways. However, the parameters continued within normal limits.

Exposure to work at high altitudes over the long term seems to have more harmful effects on the respiratory system than the presence of G overload.

This study highlights the need to better understand chronic lung changes in combat pilots since there are no reports in the literature on such aspects. Indeed, better elucidation of gaps in the respective knowledge may provide strategies for improving human performance and the man-machine relationship.

As a future perspective, we present the research proposal on exposure to flying, analyzing the aviator from school to the most advanced levels of training. This strategy could provide relevant data for understanding long-term lung behavior and complement the results described in this research.

ACKNOWLEDGMENTS

We appreciate the support of the volunteer pilots and their commanders, who spared no effort for the proper development of this research.

AUTHORSHIP AND COLLABORATIONS

All authors participated equally in elaborating the article.

REFERENCES

ALVES, L. F. A. *et al*. Avaliação dos efeitos da altitude sobre a visão. **Revista Brasileira de Oftalmologia**, Rio de Janeiro, v. 67, n. 5, p. 250–254, 2008. Available from: https://www.scielo.br/j/rbof/a/HdF64FQdndd3WSBH9SBkmGn/?lang=pt&format=pdf. Access: March 22, 2023.

ARISTIZABAL-DUQUE, R. *et al*. Reference values for spirometric parameters in healthy children living in a Colombian city located at 2640 m altitude. **Pediatric Pulmonology**, Bethesda, v. 54, n. 6, p. 886–893, 2019. Available from: https://pubmed.ncbi.nlm.nih.gov/30957980/. Access on: March 22, 2023.

AZEVEDO, K. R. S.; SANTOS, M. I. V. Medidas dos volumes pulmonares e estratégias de interpretação. **Pulmão RJ**, Rio de Janeiro, v. 27, n. 1, p. 33-38, 2018. Available from: http://www.sopterj.com.br/wp-content/themes/_sopterj_redesign_2017/_revista/2018/n_01/6-medidas-dos-volumes-pulmonares-e-estrategias-de-interpretacao.pdf. Access: March 22, 2023.

BATEMAN, A.W.; JACOBS, I.; BUICK, F. Physical conditioning to enhance +Gz force tolerance: issues and current understanding. **Aviat Space Environ Med**, v. 77, n. 6, p. 573-580, Jun 2006. Available from: https://pubmed.ncbi.nlm.nih.gov/16780233. Access: April 04, 2023.

BEER, J. *et al*. Pulmonary Effects from a Simulated Long-Duration Mission in a Confined Cockpit. **Aerospace Medicine and Human Performance**, Bethesda, v. 88, n. 10, p. 952–957, 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/28923145/. Access: March 22, 2023.

BRASIL. Ministério da Defesa. Aeronáutica. **Portaria DEPENS nº 29/DE-6, de 19 de janeiro de 2011**. Aprova a reedição da Instrução do Comando da Aeronáutica "Teste de Avaliação do Condicionamento Físico no Comando da Aeronáutica (ICA 54-1)". Brasília, DF: Ministério da Defesa, 2011. Available from: https://www2.fab.mil.br/ccise/images/ICA_54-1_TACF.pdf. Access: March 22, 2023.

BRASIL. Ministério da Defesa. Aeronáutica. **Portaria DIRSA Nº 8/SECSDTEC, de 27 de janeiro de 2016**. Aprova a Reedição da Instrução que trata das Inspeções de Saúde na Aeronáutica. Brasília, DF: Ministério da Defesa, 2016. Available from: https://www.fab.mil.br/icas/ICA_160-6_REED_NOV_2016.pdf. Access: March 22, 2023.

BULBULIAN, R. Physical training and +Gz tolerance reevaluated. **Aviat Space Environ Med**, v. 57, n. 7, p. 709-711, Jul, 1986. Available from: https://pubmed.ncbi.nlm.nih.gov/3741295. Access: April 04, 2023

BUSTAMANTE-SÁNCHEZ, A.; DELGADO-TERÁN, M.; CLEMENTE-SUÁREZ, V. J. Psychophysiological response of different aircrew in normobaric hypoxia training. **Ergonomics**,

London, v. 62, n. 2, p. 277–285, 2019. Available from: https://www.tandfonline.com/doi/full/10.1080/00140139.2018.1510541. Access: March 22, 2023.

CORDAIN, L.; STAGER, J. Pulmonary structure and function in swimmers. **Sports Med**, 6, n. 5, p. 271-278, 1988. Available from: https://pubmed.ncbi.nlm.nih.gov/3064235. Access: April 04, 2023.

DROBNIC, F.; GARCÍA-ALDAY, I.; BANQUELLS, M.; BELLVER, M. Interstitial Pulmonary Edema and Acetazolamide in High-Performance Sport: A Case Report. **Arch. Bronconeumol**, v.54, n.11, p. 584-585, Nov, 2018. Available from: https://pubmed.ncbi.nlm.nih.gov/29602623. Access: April 04, 2023.

DUBOIS, A.B.; BRODY, A.W.; LEWIS. D.H., BURGESS Jr, B. F. Oscillation mechanics of lungs and chest in mam. **J Apply Physiol**.; v. 8, n. 6, p. 587–94, 1956. Available from: https://pubmed.ncbi.nlm.nih.gov/13331841/ Access: April 04, 2023.

DUISHOBAEV, M. *et al.* FEV1 and FVC changes at high altitude residents in Kyrgyzstan. **European Respiratory Journal**, Sheffield, v. 52, n. 62, p. 1404, 2018. Available from: https://www.ers-education.org/lr/show-details/?idP=209579. Access: March 22, 2023.

EICHSTAEDT, C. A. *et al.* The Andean adaptive toolkit to counteract high altitude maladaptation: Genome-wide and phenotypic analysis of the collas. **PloS One**, San Francisco, v. 9, n. 3, p. 1–12, 2014. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0093314. Access: Aug. 20, 2022.

FRISANCHO, A. R. Developmental functional adaptation to high altitude: review. **American Journal of Human Biology**, Bethesda, v. 25, n. 2, p. 151-168, 2013. Available from: https://pubmed.ncbi.nlm.nih.gov/24065360/. Access: March 22, 2023.

GRAHAM, B. *et al*. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. **American Journal of Respiratory and Critical Care Medicine**, Bethesda, v. 200, n. 8, p. 70-88, 2015. Available from: https://pubmed.ncbi.nlm.nih.gov/31613151/. Access: March 22, 2023.

GINDHART, R.T. The air force physical fitness program is it adequate? Command and Staff College. Air University, United States Air Force. Alabama, p.14-15, April, 1999.

GÜL, M.; SALMANOĞLU, M. Long-term high +Gz effects on cardiac functions in the pilots. **Anatolian Journal of Cardiology**, Bethesda, v. 12, n. 8, p. 675, 2012. Available from: https://pubmed.ncbi.nlm.nih.gov/23018090/. Access: March 22, 2023.

HORMEÑO-HOLGADO, A. J.; CLEMENTE-SUÁREZ, V. J. Effect of iferente combat jet manoeuvres in the psychophysiological response of professional pilots. **Physiology & Behavior**, Bethesda, v. 208, p. 1-5, 2019. Available from: https://pubmed.ncbi.nlm.nih.gov/31128128/. Access: March 22, 2023.

LORENZO, F. R. *et al.* A genetic mechanism for Tibetan high-altitude adaptation. **Nature Genetics**, Oklahoma, v. 46, n. 9, p. 951-956, 2014. Available from: https://www.nature.com/articles/ng.3067. Access: March 22, 2023.

LUNDBY, C.; ROBACH, P. Does 'altitude training' increase exercise performance in elite athletes? **Exp Physiol**, v. 101, n. 7, p. 783 - 788, jun, 2016. Available from: https://pubmed.ncbi.nlm.nih.gov/27173805. Access: April 04, 2023.

MCKENZIE, D. C. Respiratory physiology: adaptations to high-level exercise. **Br J Sports Med,** v. 46, p. 381–384, 2012. Available from: https://pubmed.ncbi.nlm.nih.gov/22267571. Access: April 04, 2023.

MELO, P. L.; WERNECK, M. M.; GIANNELLA-NETO, A. Um novo espectrômetro de impedância para estudos científicos e clínicos do sistema respiratório. **Review of Scientific Instruments**, New York, v. 71, n. 7, p. 2867-2872, 2000. Available from: https://aip.scitation.org/doi/pdf/10.1063/1.1150705. Access: March 22, 2023.

MUNGOGE, W.; ANJOS, Z.; BARROS, R. Importância dos parâmetros caracterizadores da resistência das vias aéreas na avaliação funcional respiratória. Revista de Ciências da Saúde da Escola Superior de Saúde da Cruz Vermelha Portuguesa, v. 8, p.27-36, 2016. Available from: https://www.researchgate.net/publication/305703410/. Access: April 04, 2023.

NAVAJAS, D.; FARRÉ, R. Forced oscillation technique: from theory to clinical applications. **Monaldi Archives for Chest Disease**, Bethesda, v. 56, n. 6, p. 555-562, 2001. Available from: https://pubmed.ncbi.nlm.nih.gov/11980289/. Access: March 22, 2023.

NEDER, J. A. *et al*. Reference values for lung function tests. I. Static volumes. **Brazilian Journal Of Medical And Biological Research**, Ribeirão Preto, v. 32, n. 6, p. 719–727, 1999. Available from: https://www.scielo.br/j/bjmbr/a/dwWd5frtHDq5fkjZQ7BybDv/?format=pdf&lang=em. Access: March 22, 2023.

NORDAHL, S. H. *et al*. Effects of hypobaric hypoxia on postural control. **Aviation, Space, and Environmental Medicine**, Bethesda, v. 69, n. 6, p. 590-595, 1998. Available from: https://pubmed.ncbi.nlm.nih.gov/9641406/. Access: March 22,r. 2023.

OOSTVEEN, E. *et al*. The forced oscillation technique in clinical practice: methodology, recommendations and future developments. **European Respiratory Journal**, Bethesda, v. 2,

n. 6, p. 1026–1041, 2003. Available from: https://pubmed.ncbi.nlm.nih.gov/14680096/. Access: March 22, 2023.

ÖZTÜRK, C.; İLBASMIŞ, M. S.; AKIN, A. Cardiac responses to long duration and high magnitude +Gz exposure in pilots: an observational study. **Anatolian Journal of Cardiology**, Bethesda, v. 12, n. 8, p. 668–674, 2012. Available from: https://pubmed.ncbi.nlm.nih.gov/22968302/. Access: March 22, 2023.

PEREIRA, C. A. C.; MOREIRA, M. A. F. J. Pletismografia – resistência das vias aéreas. **Jornal de Pneumologia**, Brasília, DF, v. 28, n. 3, p. 139–150, 2002. Available from: https://cdn.publisher.gn1.link/jornaldepneumologia.com.br/pdf/Suple_142_45_66%20Pletismografia.pdf. Access: March 22, 2023.

PETRASSI, F. A. *et al*. Hypoxic hypoxia at moderate altitudes: review of the state of the science. **Aviation, Space, and Environmental Medicine**, Bethesda, v. 83, n. 10, p 975-984, 2012. Available from: https://pubmed.ncbi.nlm.nih.gov/23066620/. Access: March 22, 2023.

POLLARD, A. J. *et al*. Hypoxia, hypocapnia and spirometry at altitude. **Clinical Science**, Bethesda, v. 92, n. 6, p. 593-598, 1997. Available from: https://pubmed.ncbi.nlm.nih.gov/9205420/. Access: March 22, 2023.

PRISK, G. K. Pulmonary circulation in extreme environments. **Comprehensive Physiology**, Bethesda, v. 1 p. 319–338, 2011. Available from: https://pubmed.ncbi.nlm.nih.gov/23737175/. Access: 22 mar. 2023.

RODRÍGUEZ, F.A.; IGLESIAS, X.; FERICHE, B.; CALDERÓN-SOTO, C.; CHAVERRI, D., WACHSMUTH, N. B.; SCHMIDT, W.; LEVINE, B.D. Altitude Training in Elite Swimmers for Sea Level Performance (Altitude Project). **Med Sci Sports Exerc**, v. 47, p. 1965-1978, 2015. Available from: https://pubmed.ncbi.nlm.nih.gov/25628173. Access: April 04, 2023.

RUSSOMANO, T.; CASTRO, J. C. **Fisiologia Aeroespacial**: conhecimentos Essenciais para voar com segurança. Porto Alegre: EdiPUCRS, 2012.

SÁ, P. M. *et al*. Oscillation mechanisc of the respiratory system in never-smoking patients with silicosis: pathophysiological study and evaluation of diagnostic accuracy. **Clinical Science**, São Paulo, v. 68, n. 5, p. 644–651, 2013. Available from: https://www.scielo.br/j/clin/a/JXMZsRVfCM7MwdcJf8DYZ7f/?format=pdf&lang=en. Access: March 22, 2023.

SAUVET, F. *et al.* Heart rate variability in novice pilots during and after a multi-leg cross-country flight. **Aviat Space and Environmental Medicine**, Bethesda, v. 80, n. 10, p. 862-869, 2009. Available from: https://pubmed.ncbi.nlm.nih.gov/19817238/. Access: March 22, 2023.

SOCIEDADE BRASILEIRA DE PNEUMOLOGIA E TISIOLOGIA. Diretrizes para Testes de Função Pulmonar. **Jornal Brasileiro de Pneumologia**, Brasília, DF, v. 38, n. 2, 2009. Available from: https://www.jornaldepneumologia.com.br/details-supp/45. Access: March 22, 2023.

TALAMINOS-BARROSO, A. *et al.* Effects of genetics and altitude on lung function. **The Clinical Respiratory Journal**, New Jersey, v. 15, n. 3, p. 247-256, 2020. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/crj.13300. Access: March 22, 2023.

TESCH, P.A.; HJORT, H.; BALLDIN, U.I. Effects of strength training on G tolerance. **Aviat Space Environ Med**, v. 54, n. 8, p. 691-695, aug, 1983. Available from: https://pubmed.ncbi.nlm.nih.gov/6626076. Access: April 04, 2023.

TRINDADE, A. M.; SOUSA, T. L. F.; ALBUQUERQUE, A. L. P. A interpretação da espirometria na prática pneumológica: até onde podemos avançar com o uso dos seus parâmetros? **Pulmão RJ**, Rio de Janeiro, v. 24, n. 1, p. 3-7, 2015. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/lil-764757. Access: March 22, 2023.

WARBURTON, D. E. R.; SHEEL, W. A.; MCKENZIE, D. C. Cardiorespiratory adaptations to training. **In**: SCHWELLNUS, M. P. (ed.). **Olympic Textbook of Medicine in Sport**. West Sussex: Wiley-Blackwell, 2008.

WEITZ, C. A.; GARRUTO, R. M.; CHIN, C-T. Larger FVC and FEV1 among Tibetans compared to Han born and raised at high altitude. **American Journal of Physical Anthropology**, Bethesda, v 159, n. 2, p. 255-255, 2016. Available from: https://pubmed.ncbi.nlm.nih.gov/26407532/. Access: March 22, 2023.

WEST, J. B. A strategy for in-flight measurements of physiology of pilots of high-performance fighter aircraft. **Journal of Applied Physiology**, Bethesda, v. 115, p. 145–149, 2013. Available from: https://pubmed.ncbi.nlm.nih.gov/23599400/. Access: March 22, 2023.


ECEME

ARTICLE DOI 10.52781/cmm.a105

Food defense and operational health: Protection against Intentional Food Contamination in the Armed Forces

Defensa Alimentaria y Salud Operacional: Protección Contra la Contaminación Intencional de Alimentos en las Fuerzas Armadas

Abstract: The intentional adulteration of the food supply chain is a concern for governments, organizations, and societies, especially after the terrorist attacks of September 11, 2001, resulting in measures against intentional food contamination, known as Food Defense. This study aimed to systematize evidence on threat assessment and procedures that promote Food Defense actions in countries and the Armed Forces. The method consisted of a integrative literature review with searches in the Web of Science, SciELO, Lilacs, and Google Scholar databases. The results of this research reveal the application of concepts on the subject through the adoption of tools, such as software and checklists, with the development of Food Defense systems. In the government area, initiatives related to the implementation of legislation on intentional food contamination are incipient, except for the United States of America. In Brazil, it is necessary to address the Food Defense subject as a national security policy to preserve the operational health of the military.

Keywords: Food Defense; Armed Forces; Operational Health; Intentional Food Contamination.

Resumen: La adulteración intencional de la cadena de suministro de alimentos es una preocupación de gobiernos, organizaciones y sociedades, principalmente a partir de los atentados terroristas del 11 de septiembre de 2001, lo que motivó la adopción de medidas frente a este proceso de contaminación, que pasó a denominarse defensa alimentaria . El objetivo de este artículo fue sistematizar las evidencias en cuanto a la evaluación de amenazas y procedimientos que promuevan acciones de defensa alimentaria en países y Fuerzas Armadas. El método consistió en una revisión integrativa de la literatura, con investigación en las bases Web of Science, SciELO, Lilacs e Google Académico. Los resultados revelan la aplicación de conceptos sobre el tema mediante el uso de herramientas, como software y listas de cotejo, con el desarrollo de sistemas de defensa alimentaria. A nivel gubernamental, las iniciativas relacionadas con la implementación de legislaciones sobre la contaminación intencional de los alimentos son incipientes, con la excepción de los Estados Unidos de América. En Brasil, por su parte, es necesario tratar la defensa alimentaria como política de seguridad nacional para preservación de la salud operacional del efectivo militar.

Palabras clave: Defensa Alimentaria; Fuerzas Armadas; Salud Operativa; Contaminación intencional de alimentos.

Jader Oliveira da Silva
Universidade Federal de São Paulo e Comando do Exército Brasileiro.
São Paulo, SP, Brasil.
helegomes37@gmail.com

Laís Mariano Zanin
Universidade de São Paulo.
São Paulo, SP, Brasil.
zanin.lais@gmail.com

José Roberto Pinho de Andrade Lima
Escola Superior de Defesa. Ministério da Defesa. Brasília, DF, Brasil.
jose.roberto@defesa.gov.br

Elke Stedefeldt
Universidade Federal de São Paulo.
São Paulo, SP, Brasil.
elke.stedefeldt@unifesp.br

Received: Oct 29, 2022
Approved: Apr 17, 2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

The global population is expected to reach at least nine billion inhabitants by the year 2050, requiring up to 70% more of the resources currently used. This will create the need for other productive food systems and the development of sustainable logistics articulations (FRITSCHE, 2018).

According to Pitaluga and Le Bourlegat (2022), the food system is the junction of elements and activities related to production, processing, distribution, preparation, and consumption, with particularities intrinsic to the food supply chain. This configuration presents a continuous increase in complexity, diversity, and interdependence of domestic and global systems, with the development of risk management strategies to protect food supply processes from possible adulterations, regardless if intentional or not, establishing parameters in order to minimize economic impacts and public health problems (ANDRADE; OLIVEIRA; SILVA, 2021).

For decades, the intentional contamination of food has been a concern to various sectors in developed countries. In December 2004, at a press conference in which he would announce his departure from the U.S. Department of Health and Human Services, then-secretary Tommy Thompson questioned why terrorists had not attacked the food chain in American territory, "because it was so easy to do" (NATIONAL ACADEMY OF SCIENCES, 2006). The World Health Organization recognizes the intentional contamination of food as one of the greatest health threats of the 21st century, which can be used as a tool for terrorist attacks (WORLD HEALTH ORGANIZATION, 2007).

The issue of Food Defense is an important topic in protecting businesses and consumers from internal and external threats (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2019), especially after September 11, 2001, which has since brought a concern about food supply chain security to governments, organizations and societies worldwide. The topic of food defense relates to all forms of malicious action to contaminate batches or supply chains (MANNING, 2023). The United States Food and Drug Administration (FDA) (2022) defines food defense as the effort to protect food from acts of intentional adulteration.

The potential impact of intentional contamination on human health can be estimated by extrapolating the many documented examples of unintentional outbreaks of Food and Waterborne Diseases (FWD) (SOBEL, 2005). However, some typical cases of intentional contamination have gained repercussions among consumers. For example, the contamination of lots of strawberries with needles in Australia in 2018, which brought a very negative impact on the product with economic losses and the drastic reduction of consumption due to the loss of confidence in its sanitary quality.

According to Andrade, Oliveira and Silva (2021), there is a knowledge gap about which food defense strategies need to be addressed, with the need for organizations in the food chain to adopt different defense plans. To identify these strategies, it is important to recognize the different agents that can be qualified as threats, and which are classified by Manning (2023) into five categories: agents that practice espionage; extortion; sabotage; extremists and activists.

Causing food shortages has always been a method of warfare, with the restriction or destruction of food being a way to obtain military advantage either by offensive or defensive actions, and that not infrequently determines the results of a battle (SEVERINO; ALMEIDA, 2017).

The objectives of this article were to systematize the evidence on the evaluation of threats and procedures that promote actions in food defense, ensure the food supply chain protection against intentional contamination; the protection of health and operationality in the Brazilian military and abroad, as well as present the history and concepts of food defense addressed by different organizations and researchers.

2 METHODS

This article was developed by means of a integrative literature review through research conducted by the authors. The research sought initial information of a reality for the formulation of hypotheses on the reality of food defense. Bibliographic sources, documents, laws, regulations and technical references were used. In addition, existing systems related to food defense were studied.

The following guiding question was used to complete the research: what are the evidence, concepts and actions in Food Defense used in the military and civilian environments of different countries? With this, the history of incidents of intentional food contamination, as well as the possible characteristics of the individuals who carry out these actions were considered. For the selection of the studies, the PICO (Participant, Intervention, Comparison, and Outcome) strategy was chosen, according to Schveitzer et al. (2016), and described in Table 1. The elaboration of the research question and the literature search allowed obtaining the best information available and directing the literature review performed. Finally, it is emphasized that the search was limited to articles written in English and Portuguese.

Table 1 - Inclusion criteria adopted by means of the PICO strategy

Acronym	Definition	Description
P	Participants	Military and Civilian Agencies
I	Intervention	Analysis of actions (procedures) in food defense in the military and civilian environments of various countries, in face of intentional food contamination
C	Comparison	Situation of food defense in Brazil and in other nations (civil and military environment). History of malicious actions of food contamination in Brazil and in the world
O	Outcome	Armed Forces presenting functional food defense plan

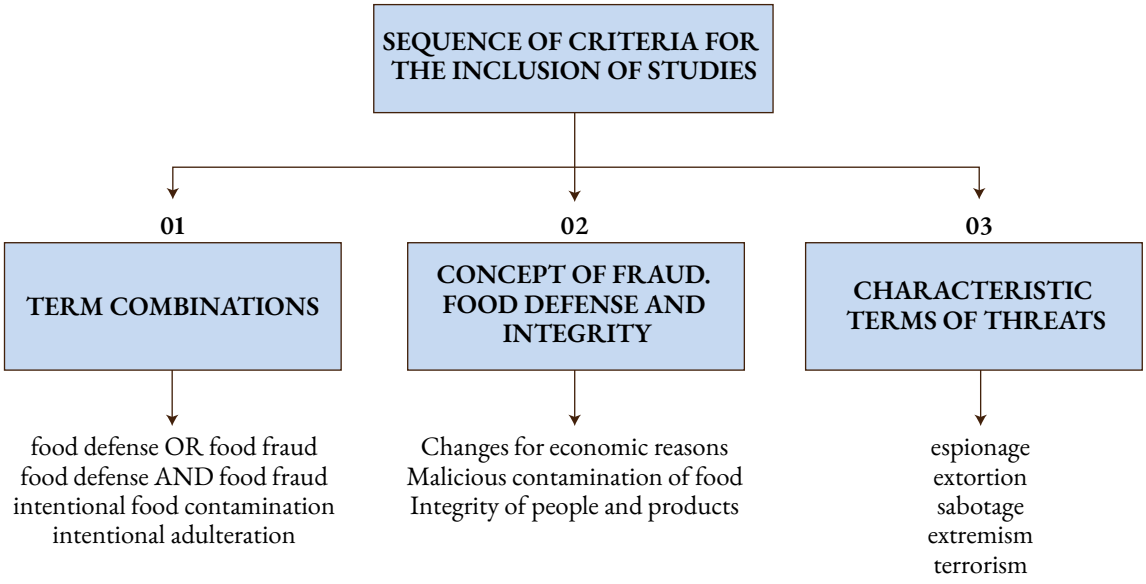
Source: Prepared by the authors, 2023.

A retrospective observational study was conducted, organized according to the Preferred Reporting Items for Systematic Reviews and Meta Analysis (Prism), based on the literature on food defense.

Literature review was independently performed by the main author and a researcher, assisted by a selection of studies published in Pubmed; Capes; Scielo; Lilacs; Web Science and Google Academic, using the same search criteria for all databases. Regarding the location of the articles, the following combinations were used: food defense OR food fraud AND food defense AND food fraud OR intentional food contamination AND intentional adulteration. The references of eligible studies were analyzed to find other publications of interest by the cross-reference method.

Thus, the inclusion factors were defined according to the words and combinations essential to the search, the conceptualizations needed to understand the factors linked to intentional food adulteration, and the key characteristics intrinsic to the types of threats of this intentional contamination. After the search, the articles were selected by title and abstract. Figure 1 presents the sequence for establishing the criteria for inclusion of studies in the search.

Figure 1 - Sequence of Criteria for Including Studies



Source: Prepared by the authors, 2023.

There was no limitation as to the period of publication, in order to contemplate the scientific production up to the time of the research.

After reading the title and abstract, we adopted as exclusion criteria the studies that predominantly focused on food safety, whose concepts refer to unintentional contamination of food.

Reading the articles in their entirety was the final step of inclusion. Original articles meeting the inclusion and exclusion criteria were consulted and selected. The search was conducted

from February 2018 to September 2022. The levels of evidence were ranked according to the Grid system of the *Methodological Guidelines* handbook of the Brazilian Ministry of Health (BRASIL, 2014), presented in Chart 1.

Chart 1 - Ranking of levels of evidence

LEVEL	DEFINITION	IMPLICATIONS	SOURCE OF INFORMATION
HIGH	There is strong confidence that the true effect is close to the estimated one	It is unlikely that additional work will change confidence in the effect estimate	- Well-designed clinical trials with a representative sample - In some cases, well-designed observational studies with consistent findings
MODERATE	There is strong confidence that the true effect is close to the estimated one	Future work may change confidence in the effect estimate, and may even modify the estimate	- Clinical trials with mild limitations - Well-designed observational studies with consistent findings
LOW	Limited confidence in the effect	Future work is likely to have a major impact on our confidence in the effect estimate	- Clinical trials with moderate limitations. - Comparative observational studies: cohort and case-control
VERY LOW	Confidence in the effect estimate is very limited. There is an important degree of uncertainty in the findings	Any effect estimate is uncertain	- Clinical trials with severe limitations - Comparative observational studies with presence of limitations - Non-comparative observational studies Expert opinion

Source: Brazilian Ministry of Health (2014).

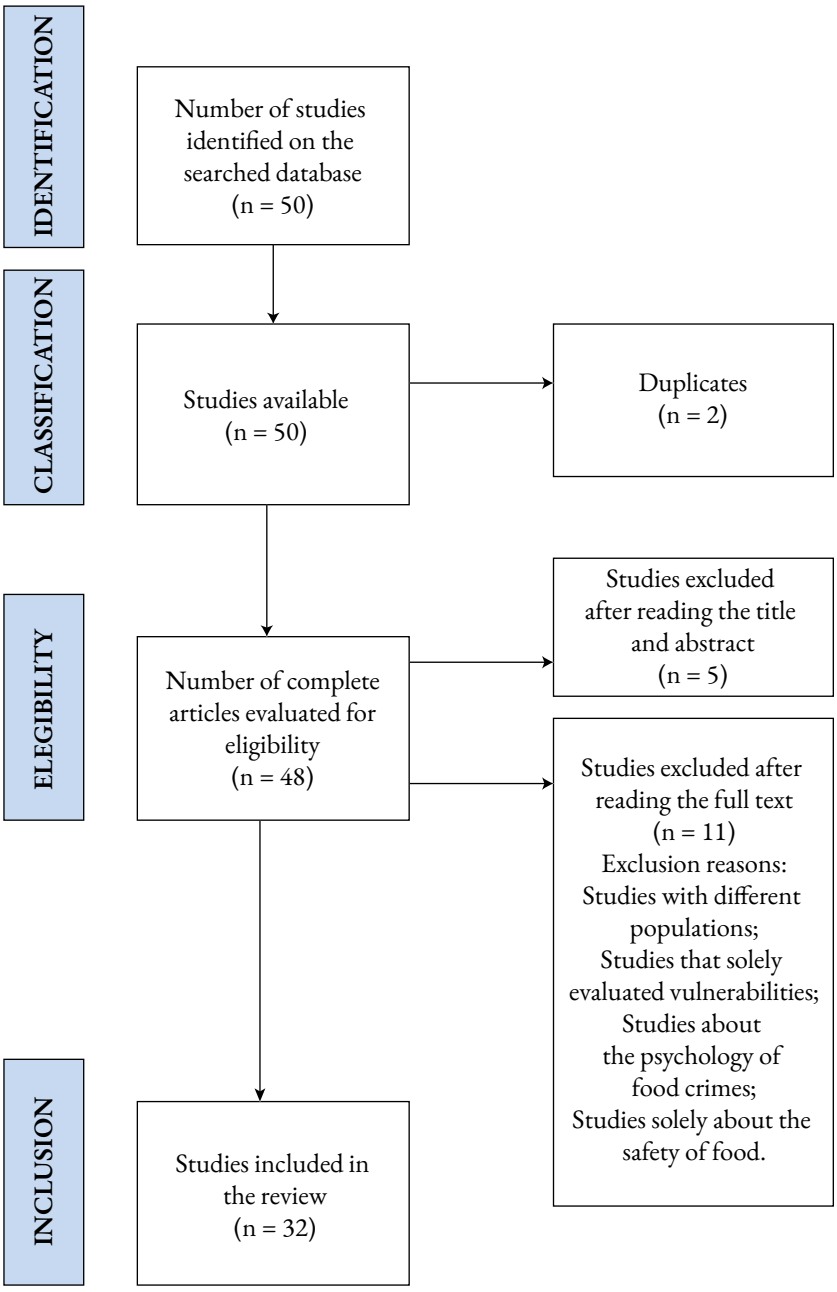
3 RESULTS AND DISCUSSION

The objectives of this article were to systematize the evidence on the evaluation of threats and procedures that promote actions in food defense capable of ensuring the food logistic chain protection against intentional contamination; the protection of health and operationality in the Brazilian military and abroad. In addition, it intends to present a history regarding voluntary contamination, and to investigate some food defense concepts addressed by different organizations and researchers.

In total, 32 articles were included in the final review, as indicated in the flow diagram (Figure 2). The results of this review show the diversity of the variables between the types of malicious threats practiced, of system vulnerabilities, and the strategies used for analysis and adoption of measures related to food defense.

The total of 12 studies surveyed addressed tools for applying food defense checklists in a system, infrastructure, or mass food service, enabling assessing the risk of intentional food contamination and their levels of evidence, as shown in Table 2.

Figure 2 - Flow diagram of the studies included in the integrative literature review



Source: adapted from Moher et al., 2009

Table 3 presents 20 studies included in the review after evaluation for inclusion in this article. The studies listed in Tables 2 and 3 were those included in the review (n = 32). Based on the results obtained in the use of these tools (Table 2) and, together with the application of the conceptual bases (Table 3), the conditions for adopting measures that promote actions in food defense and ensure the protection of the food supply chain were provided.

Table 2 - Included studies addressing tools for assessing requirements in Food Defense and levels of evidence

STUDY	CHARACTERISTICS OF THE SAMPLE	ACTIVITY	EVALUATION	RESULT	LEVEL OF EVIDENCE
United States Department of Agriculture (2007)	Animal product trading facilities in the United States of America	Poultry and cattle slaughtering	Evaluation of vulnerabilities in Food Defense in the audited facilities	Reduction of the risk of malicious action during poultry and cattle slaughter operations in facilities in the United States of America	HIGH
United States of America (2009a)	Animal products slaughtering and processing facilities in the United States of America	Animal product trading facilities in the United States of America		Reduction of the risk of malicious action during processing and storage of products of animal origin in the United States of America	HIGH
United States of America (2009b)	Food companies in multiple nations	Food supply chain		Worldwide use of free software Carver + Shock Primer	HIGH
Indiana State Department of Health (2011)	Producing, processing, and food service facilities in the state of Indiana (USA)	Food Supply Chain in the State of Indiana (USA)		Standardization of the statewide food defense evaluation method	HIGH
United States of America (2012)	School feeding facilities in the United States of America	Education		Reducing the risk of intentional contamination or adulteration of school food	HIGH
Kraft Foods (2015) (Current Kraft Heinz)	Companies supplying ingredient to prepare food products	Food company	Company's suppliers evaluation	Adoption of procedures to prevent the receipt of raw materials contaminated by malicious action	LOW

continue

Table 2 – Continuation

STUDY	CHARACTERISTICS OF THE SAMPLE	ACTIVITY	EVALUATION	RESULT	LEVEL OF EVIDENCE
DLA Troop Support (DEFENSE LOGISTICS AGENCY, 2016) Combat logistics support agency for the United States of America military forces	Food suppliers under contract with the Defense Logistics Agency	Food supply chain	Auditing companies on the implementation and application of the fundamentals in Food Defense by companies supplying food to military organizations	Reducing risks of receiving intentionally contaminated foodstuffs by military troops supported by the agency	HIGH
Universidade de Lisboa (PORTUGAL, 2017)	Food industrial plants in Portugal	Animal products industry	Evaluation of the implementation of food defense requirements	Food defense checklist for food industry operator developed and applied	MODERATE
Severino; Almeida (2017) Food Defense: Management systems against food terrorism	Companies in the supply chain	Research and Development	Management systems against food terrorism	Reducing the risk of food terrorism actions	MODERATE
British Standards Institution PAS 96 (2017)	Food companies	Food supply chain	Evaluation of threats and vulnerabilities in Food Defense	Protection of the integrity and sanity of food and food chain Food Defense	HIGH
Portuguese Army (2017)	Food services of the Portuguese Army	Military		Adoption of procedures to eliminate risks of intentional food contamination in peacetime and military operations of the Portuguese Army	HIGH
NATO (2019)	North Atlantic Treaty Organization (NATO) food services.	Military		Adoption of procedures to eliminate risks of intentional food contamination and maintenance of operationality in the different Operations of the organization	HIGH

Source: Prepared by the authors, 2023.

Table 3 - Studies included in the integrative review addressing conceptual issues

STUDY	GROUP OF INTEREST	ACTIVITY	OBJECTIVE	RESULT
World Health Report (2007)	World Health Organization Member States	Health protection	Promote international discussions and exercises on bioterrorism	Identification of risks and methods of containment and control
World Health Organization (2008)	World Health Organization Member States	Food preparation, production and processing	Warn the Member States about the possibility of food being used as a vehicle for terrorist acts, and provide guidance on countering, preventing, and responding to such acts	Guide to strengthening, preventing, and responding to acts of food terrorism
Mara; McGrath (2009)	The United States Army	Military logistics	Discuss the most vulnerable areas of the United States military food supply and Food Defense for troops stationed outside the U.S. Territory	Guide to the American Food Defense system in the processes of procurement, preparation, and protection at U.S. military installations
Dalziel (2009)	Food supply chain	National Security	Comprehensively examine and systematize all incidents of malicious and intentional contamination of the supply chain, where the supply chain is a vehicle for dissemination of these chemical, biological physical and nuclear agents	Production of survey material on intentional contamination of the food supply chain at global level
Association Française de Normalisation (2015)	French food production chain	Food preparation, production and processing	Promoting Food Defense in the French supply chain	Guide for protecting the French food chain against malicious, criminal or terrorist actions
Manning; Soon (2016)		Research	Conceptual literature review	Finding contradictory definitions in literature; comparing and contrasting existing food crime risk assessment tools and their application

continue

Table 3 – Continuation

STUDY	GROUP OF INTEREST	ACTIVITY	OBJECTIVE	RESULT
Severino; Almeida (2017)	Food production chain in Portugal and Portuguese-speaking countries	Food preparation, production and processing	Discuss methodologies against intentional food contamination	Guide on integration of food safety management systems
Davidson, *et al*. (2017)	European food production chain	Food supply chain at pre-retail stage	Analyze how food defense contributes to the integrity of the food supply chain	Demonstrated how Food Defense should be an integral part of food supply chain integrity, rather than just an afterthought after an incident
Ministry of Defense (BRAZIL, 2018)	Military personnel from Brazil's Navy, Army, and Air Force	Military logistics	Discuss the implementation of the Food Defense system within Brazil's military scope	Creation of the working group on Food Defense of the Ministry of Defense
United States of America (2018)	Food facilities in the United States of America	Food safety and inspection service	Develop a 4-phase food defense plan	Functional Food Defense Plan
Figueira (2018)	Meat seasoning production companies	Education and research	Describe the possible forms of intentional contamination in the inputs used in meat seasoning production plant	Identifying vulnerability and creating Food Defense plan for meat product input factory
Moerman (2018)	Agriculture and food production industry	Education and research	Providing an overview of different targets prone to acts of intentional food contamination	Guidance on Food Defense in practice in the phases of operations, receiving, storage, processing, packaging, and shipping of products
Manning (2019)	Food facilities	Research	Positioning Food Defense as a supply chain risk mitigation strategy	Production of material refining the taxonomy of food defense threats

continue

Table 3 – Continuation

STUDY	GROUP OF INTEREST	ACTIVITY	OBJECTIVE	RESULT
Chammem; Issaoui; De Almeida et al. (2019)	Food industry at all stages and consumers	Research	Discussing the regulatory characteristics of food control agencies, in different regions of the world	Production of material on the subject
Lopes, et al. (2020)	Dairy processing industry	Education and research	Assessing the perception of the Brazilian dairy processors regarding food defense	In the view of the companies audited in Brazil on Food Defense, external safety was the most important (84%), followed by personal safety (82%), generalities (81%), and internal safety (74%)
Centre for the Protection of National Infrastructure (2021)	The UK agriculture sector	Security of the UK infrastructure areas	Providing protection to areas considered critical to the UK infrastructure, including agriculture	Protection of physical and cyber facilities
Alves (2021)	The European Union agriculture sector	National security and defense	Food Defense as an instrument of prevention against agroterrorism, terrorism and food crime in the European Union	Production of material exposing the possibility of using pathogens in supply chains
Praia; Henriques (2021)	Meat food industry in Portugal	Research	Food Defense Audits in meat products industries	Verification of vulnerabilities and non-existence of food defense plans
Rapid Alert System for Food and Feed (2022)	Food chain in the European Union member countries	Food safety in the European Union	Promote exchange of information between the European Union Member Countries in support of health authorities for a rapid reaction in cases of public health risks	Food protection in the European Union Members

Source: Prepared by the authors, 2023.

continue

3.1 History

History describes several examples of supply disruptions or purposeful food contamination being used as military attacks on the enemy (BUCHANAN; APPEL, 2010). The importance of logistical support has long been considered vital to staying in combat, legitimizing the famous phrase asserted by Napoleon Bonaparte: "An army marches on its stomach" (BRAZIL, 2019a).

The history of intentional contamination events is highlighted in the studies presented by Dalziel (2009), Severino; Almeida (2017) and Praia; Henriques (2021) (Table 3).

During the siege of Leningrad in World War II, Hitler sought extermination by starvation of the dominated populations, as recorded by Max Hastings (2012):

> Professor Ernst Ziegelmeyer of the Munich Nutrition Institute - one of the many scientists who gave diabolical advice to the Nazis - was consulted about the practicalities (imposing starvation on Leningrad). He agreed that there was no need for a battle; it would be impossible for the Russians to provide their besieged citizens with more than 250 grams of bread per day, a ration insufficient to sustain human life for an extended period of time. (HASTINGS, 2012, p. 183-184)

In 2001, material found at the Tarnak farm training camp in Afghanistan suggested the interest of the terrorist group Al-Qaeda in pathogens of plant and animal origin (DALZIEL, 2009).

From 1998 to 2008, the following agents have been identified as being involved in deliberate food contamination events: arsenic, cyanide, feces, herbicide, household cleaning chemical, insecticide, nicotine sulfate, pesticide, rodenticide, and tetramine. It is worth noting that some countries have already experienced intentional contamination events with repercussions on public health, for example, Australia, Canada, China/Hong Kong, Iraq, Italy, Japan, Korea, the Philippines, Taiwan, Thailand, and the United States of America (DALZIEL, 2009).

In Brazil, the Figueiredo Report describes that the *Cinta Larga* tribe in Mato Grosso would have been exterminated in July 1963 due to dynamites thrown from an airplane toward the indigenous community. In addition, it is known that strychnine, a toxic substance, was added to sugar. This crime became known as the Massacre of Parallel 11, resulting in 3,500 indigenous deaths (VANÇAN; RODRIGUES, 2021).

In 1981, Spain had one of the largest outbreaks in history, in which a case called Toxic Oil Syndrome was reported, leaving 19,904 people sick and more than 300 people dead. The Raelca company was distributing olive oil characterized as pure, but in a suspect product denatured rapeseed oil was found with 2% aniline mixed with animal and vegetable fat (MCKAY; SCHARMAN, 2015). This case refers to a crime against public health, due to an adulteration for economic reasons (food fraud).

In 1989, a shipment of grapes from Chile was identified as being contaminated with cyanide. An anonymous tip made to the United States Embassy in Santiago alerted the authorities about the potential intentional contamination. The FDA banned imports of fruit produced

on Chilean territory, including nectarines, plums, peaches, apples, pears, raspberries, and strawberries, among others. At the time, fruit exports represented the second most important economic activity in the Latin American country. The incident resulted in the loss of US $300 million in revenue, and consumers became suspicious of products of Chilean origin (FOOD AND DRUG ADMINISTRATION, 2015).

In the last three decades, there have been some cases caused by the deliberate use of biological agents. Noteworthy is the salmonellosis outbreak that, in 1984, affected 751 people, with 45 hospitalizations due to contamination of a restaurant salad buffet perpetrated by an Indian religious sect (RAMBAUSKE; CARDOSO; NAVARRO, 2014).

In 2018, Australia investigated a series of cases in which sewing needles were found inside strawberries sold at retail, a fact reported in at least six states and territories. One man was taken to hospital after eating one of the fruits. Several brands of the product have been pulled from the country's shelves, while New Zealand's largest supermarkets have stopped selling Australian strawberries as a precautionary measure. At the time, Australia's Minister of Health, Greg Hunt, said that such an action was a brutal crime as well as an attack on the public. In 2018, Australia revised its food protection regulations based on these incidents of intentional adulteration (BASHURA, 2020).

Brainard and Hunter (2016) verified 84 incidents of water supply poisoning, of which 65% were against the consuming community and 9.5% affected the water supply of police, military, or refugees. With regard to food, the authors report that out of a total of 224 attacks, 25% were unaccounted for; 22% were for extortion; 10% were for other financial reasons; 16% were politically motivated; 9% were malicious attacks; 5% were for labor disputes, and 12% were for other reasons.

Chart 2 lists some incidents in which malicious actions of intentional food contamination had repercussions in the media for the consequences (social, political, economic or health) of the malicious act.

Chart 2 - Incidents of intentional food contamination with media repercussions and their motivations

Date	Site	Event	Motivation
1984	Oregon (USA)	*Salmonella* sp. contamination in ready-to-eat salads in a restaurant	Boycott of local elections by the Rajneesh sect
1990	United Kingdom	Food contamination with glass and razor blades	Malicious contamination
2005	England	Contamination of bread with needle fragments	Malicious contamination
2008	China	Infant milk powder adulterated with melanin	Economic Motivation
2013	Not reported	Substitution of alcoholic beverages with acids	Malicious contamination
2018	Australia	Series of cases where sewing needles were found inside strawberries sold in retail	No rational reason for the action

Source: Adapted from Dalziel (2009); Severino; Almeida (2017); Praia; Henriques (2021).

3.2 Concepts

The concepts of safety, accessibility, defense, fraud and quality share some semantic features, and hold proximity to each other when it comes to food area (SEVERINO; ALMEIDA, 2017).

The term food safety, associated with food sanitary safety, refers to the conditions and practices to preserve the safety of food in the production chain. Its goal is to pay attention to biological, physical or chemical hazards in order to avoid contamination and food- and water-borne illnesses (DTHA) (SEVERINO, 2016).

In turn, food security (accessibility) is defined by the World Health Organization(2002) "as sufficient, safe access to food with sufficient nutrients to maintain people's health and life". The concept of accessibility is multidimensional and refers both to the security of food supply and the physical and economic accessibility of nutritious food (SEVERINO; ALMEIDA, 2017).

Food fraud, in turn, including the subcategory of economically motivated adulteration (EMA), is an intentional illegal action for economic gain (SPINK, et al., 2019). Incidents of this type of fraud pose a considerable threat to the economic stability of the agri-food industry, as well as the health and welfare of consumers (LEE; FENOFF; SPINK, 2021).

The broader concept of food quality refers to the characteristics that determine the value of the product for customers and consumers, and the ability of food to satisfy the needs of those who consume it (SEVERINO; ALMEIDA, 2017). According to Moerman (2018), food quality also refers to the technical specifications of a given food.

The Institute of Food Science & Technology (2018) understands that food integrity is associated not only with the nature, composition, quality, and safety of food, but also with other aspects of production, including modes of procurement and distribution. Manning and Soon (2016) describe four types of food integrity issues: (i) product integrity (authenticity); (ii) process integrity; (iii) people integrity; and (iv) data integrity.

According to the Food Safety System Certification 22000 (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2019), food defense is an important topic for protecting businesses and consumers from internal and external threats.

There are several definitions of food defense by technical entities and official bodies, and all have similarities in their fundamentals. Table 4 presents these concepts and their different objects.

According to Robson et al. (2021), all concepts about food defense refer to actions to protect against willful contamination whose purpose is to cause some kind of harm.

Table 4 - Concepts in Food Defense

REFERENCE	CONCEPT	CONCEPT OBJECTS
British Retail Consortium (2015)	It considers Food Defense as the procedures adopted to ensure the safety of raw materials and products against malicious contamination	Certifiable standards and new methodologies in Food Defense
Manning; Soon (2016)	Food Defense reflects the protective activities and/or the process or procedures that ensure product safety regarding intentional acts of adulteration	Food fraud and Food defense
PAS 96 (2017)	These are procedures adopted to ensure that food and beverage and their supply chains are protected from ideological or malicious attacks leading to contamination or disruption of supply	Types of threats to the supply chain; describes threat evaluation and critical control points
GFSI (GLOBAL FOOD SAFETY INITIATIVE FOUNDATION, 2017)	Process for ensuring the safety of food and beverages regarding all forms of intentional malicious attacks, including those ideologically motivated that lead to contamination	Types of supply chain threats
FDA (2009)	It is the effort to protect food from intentional adulteration through acts intended to cause large-scale harm to public health, including acts of terrorism targeting the food supply	Prevention of actions against food terrorism, agroterrorism, national security and defense, and supply chain protection
Moerman (2018)	Food Defense focuses on reducing the occurrence and impact of intentional contamination or adulteration of food that is politically, economically motivated, or revenge-based	Framework in Food Defense from "field to plate"

Source: the authors (2023).

3.3 Food Defense and the International Reality

The global food trade is very connected, and a country's food supply must be domestically monitored to prevent contamination, adulteration, and fraudulent activities (LOPES et al., 2020). This trade is complex and constantly evolving. Due to discrepancies in the food law systems of different countries, the standardization of international food safety rules is of utmost importance to reduce trade barriers (PRAIA; HENRIQUES, 2021).

The studies presented in Table 3, such as World Health Organization (2002, 2007), Dalziel (2009), Moerman (2018), Manning (2019) approach food defense as a topic of international relevance in the military and civilian spheres.

Intentional contamination can have diverse origins and be caused by employees or individuals external to the food preparation environment, such as members of terrorist groups (BRITISH STANDARD INSTITUTION, 2017). Furthermore, this adulteration can be the result of a process of food counterfeiting or product detour (PRAIA, 2017).

Another possibility is the specific activity linked to agroterrorism, an action perpetrated by a person or a group aimed at destroying the agricultural industry and/or disrupting a country's food supply (MOERMAN, 2018). Food terrorism is an act of deliberate post-harvest contamination, in which the product is adulterated with chemical, physical and biological agents or radioactive material in order to cause illness or death in the civilian population, in addition to causing social, economic and political instability (WORLD HEALTH ORGANIZATION, 2008).

In recent years, regulatory authorities, food companies and consumers have glimpsed the need to develop effective defense systems regarding these products (DAVIDSON et al., 2017). Given this reality, food business operators have been required to develop and implement defense strategies and thus ensure market entry by having their management systems certified by specialized companies (MANNING, 2019).

The importance of food defense has been recognized by becoming a requirement in global certifying standards, such as International Featured Standards (IFS) (INTERNATIONAL FEATURED STANDARDS, 2020), British Retail Consortium (BRC) (BRITISH STANDARD INSTITUTION, 2017) and Food Safety System Certification 22000 (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2019), as well as in government strategies, for example, those adopted by the FDA, the American body responsible for controlling and regulating the production of food and medicines in the United States (CAVALHEIRO; RUIZ, KUSHIDA, 2021).

After the event of September 11, 2001, several countries started to adopt measures against malicious actions in food. In China, the Certification and Accreditation Administration (CNCA) - established under the administration of the Supervision of Quality, Inspection and Quarantine (AQSIQ) - has published 40 guidelines and some requirements for regulating food defense plans for export companies. It is worth noting that both the United Kingdom and Germany also have robust food defense initiatives (MOERMANN, 2018).

In late 2001, the FDA and the United States Department of Agriculture (USDA) tried to determine the readiness of the U.S. food system against an intentional attack, thus emerging the first law passed in June 2002, also known as the Public Health Security and Bioterrorism Preparedness and Response Act (SEVERINO; ALMEIDA, 2017).

The Asia-Pacific Economic Cooperation (APEC) Counter-Terrorism Force (CTTF) started examining this issue in 2006, with initiatives to mitigate the food supply terrorism threat (DALZIEL, 2009).

3.3.1 Food Defense in the United States of America and European Countries

Cited in Table 3, the studies by Mara; McGrath (2009) and USDA (2018) address food defense in the United States of America. In addition, analyses by the *Association Française de Normalisation* (2015); Severino; Almeida (2017); Davidson, et al. (2017); Centre for the Protection of National Infrastructure (2021); Alves (2021); Praia; Henriques (2021); Rapid Alert System for Food and Feed (RASFF) (2022) in European countries.

The United States of America considers the food and agriculture industry as one of the 16 critical infrastructure sectors, and the USA is the country where the concepts of food defense emerged. The FDA plays a leading role in various initiatives to protect food from acts of intentional and unintentional adulteration, as well as to help organizations prevent, prepare for, respond to, and recover from acts of intentional adulteration of the food supply (FOOD AND DRUG ADMINISTRATION, 2022). The Federal Bureau of Investigation (FBI) has already demonstrated concern about the dangers related to agroterrorism and food terrorism and their consequences, promoting workshops on the subject among several state and non-state agencies (FEDERAL BUREAU OF INVESTIGATION, 2007).

After the September 11, 2001 attacks, food defense gained legal consistency through the Public Health Security and Bioterrorism Preparedness and Response Act in 2002. In January 2011, a new legal framework was adopted for food safety in the United States through the Food Safety Modernization Act (FSMA), when the development of management systems for food supply defense, analysis methodologies, support software, and educational resources was intensified (SEVERINO; ALMEIDA, 2017).

The United States Food Safety and Inspection Service has functional food defense plans, an important tool that a producer can use to prevent, protect, mitigate, respond, and recover from an intentional contamination incident (UNITED STATES OF AMERICA, 2018).

Several actions are taken by various agencies and institutes around the country, such as the National Center for Food Protection (FOOD PROTECTION AND DEFENSE INSTITUTE, 2022), which has developed multidisciplinary research and guided programs that address the vulnerabilities of the nation's food system to attacks by intentional contamination with biological or chemical agents. The Indiana State Department of Health (2011) presents a food protection program with a food defense section. The FBI (2014), with the FDA participation, has held a few workshops demonstrating the real threat and the devastating effect of a successful malicious food contamination action.

Although the threat of intentional and malicious contamination is a reality of food terrorism, European policy-makers have not yet legally defined food defense, let alone framed it in legislation (ALVES, 2021). According to Moermann (2018) there are few government regulations that deal with food defense.

In Portugal, issues regarding vulnerabilities are contained in the strategic concept of national defense (PORTUGAL, 2013). The legal framework of food defense in Portugal will be done through the European food legislation. However, companies certified by BRC Food, IFS Food and FSSC 22000 standards present a more robust concept regarding food defense (SEVERINO; ALMEIDA, 2017).

France has the methodological guide *Protection de la chaîne alimentaire contre les risques d'actions malveillantes, criminelles ou terroristes*, which was prepared by the French Association of Technical Standards (ASSOCIATION FRANÇAISE DE NORMALISATION, 2015), which formed a pool of organizations to reflect on the

solutions they could implement within a Food Defense approach, considering, above all, the requirements of the IFS Food 6.

In the United Kingdom, the Critical National Infrastructure (CENTRE FOR THE PROTECTION OF NATIONAL INFRASTRUCTURE, 2021) has identified the food sector as one of 13 sectors necessary for the functioning of the country. Unlike the continental Europe, the United Kingdom has followed the United States in food defense (SEVERINO; ALMEIDA, 2017).

As part of the studies and discussion, the British Standards Institution (2017) published the PAS 96:2017, i.e. a guide intended to protect and defend food and drink from deliberate attacks.

3.3.2 Food Defense in Brazil

Brazil is internationally recognized for its agricultural vocation. It produces and exports meats, fruits, cookies, chocolates, wines, *cachaça*, special coffees, organic products, honey, dairy products, nuts and other products, which support the image of a competitive, innovative and sustainable country (AGÊNCIA BRASILEIRA DE PROMOÇÃO DE EXPORTAÇÕES E INVESTIMENTOS, 2022). In the food sector, the National Health Surveillance Agency (*Agência Nacional de Vigilância Sanitária*, Anvisa) coordinates, supervises, and controls the activities of registration, inspection, surveillance, and risk control, and is responsible for establishing norms and quality standards (BRASIL, 2022). This agency has a library that gathers documents and all the current food regulations. Added to this is the fact that the Ministry of Agriculture, Livestock and Supply (Mapa) performs activities throughout the country related to the areas of safety, quality and fraud in food related to agricultural defense.

Research addressing food defense in Brazil is found in Table 3, including: Figueira (2018), Chammem et al. (2019), Lopes, et al. (2020).

Although it has active laws and bodies, Brazil and countries such as Argentina and China usually present a lower classification regarding food quality and safety scores, even though there are internal control programs and verification of origin in commercial partner countries, for example, some members of the European Union (CHAMMEN et al., 2018). These data, if compared to the current situation of actions in food defense, unveil the vulnerability, considering the lack of national laws pertinent to intentional actions of food contamination.

According to Chammen et al. (2018), Rasff, a European platform for alerts on public health risks related to food safety, showed 23% of observed notifications corresponding to food originating from Brazil, especially meat products and seasonings containing food pathogens above the permitted limits.

Despite the relevance of the topic to strengthen the food chain, few countries have established the principles in food defense as a legal requirement, including Brazil (LOPES et al., 2020). Indeed, Brazil, when compared to major economies, presents a limited number of companies prepared to meet food defense requirements (FIGUEIRA, 2018).

Although food defense is not a legal requirement in Brazil, it has taken on an increasingly important role in Brazilian programs, notably those related to dairy products, as many of the producers need to meet foreign regulatory requirements for exports to these markets (LOPES et al., 2020).

Among the measures taken - not exactly targeted to food defense, but which can be considered as one of the first steps - is the measure of December 4, 2009 by the Chamber of Foreign Relations and National Defense of the Government Council of Brazil, which edited CREDEN Resolution No. 02/2009, in which it formulated guidelines related to intelligence activities with the following resolution:

> Art. 1 Establish the following priorities for the agencies and entities integrating the Brazilian Intelligence system, which will direct their efforts, in the national and international spheres, to the areas listed below, all considered of equal relevance:
> *d) biodefense of the population, and of natural and agricultural resources. (BRASIL, 2023)

This measure, which defined guidelines to the areas of biodefense of the population and of agricultural resources, may impact the action against agroterrorism and food terrorism, making it possible to encompass the intelligence area in issues related to Food Defense. However, it is worth noting that Brazil's cultural diversity, as well as its continental size, may facilitate terrorism's access in the territory (FIGUEIRA, 2018).

3.3.3 Food Defense and the Armed Forces

Research by the Brazilian Ministry of Defense (BRAZIL, 2018) and by Mara; Mcgrath (2009), which addresses the military issue, are presented in Table 3. The supply chain is known to be long and complex, which makes a comprehensive examination of military food defense extremely difficult (MARA; MCGRATH, 2009).

After the events of September 11, 2001, the United States Armed Forces began to show more concern about intentional food contamination, with the development and implementation of methods to prevent or mitigate these actions. In the risk evaluation methodology, operational risk management is a tool developed by the medical services of the United States Air Force, with the purpose of acting in the articulation between food safety and food defense (SEVERINO; ALMEIDA, 2017).

In the USA, every military installation is required to have a food defense plan, in which the Army provides a framework for its development, and every installation must have a defense team defined and prepared (MARA; MCGRATH, 2009).

In developed nations, the goal of malicious actions against the agri-food chain is mainly to create political instability and undermine socioeconomic stability, impacting the military power (MOERMAN, 2018).

In Europe, the North Atlantic Treaty Organization (NATO) has the Allied Medical Publication (NORTH ATLANTIC TREATY ORGANIZATION, 2019): Defense Food Safety and Production Standards in Deployed Operations, which was approved by the member

nations of NATO at the Medical Standardization Council of the Military Committee. The agreement of the 28 member nations of the organization to use this publication is recorded in the Standard Agreements (Stanag), which defines processes, terms and conditions for common military-technical procedures among the alliance member nations (NORTH ATLANTIC TREATY ORGANIZATION, 2019).

In Brazil, the Ministry of Defense, following the evolution of the theme and interested in maintaining national security, included a new content in the Doctrine of Food and Nutrition of the Armed Forces - MD42-M-05, Chapter IV - Food Defense (BRAZIL, 2018). In 2019, the Chief of Logistics and Mobilization of the Ministry of Defense established the Food Defense Working Group, made up by food safety experts from the Army, Navy and Air Force, in order to draft the Food Defense Regulations of the Armed Forces (BRASIL, 2019c).

Among the actions of the group established, and as a result of the regulation prepared by the Ministry of Defense, we could mention:

- Diagnosis, mapping and evaluation of threats, defined as the ability of a malicious action to cause harm or damage to health, and of vulnerabilities, which indicates the ease that the threat has to perform a malicious action through the characterization of the target and facilities;
- Ensure that the food supply logistic chain is protected from contamination and disruption;
- Provide the mechanisms for health protection and operationality as provided in the Military Logistics Doctrine (MD42-M-02, 2016).

Food Defense measures should prioritize the operational health of the military personnel, including actions to prevent malicious contamination of food, in order to ensure health protection and military operations in Brazil and abroad.

The Brazilian Army, through a partnership with the *Universidade Federal de São Paulo* (Unifesp) and the Logistics Command (Colog) in 2020 carried out a pilot project in one of the 12 Military Regions. A Food Defense checklist was developed and applied to 24 Military Organizations (OM) located in the state of São Paulo, allowing the audited OMs to assess the degree of risk to intentional food service attacks. This article sought available data on threat evaluation and procedures in food defense in different environments. However, one limitation was the small number of available research in Brazil. Future studies evaluating the situation of food defense in Brazil are needed, proposing measures regarding the topic.

4 CONCLUSION

The current global scenario has introduced the need for greater attention to the issue of intentional food contamination. The history and existing concepts on the subject have promoted the development of threat evaluation methodologies through checklists and software, as well as procedures adopted in food defense plans. However, at the governmental level, the initiatives relevant to legislation are incipient, with the exception of the United States of America. In Brazil, where the concepts of food defense are relatively new and little researched, the Armed Forces, through the establishment of a working group assisted by its technical staff and the

partnership with Unifesp, have been working to deepen the issue, following the good practices of the global military context, which pays special attention to the subject.

Facing the countless forms of malicious actions of food contamination that, although uncommon, may have serious consequences, it is necessary to handle food defense as a national security policy, preserving the consumer's health, political and social stability, and maintaining the operational health of human resources and the Armed Forces.

AUTHORSHIP AND COLLABORATIONS

All authors participated equally in elaborating the article.

REFERENCES

ALVES, J. B. Food Defense: um instrumento contra o terrorismo e a criminalidade no sector alimentar. **Revista Militar**, Lisboa, n. 2637, 2021. Available from: https://www.revistamilitar.pt/artigo/1586. Access: April 25, 2023.

ANDRADE, E. L. I.; OLIVEIRA, G. C.; SILVA, O. F. S. Food Defense: do conceito às atuais exigências do mercado internacional. **Research, Society and Development**, São Paulo, v. 10, n. 17, p. 1-14, 2021. Available from: https://rsdjournal.org/index.php/rsd/article/view/24175. Access: April 25, 2023.

AGÊNCIA BRASILEIRA DE PROMOÇÃO DE EXPORTAÇÕES E INVESTIMENTOS. **Alimentos, Bebidas e Agronegócio**. Brasilia, DF: APEX, 2022. Available from: https://apexbrasil.com.br/. Access: Oct. 2, 2022.

ASSOCIATION FRANÇAISE DE NORMALISATION. **Guide Méthologique Food Defense** – Bonnes pratiques et retours d'expérience. Paris: Afnor, 2015. Available from: https://draaf.nouvelle-aquitaine.agriculture.gouv.fr/IMG/pdf/Guide-food-defense-AFNOR_2015_cle82f6d8.pdf. Access: Sept. 30, 2022.

BASHURA, J. P. Food defense: Back to the basics. **In**: DETWILER, D. (ed.). **Building the Future of Food Safety Technology**. London: Academic Press, 2020. p. 85-101.

BRAZIL. Agência Brasileira de Inteligência. **Legislação sobre SISBIN**. Brasilia, DF: Abin, 2023.

BRAZIL. Agência Nacional de Vigilância Sanitária. **Biblioteca de alimentos**. Brasilia, DF: Agência Nacional de Vigilância Sanitária, 2022. Available from: www.gov.br/anvisa/pt-br/assuntos/regulamentacao/legislacao/bibliotecas-tematicas/arquivos/biblioteca-de-alimentos. Access: Sept. 27, 2022.

BRAZIL. Exército. Dia da Intendência. **Noticiário do Exército**, Centro de Comunicação do Exército, Brasília, DF, 12 abr. 2019a. Available from: https://www.eb.mil.br/documents/16541/9533050/alusivo+dia+intendencia.pdf/9eede1f2-b94b-0a80-a71f-eed04e643bbb. Access: March 15, 2023.

BRAZIL. Ministry of Agriculture, Livestock and Supply (*Ministério da Agricultura, Pecuária e Abastecimento*). Ministério proíbe venda de azeite de oliva de seis marcas após descoberta de fraudes. **Portal** Único **do Governo**, Brasília, DF, 5 jul. 2019b. Available from: https://www.gov.br/agricultura/pt-br/assuntos/noticias/ministerio-proibe-venda-de-azeites-de-oliva-de-seis-marcas. Access: Sept. 19, 2019.

BRAZIL. Ministry of Defense. **Ordinance N° 13/ MD, March 23, 2018**. Passes the Doctrine of Food and Nutrition - MD42-M-05. Brasilia, DF: Federal Official Gazette, 2018.

BRAZIL. Ministry of Defense. **Ordinance N° 215, January 16, 2019**. Established the Work Group (WG) related to the project on Food Defense by the Ministry of Defense. Brasilia, DF: Federal Official Gazette, 2019c.

BRAZIL Ministry of Health. *Secretaria de Ciência, Tecnologia e Insumos Estratégicos. Departamento de Ciência e Tecnologia*. **Diretrizes metodológicas**: Sistema GRADE – manual de graduação da qualidade da evidência e força de recomendação para tomada de decisão em saúde. Brasilia, DF: Ministry of Health, 2014.

BRITISH STANDARD INSTITUTION. **PAS 96:2017**. Guide to protecting and defending food and drink from deliberate attack. London: British Standard Institution, 2017. Available from: www.food.gov.uk/sites/default/files/media/document/pas962017_0.pdf. Access: Sept. 19, 2021.

BUCHANAN, R. L.; APPEL, B. Combining analysis tools and mathematical modeling to enhance and harmonize food safety and food defense regulatory requirements. **International Journal of Food Microbiology**, Bethesda, v. 139, n. 1, p. 48-56. 2010. Available from: https://pubmed.ncbi.nlm.nih.gov/20149936/. Access: April 25, 2023.

CAVALHEIRO, A.; RUIZ, V. L. de A.; KUSHIDA, M. M. Food defense e publicly available specification 96/2017: releitura e importância para a cadeia de alimentos de origem animal brasileira. **Segurança Alimentar e Nutricional**, Campinas, v. 28, p. 1-10, 2021. Available from: https://periodicos.sbu.unicamp.br/ojs/index.php/san/article/view/8661489. Access: March 20, 2023.

CENTRE FOR THE PROTECTION OF NATIONAL INFRASTRUCTURE. **Critical National Infrastructure**. London: National Protective Security Authority, 2021. Available from: https://www.cpni.gov.uk/critical-national-infrastructure-0#sthash.NfPnzlNO.dpuf. Access: Sept. 26, 2022.

CHAMMEM, N.; ISSAOUI M.; DE ALMEIDA, A. I. D.; DELGADO, A. M. Food crises and food safety incidents in European Union, United States, and Maghreb Area: current risk communication strategies and new approaches. **Journal of AOAC International**, Oxford, v. 101, n. 4, p. 923-938, 2018.

DALZIEL, G. R. **Food Defense incidents 1950-2008**. A Chronology and analysis of incident involving the malicious contamination of the food supply chain. Singapore: Nanyang Technological Universal, 2009.

DAVIDSON, R. K.; ANTUNES, W.; MADSLIEN, E. H.; BELENGUER, J.; GEREVINE, M.; PEREZ, T. T.; PRUGGER. R. From Food Defence to food supply chain integrity. **British Food Journal**, Bingley, v. 119, n. 1, p. 52-66, 2017.

DEFENSE LOGISTICS AGENCY. **The Nation's Combat Logistics Support Agency DLA Troop. Support food defense checklist**. Virginia: DLA Troop, 2016. Available from: https://www.usa.gov/federal-agencies/defense-logistics-agency. Access: Oct. 21, 2018.

FOOD AND DRUG ADMINISTRATION. **CARVER + Shock Primer**. An overview of the Carver Plus shock Method for Food Sector Vulnerability. Silver Spring: U. S. Food & Drug, 2009. Available from: https://www.fda.gov/food/food-defense-initiatives/carver-shock-primer. Access: Jan. 7, 2018.

FEDERAL BUREAU OF INVESTIGATION. **Agroterrorism Training Exercise to be Held in Seattle**. Washington, D.C.: FBI, 2007. Available from: https://archives.fbi.gov/archives/news/pressrel/press-releases/agroterrorism-training-exercise-to-be-held-in-seattle. Access: Oct. 21, 2022.

FOOD PROTECTION AND DEFENSE INSTITUTE. **Food protection and Defense**. Minnesota: University of Minnesota, 2022. Available from: http://foodprotection.umn.edu. Access: Sept. 30, 2022.

FIGUEIRA, L. C. **Os conceitos de defesa dos alimentos (Food Defense) e fraude em alimentos (Food Fraud) aplicados em fábrica de temperos cárneos: um estudo de caso**. 2018. Dissertação (Mestrado em Engenharia de Alimentos) – *Universidade de São Paulo*, São Paulo, 2018.

FRITSCHE, J. Recent developments and digital perspectives in food safety and authenticity. **Journal of Agricultural and Food Chemistry**, Washington, D.C., v. 66, n. 29, p. 7562-7567, 2018. Available from: https://pubmed.ncbi.nlm.nih.gov/29920081/. Access: April 25, 2023.

GLOBAL FOOD SAFETY INITIAVE FOUNDATION. Guidance Document. Paris: GFSI, 2020. Available from: https://mygfsi.com. Access: Dec. 10, 2021.

HASTINGS, M. **Inferno**: O mundo em guerra 1939-1945. São Paulo: Intrínseca, 2012.

INDIANA. State Department of Health. **A guide to developing a food defense plan for food establishments**: Indiana State Department of Health Food Protection Program. Indianapolis: ISDH, 2011. Available from: https://www.in.gov/health/food-protection/food-defense/. Access: April 25, 2023.

INTERNATIONAL FEATURED STANDARDS. **Food Standard for assessing product and process compliance in relation to food safety and quality**. Berlin: IFS, 2020, Available from: https://www.ifs-certification.com/images/ifs_documents/IFS_Food_v7_standard_EN_1679760824.pdf. Access: Sept. 30, 2022.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. **Food Safety System Certification** – ISO 22000. Geneva: International Organization for Standardization, 2019. Available from: www.iso.org/iso-22000-food-safety-management.html. Access: March 15, 2023.

KRAFT FOODS. **Food Defense Supplier Guidelines**. Silver Spring: U. S. Food & Drug, 2022. Available from: https://kraftheinzsupplier.com/. Access: Oct. 20, 2018.

LEE, B.; FENOFF, R.; SPINK, J. Routine activities theory and food fraud victimization. **Security Journal**, New York, n. 35, p. 506–530, 2021. Available from: www.doi.org/10.1057/s41284-021-00287-1. Access: Sept. 30, 2022.

LOPES, L. O. *et al*. Food defense: Perceptions and attitudes of Brazilian dairy companies. **Journal of Dairy Science**, Nebraska, v. 103, n. 9, p. 8675-8682, 2020. Available from: https://www.sciencedirect.com/science/article/pii/S0022030220304689. Access: April 25, 2023.

MANNING, L. Food defence: refining the taxonomy of food defence threats. **Trends in Food Science & Technology**, Amsterdam, v. 85, p. 107-115, 2019. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0924224418307520. Access: April 25, 2023.

MANNING, L.; SOON, J. M. Food safety, food fraud, and food defense: a fast evolving literature. **Journal of Food Science**, Bethesda, v. 81, n. 4, p. 823-34, 2016. Available from: https://pubmed.ncbi.nlm.nih.gov/26934423/. Access: April 25, 2023.

MANNING, L. Food defense: types of threat, defense plans, and mitigation strategies **In**: KNOWLES, M. E.; ANELICH, L. E.; BOOBIS, A. R.; POPPING, B. **Present Knowledge in Food Safety**: A risk-based approach through the food chain. London: Academy Press; 2023. p. 536-48

MARA, A.; MCGRATH, L. **Defending the military food supply acquisition, preparation, and protection of food at U.S. Military installations**. Washington, D.C.: National Defense University Center for Technology and National Security Policy, 2009.

MCKAY, C.; SCHARMAN, E. J. Intentional and Inadvertent Chemical of Food, Water and Medication. **Emergency Medicine Clinics of North America**, Bethesda, v. 33, n. 1, p. 153-177, 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/25455667/. Access: April 25, 2023.

MOERMAN, F. Food Defense. **In**: GRUMEZESCU, A.; HOLBAN, A. M. (ed.). **Food Control and Biosecurity**. Leuven: Academic Press; 2018.

MOHER, D.; LIBERATI, A.; TETZLAFF, J.; ALTMAN, D. G.; ALTMAN, D.; ANTES, G. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. **PLoS Medicine**, San Francisco, v. 6, n. 7, 2009. Available from: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1000097. Access: Sept. 10, 2022.

NATIONAL ACADEMY OF SCIENCES. Addressing foodborne threats to health: policies, practices, and global coordination. **Institute of Medicine (US) Forum on Microbial Threats**, Bethesda, 2006. Available from: https://pubmed.ncbi.nlm.nih.gov/21850788/. Access: April 25, 2023.

NORTH ATLANTIC TREATY ORGANIZATION. **Allied Medical Publication**: Food Safety, Defence, and Production Standards in Deployed Operations. Brussels: NATO, 2019. Available from: https://www.coemed.org/files/stanags/03_AMEDP/AMedP-4.6_EDB_V1_E_2556.pdf. Access: Sept. 10, 2022.

PITALUGA, C. M.; LE BOURLEGAT, C. Transições para sistemas alimentares sustentáveis: contribuições e desafios da Conab e Comsan no MS. **Revista Grifos**, Chapecó, v 31, n 57, p 1-26, 2022.

PORTUGAL. Presidência do Conselho de Ministros. **Resolução do conselho de ministros n. 19/2013, de 21 de março de 2013**. Conceito estratégico de Defesa Nacional de defesa nacional. Lisbon: Diário da República, 2013. Available from: https://dre.pt/dre/detalhe/resolucao-conselho-ministros/19-2013-259967. Access: April 25, 2023.

PRAIA, E. F. **Avaliação da implementação de requisitos de food defense em unidades industriais alimentares**. 2017. Dissertação (Mestrado em Medicina Veterinária) – *Universidade de Lisboa*, Lisbon, 2017.

PRAIA, E. F.; HENRIQUES A. R. Assessing the implementation of food defense requirements in industrial meat-based food processors. **Brazilian Journal of Food Technology**, Campinas, v. 26, n. 24, p. 1-14, 2021. Available from: https://www.scielo.br/j/bjft/a/TNfqsx5WsyR5d7qwBDdtRyx/?lang=en. Access: April 25, 2023.

RAMBAUSKE, D.; CARDOSO, T. A. O.; NAVARRO, M. B. M. A. Bioterrorismo, riscos biológicos e as medidas de biossegurança aplicáveis ao Brasil. **Physis**, São Paulo, v. 24, n. 4, p. 1181-1205, 2014. Available from: https://www.scielo.br/j/physis/a/FQHTMb8P9ZHVqbvffqyPP7N/abstract/?lang=pt. Access: April 25, 2023.

RAPID ALERT SYSTEM FOR FOOD AND FEED. **Food and feed safety alerts**. Brussels: RASFF, 2022. Available from: https://food.ec.europa.eu/safety/rasff. Access: Sept. 30, 2022.

ROBSON, K., DEAN, M., HAUGHEY, S., ELLIOTT, C. A comprehensive review of food fraud terminologies and food fraud mitigation guides. **Food Control**, Belfast, v. 120, p. 283-296, 2021. Available from: https://pure.qub.ac.uk/en/publications/a-comprehensive-review-of-food-fraud-terminologies-and-food-fraud. Access: April 25, 2023.

SCHVEITZER M. C.; ZOBOLI, E. L. C. P.; VIEIRA, M. M. S. Nursing challenges for universal health coverage: a systematic review. **Revista Latino-Americana de Enfermagem**, São Paulo, v. 24, p. 1-14, 2016. Available from: dx.doi.org/10.1590/1518-8345.0933.2676. Access: June 22, 2023.

SEVERINO, P. R. **Food Defense e a sua relação com as normas IFS V6, BRC V7 e FSSC 22000**. 2016. 105 f. Dissertação (Mestrado em Engenharia de Alimentos – Qualidade e Segurança Alimentar) - *Universidade de Lisboa*, Lisbon, 2016.

SEVERINO, P.; ALMEIDA, D. **Food Defense**: sistemas de gestão contra o terrorismo alimentar. Portugal: Agrobook, 2017. 142 p. v. 1.

SOBEL J. Food and Beverage Sabotage. **In**: KATZ, R.; ZILINSKAS, R. A. **Encyclopedia of Bioterrorism Defense**. Hoboken: Wiley-Blackwell, 2005.

SPINK, J.; EMBAREK, P. B.; SAVELLI, C. J.; BRADSHAW, A. Food fraud data collection needs survey. **Science of Food**, New York, v. 3, n. 8, p. 1-8, 2019. Available from: https://www.nature.com/articles/s41538-019-0036-x. Access: April 25, 2023.

UNITED STATES OF AMERICA. Department of Agriculture. **Food Safety and Inspection Service. Food Defense Guidelines for Slaughter and Processing Establishments**. Washington, D.C.: USDA, 2009a. Available from: https://www.fsis.usda.gov/sites/default/files/media_file/2020-08/SecurityGuide.pdf. Access: Jan. 20, 2019.

UNITED STATES OF AMERICA. Department of Agriculture. **Functional Food Defense Plans**. Washington, D.C.: USDA, 2018. Available from: https://www.fsis.usda.gov/food-safety/food-defense-and-emergency-response/food-defense/functional-food-defense-plans. Access: Sep. 20, 2022.

UNITED STATES OF AMERICA. Food and Drug Administration. **CARVER + Shock Primer, An Overview of the Carver Plus Shock Method for food Sector Vulnerability Assessments**. Washington, D.C.: FDA, 2009b. Available from: https://www.fda.gov/food/food-defense-initiatives/carver-shock-primer. Access: Sept. 06, 2021.

UNITED STATES OF AMERICA. Food and Drug Administration. **Food Safety Modernization Act (FSMA)**. Washington, D.C.: FDA, 2011. Available from: https://doi.org/10.1016/b978-0-12-805470-3.00007-7. Access: May 03, 2018.

UNITED STATES OF AMERICA. Food and Drug Administration. **Food Defense Awareness**. Washington, D.C.: FDA, 2014.

UNITED STATES OF AMERICA. Food and Drug Administration. **Food Defense Initiative**. Washington, D.C.: FDA, 2022. Available from: https://www.fda.gov/food/food-defense-initiatives/food-and-agriculture-sector-and-other-related-activities. Access: Sept. 25, 2022.

VANÇAN, A. C.; RODRIGUES, M. V. O. Massacre do Paralelo 11 e os Direitos Fundamentais a partir do Direito de Memória Indígena e a descolonização do Direito Brasileiro. **Revista Latino-Americana de Estudos em Cultura e Sociedade**, Foz do Iguaçu: v. 7, n. 1, p. 1-16, 2021. Available from: https://periodicos.claec.org/index.php/relacult/article/view/2135/1436. Access: April 25, 2023.

WORLD HEALTH REPORT. Washington, D.C.: World Health Organization, Aug. 2007. Retrieved from: www.who.int/whr/2007/07_overview_en.pdf. Access: Sept. 20, 2022.

WORLD HEALTH ORGANIZATION. **Terrorist threats to food**: guidance for establishing and strengthening prevention and response systems. Geneva: WHO, 2008.

ARTICLE DOI 10.52781/cmm.a106

Does physical fitness level affect body balance and physiological responses after a 4 km load carriage task?

¿El nivel de aptitud física afecta el equilibrio corporal y las respuestas fisiológicas después de realizar un ejercicio en el cual se transporta una carga durante 4 km?

Abstract: It is not known whether higher physical fitness level (PFL) is really an advantage for military personnel in operational tasks. Objective: To investigate the effects of PFL on body balance and physiological responses in a 4 km load carriage task. Body balance was analyzed (n=22) using personal equipment (22 kg) before and after the 4km load carriage (treadmill). Heart rate (HR) was assessed throughout the task and PFL considered the result of the most recent Brazilian Army physical fitness test. Two-way mixed ANOVA and independent t-tests were applied ($p<0.05$). Load carriage significantly increased sway area (72.21±30.94 to 102.68±48.57 mm^2) and other balance variables, without effects of PFL. The group with excellent PFL had lower mean HR values (104.55±9.37 bpm) compared with the group with good or very good PFL (115.07±10.14 bpm). Carrying 22 kg for 4 km worsened body balance and the military personnel with better PFL performed this task with less cardiac effort.

Keywords: postural control; cardiovascular system; weight-bearing; military sciences; military personnel.

Resumen: No está claro si un mejor nivel de aptitud física (PFL) es realmente una ventaja para el personal militar en funciones operativas. Propósito: investigar los efectos del PFL en el equilibrio corporal y las respuestas fisiológicas, en un ejercicio en el cual se transporta una carga durante 4 km. Se registró el equilibrio corporal (n=22) utilizando el equipo personal (22 kg), antes y después del transporte de la carga durante 4 km (cinta ergométrica). La frecuencia cardíaca (FC) se evaluó a lo largo del ejercicio, y con el resultado más reciente de la prueba de aptitud física del ejército se consideró el PFL. Se aplicaron pruebas del tipo ANOVA de diseño mixto bidireccional y t independientes ($p<0.05$). El transporte de carga aumentó significativamente el área de oscilación (72,21±30,94 a 102,68±48,57 mm2) y otras variables de equilibrio, sin efecto del PFL. Se observaron valores medios de FC más bajos para el grupo con el PFL excelente (104,55±9,37 lpm), en comparación con el grupo con el PFL buena/muy buena (115,07±10,14 lpm). Transportar 22 kg durante 4 km empeoró el equilibrio corporal y los militares con mejor PFL realizaron este ejercicio con menos esfuerzo cardíaco.

Palabras clave: control postural; sistema cardiovascular; soporte de peso; ciencias militares; militares.

Míriam Raquel Meira Mainenti[1]
miriam.mainenti@hotmail

Ricardo Alexandre Falcão[1]
ricfal9@gmail.com

Jonathan Vieira da Silva[1]
mattbarryan@gmail.com

Victor Vinícius Ribeiro de Lima[1]
victorvrlima@gmail.com

Fabio Alves Machado[2]
machado.fa@gmail.com

Adriane Mara de Souza Muniz[1]
adriane_muniz@yahoo.com

Luis Aureliano Imbiriba[3]
luis_aureliano@hotmail.com

[1]Exército Brasileiro. Escola de Educação Física do Exército. Rio de Janeiro, RJ, Brasil.

[2]Exército Brasileiro. Instituto de Pesquisa da Capacitação Física do Exército. Rio de Janeiro, RJ, Brasil.

[3]Universidade Federal do Rio de Janeiro. Escola de Educação Física e Desportos. Rio de Janeiro, RJ, Brasil.

Received: June 23, 2022
Approved: Apr 17, 2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

Military personnel are required to perform many combat qualification and training activities. These physical and operational tasks involve complex challenges of varying degrees of difficulty, such as physical activities and strenuous tactical and technical maneuvers. For example, military troops walk long distances carrying heavy loads of supplies, ammunition, and equipment, besides facing psychological and physical obstacles, often resulting in what the literature calls combat fatigue (MALA et al., 2015).

The load carried by soldiers is usually stored in backpacks or packages that tend to require a mechanical body response and postural adjustments to maintain standing balance (KNAPIK; REYNOLDS; HARMAN, 2004). Postural balance can be defined as the processes for maintaining the body within a base of support by the congruence between the inputs of the visual, proprioceptive, and vestibular systems and the appropriate outputs of the neuromuscular system (KLEINER; SCHLITTLER; SÁNCHEZ-ARIAS, 2011; SHUMWAY-COOK; WOOLLACOTT, 2016). Usually, this physical capacity is objectively measured by a force plate (DUARTE; FREITAS, 2010) to evaluate the displacement of the center of pressure (COP). This parameter refers to the location of the vector resulting from the ground reaction forces applied on the base of support, which constitutes of the base of the feet (WINTER, 1995). Many variables are estimated from the COP displacements, such as area, velocity, amplitude, standard deviation, and frequency, which help understand the individual's body sway pattern (DUARTE; FREITAS, 2010).

Previous studies showed that supporting a load (without carrying it) significantly increases the COP sway area, mean velocity, and sway path length (SPL) (GOLRIZ et al., 2015; HELLER; CHALLIS; SHARKEY, 2009; RUGELJ; SEVŠEK, 2011; ZULTOWSKI; ARUIN, 2008). However, the behavior of these COP-based variables after load carriage tasks, which are very common in the routine of military troops, who need to carry equipment and armaments by themselves, is still unknown. Although Dahl et al. (2016) evaluated the effect of this activity on postural alignment (but not postural balance), resulting in greater forward head posture after a six-minute walk with a two-strap backpack, their studied time (only six minutes) does not represent real occupational tasks.

Moreover, load carriage can clearly become very strenuous depending on the specific performance conditions, and measuring heart rate (HR) during the activity is a way to quantify the level of effort made by the troops. The scientific literature describes this parameter as a physiological marker of fatigue and effort used to quantify the stress resulting from physical training load (FERREIRA et al., 2017; FREITAS; MIRANDA; BARA FILHO, 2009). HR recording is a simple, non-invasive, and frequently applied method, which has been widely used to prescribe training loads due to its ease of use in monitoring the intensity of physical activities (LOPES; OSIECKI; RAMA, 2012).

Besides HR, rating of perceived exertion (RPE) is another physiological marker of physical activity intensity. This scale was developed by Gunnar Borg (1982) as a tool to quantify the perception of effort in a given task and is widely used for training prescription due to its low cost and easy application (ESTON, 2012). In general, studies on

the physiological demands of individuals who carry loads over long distances showed an increase in HR and other variables such as oxygen consumption and RPE (GILES et al., 2019; GRENIER et al., 2012; PIHLAINEN et al., 2014). The joint assessment of postural balance, HR, and RPE during a load carriage task shows biomechanical, neurological, and physiological responses. This integrated view would help evaluate the physical performance of soldiers in this operational task.

Brazilian operational military bases (which include long-distance load carriage tasks) require military units to have a high physical fitness level (PFL), and this level is classified as good, very good, or excellent in Brazilian Army (BRASIL, 2022). However, although military personnel are recognized as a well-conditioned group, it is not known whether higher PFL is really an advantage for operational tasks such as load carriage. Moreover, no study has assessed whether the aforementioned variables are associated with each other and could really promote an integrated view, as previously proposed. Individuals with better cardiopulmonary fitness are expected to have lower mean absolute HR during physical activities, according to a previous study (DU et al., 2005). However, to our knowledge, no study has evaluated the association between physiological demand and PFL for this specific military task: load carriage. We hypothesize that well-conditioned military personnel would perform load carriage tasks with lower body balance and physiological responses, suggesting a possible delay in the development of fatigue.

Studying the effects of load carriage on postural balance and physiological variables may show the physical repercussions of this task performed by many occupational groups, such as military personnel, both during training and in real-life scenarios. With this knowledge, military physical instructors will be able to develop specific strategies to minimize the effects and ensure the readiness of the troops even after a long-distance load carriage. Therefore, this study aimed to investigate the effects of PFL on body balance and physiological responses in a 4 km load carriage task and the relationship between balance and physiological changes caused by the task.

2 METHODS

2.1 Sample and study design

This cross-sectional observational study included a sample of 22 men from the Physical Education College of the Brazilian Army(EsEFEx), a military organization located in Rio de Janeiro, Brazil (convenience sample). Being men aged 18 to 30 years with a minimum score of "good" on the latest Army physical fitness test (APFT – *Teste de Aptidão Física*), which is applied every four months, were the inclusion criteria. These criteria represent the military personnel who usually perform load carriage tasks in the Brazilian Army: soldiers serving in operational bases, which require a minimum score of "good." No individual had a history of musculoskeletal or neurological disease. All participants completed and signed the informed consent form. This study was approved by the local Research Ethics Committee (Protocol No. 83493618.1.00000.5235).

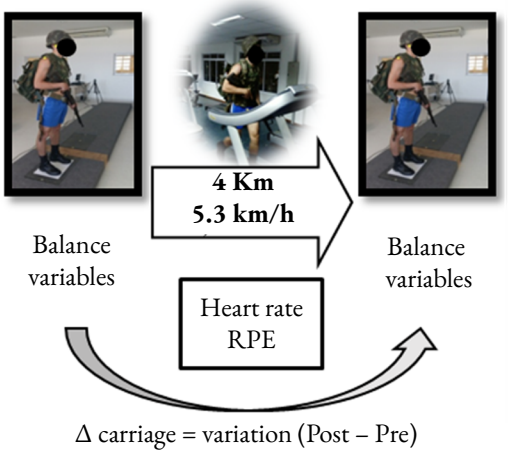
A sample size of 20 was estimated by G*Power (version 3.1.9.7, Germany) for the following parameters: power (0.80), coefficient α (0.05), and effect size (0.35). This study also used a F-tests and ANOVA (repeated measures, within-between interaction). Since no previous study had done this assessment (before and after load carriage with body balance variables), the effect size value was chosen to classify this effect as a "not high" effect size. Usually, 0.40 or 0.50 is adopted as the limit for high effects (for eta analysis), thus, a value just below it (0.35) was used in G*Power. In total, 22 soldiers were selected to prevent that possible dropouts could reduce the study analysis power.

2.2 Simulated 4 km road march

All participants walked the distance of 4 km in 45 minutes at a constant speed of 5.3 km/h on a treadmill (Technogym Excite Run 900, Italy) at the same time of the day, in a temperature and humidity controlled environment at the EsEFEx Biosciences Laboratory. This protocol was based on the characteristics of road marches established by the guidelines of the Brazilian Army (BRASIL, 2019). Participants wore their personal equipment (mean: 21.8±0.77 kg), which included a rifle, a helmet, a medium-sized backpack weighing 15 kg, suspenders, and a tactical belt with a one-liter water canteen attached on the left side, during the whole experimental protocol.

The experimental procedures were performed in the following order: (i) assessment of postural balance when carrying personal equipment; (ii) HR assessment (Polar FT1, Finland) and RPE when carrying load during a simulated 4 km road march on the treadmill; and (iii) assessment of postural balance with personal equipment after road march (Figure 1). All data for each participant were collected in about 80 minutes.

Figure 1 – Schematic representation of the experimental protocol for postural balance and physiological (heart rate and rating of perceived exertion – RPE) assessments



Source: prepared by the authors, 2023

All personal equipment was weighed on a Filizola® scale, model PL 2007 (Brazil), which was also used to measure the participants' total body mass. Their height was measured with a Sanny® stadiometer (Brazil), according to a standard protocol.

2.3 Assessment of postural balance (stabilometry)

A force plate (Bertec, USA) was used to evaluate the displacement of the center of pressure (COP). Three trials of postural balance assessment were performed to ensure greater data reliability (RUHE et al., 2010), and their mean was used for analysis. Each stabilometric trial lasted 80 seconds, with the initial 20 seconds discarded to avoid possible transient disturbances (CARROLL; FREEDMAN, 1993; LIN et al., 2008). The interval between each measurement was 45 seconds, during which participants remained seated, but without removing the personal equipment. Stabilometric data were collected at a sampling rate of 1 kHz and filtered using a 2nd order bidirectional Butterworth low-pass filter with a cutoff frequency of 5 Hz (DUARTE; FREITAS, 2010).

Participants were instructed to remain in a comfortable position, with their feet approximately shoulder width apart. The position of the participant's feet was marked on a sheet of paper on the force platform to avoid changes in the area of the base of support during the tests. All participants were instructed to avoid movements during the measurements and fixed their eyes on a point 3 m in front of them.

The following dependent variables were estimated from the COP displacement: sway area (mm^2), sway path length (SPL; mm), and, separately, velocity, standard deviation, and amplitude in the anterior-posterior (AP) and medial-lateral (ML) directions (PRIETO et al., 1996). These COP variables were estimated using specific routines in the MATLAB 2020 software (MathWorks, USA).

2.4 Assessment of physiological variables

During the simulated road march, HR was monitored and recorded every five minutes by a portable heart rate monitor (FT1, Polar, Finland). RPE was also recorded every five minutes, using the modified Borg scale, which ranged from 0 (no exertion) to 10 (maximal exertion) (BORG, 2000). Before the task, participants were introduced to the scale and the researchers highlighted the meaning of each number, stating, for example, that the number 5 did not refer to "moderate exertion," as many might think (since it is the midpoint between 0 and 10), but to "severe." Mean HR and mean RPE were estimated considering the nine measurements obtained during the 45-minute walk. Maximal heart rate (max HR) and RPE (max RPE), which represented the highest value measured in the last 15 minutes of load carriage, were also analyzed.

2.5 Physical fitness level (PFL)

The participants' PFL was obtained using their score on the latest Brazilian Army physical fitness test (APFT), which was recorded in individual institutional files. The APFT consists of a 12-minute run, floor push-ups, bar pull-ups, and sit-ups. Military personnel are classified into fitness scores according to their test results: I (insufficient), R (regular), G (good), VG (very good), or E (excellent) (BRASIL, 2022). The final PFL, which is recorded in the individual institutional file, is the worst score among the four tests.

To avoid selection bias and bias from other sources, some standard conducts were established: (i) eligibility data were assessed in the anamnesis form by specific questions; (ii) the researcher who helped the participant to complete this form did not evaluated him in the simulated 4 km road march; and (iii) the APFT scores were the last data included in the spreadsheet used for the analysis.

2.6 Data analysis

Initially, participants were divided into two groups according to their PFL: one group included participants with an excellent APFT score (EX; n = 11) and the other participants with a good or very good APFT score (GVG; n = 11). Data distribution was assessed using the Shapiro-Wilk normality test. In order to identify the effects of load carriage, considering PFL, two-way mixed ANOVA (for postural balance variables) and t-tests (for independent samples - cardiac behavior during the load carriage task: mean HR and max HR) were performed. For RPE, the PFL of groups was analyzed using Fisher's exact test, which compared the frequencies of RPE scores for both groups (EX vs. GVG).

Finally, Pearson's correlation tests between stabilometric and HR variables were used to assess the relationship between changes in postural balance caused by load carriage (Δ carriage, for variables with significant changes from the previous analysis) and the cardiac demand of the task (mean HR and max HR).

Data were presented as mean ± standard deviation and frequency. All analyses were performed using IBM SPSS Statistics version 27. Statistically significant differences were considered for p-values < 0.05. The correlation coefficient (r) was considered very strong when $r \geq 0.9$, strong when r ranged from 0.6 (inclusive) to 0.9, regular when r ranged from 0.3 (inclusive) to 0.6, and weak when r ranged from 0 to 0.3 (CALLEGARI-JACQUES, 2003).

3 RESULTS

We evaluated 22 soldiers (27.09 ± 2.07 years of age, 75.70 ± 9.14 kg body weight, and 1.77 ± 0.07 m tall). Regarding the latest APFT score, 31.80% of participants had good (G) PFL, 18.20% had very good (VG) PFL, and 50.00% had excellent (EX) PFL. The anthropometric characteristics of the EX group (n = 11) were 27.09 ± 1.97 years of age, 70.26 ± 7.73 kg body

weight, and 1.75 ± 0.07 m tall. Participants in the GVG group (n = 11) were 27.09 ± 2.26 years old, 1.79 ± 0.07 m tall, and weighed 81.13 ± 7.13 kg.

Two-way mixed ANOVA showed changes due to the main effect of load carriage, with significantly increases in sway area (F = 13.174; p = 0.002), medial-lateral (ML) standard deviation (F = 16.836; p = 0.001), and ML amplitude (F = 26.648; p < 0.001) (Table 1). We observed no difference for the main effect of PFL or interaction.

Table 1 – Body balance variables before and after the 4 km load carriage for the total sample (n = 22) and for the groups with excellent (n = 11) and good or very good (n = 11) physical fitness level

Variables	Before load carriage	After load carriage
Sway area (mm2)		
EX	69.03 ± 38.59	94.04 ± 57.18
GVG	75.39 ± 22.33	111.32 ± 38.98
Total	72.21 ± 30.94	102.68 ± 48.57*
Mean ML velocity (mm/s)		
EX	2.61 ± 0.75	2.53 ± 0.73
GVG	2.56 ± 0.50	2.71 ± 0.56
Total	2.59 ± 0.62	2.62 ± 0.64
Mean AP velocity (mm/s)		
EX	4.51 ± 0.76	4.37 ± 0.93
GVG	4.68 ± 1.15	4.86 ± 0.97
Total	4.59 ± 0.95	4.61 ± 0.96
ML standard deviation (mm)		
EX	1.88 ± 0.71	2.46 ± 0.97
GVG	1.80 ± 0.41	2.56 ± 0.55
Total	1.84 ± 0.57	2.51 ± 0.77*
AP standard deviation (mm)		
EX	3.28 ± 1.01	3.64 ± 1.55
GVG	3.72 ± 0.83	3.79 ± 1.01
Total	3.50 ± 0.93	3.71 ± 1.28
ML amplitude (mm)		
EX	9.88 ± 3.44	12.15 ± 4.30
GVG	9.37 ± 1.95	13.47 ± 2.40
Total	9.62 ± 2.74	12.81 ± 3.46*
AP amplitude (mm)		
EX	17.24 ± 5.07	17.67 ± 5.66
GVG	19.10 ± 3.81	19.91 ± 5.18
Total	18.17 ± 4.48	18.79 ± 5.41
SPL (mm)		
EX	340.11 ± 60.55	328.33 ± 71.38
GVG	347.05 ± 65.98	362.36 ± 62.94
Total	343.58 ± 61.90	345.34 ± 67.94

Data are presented as mean ± standard deviation. AP: anterior-posterior direction.

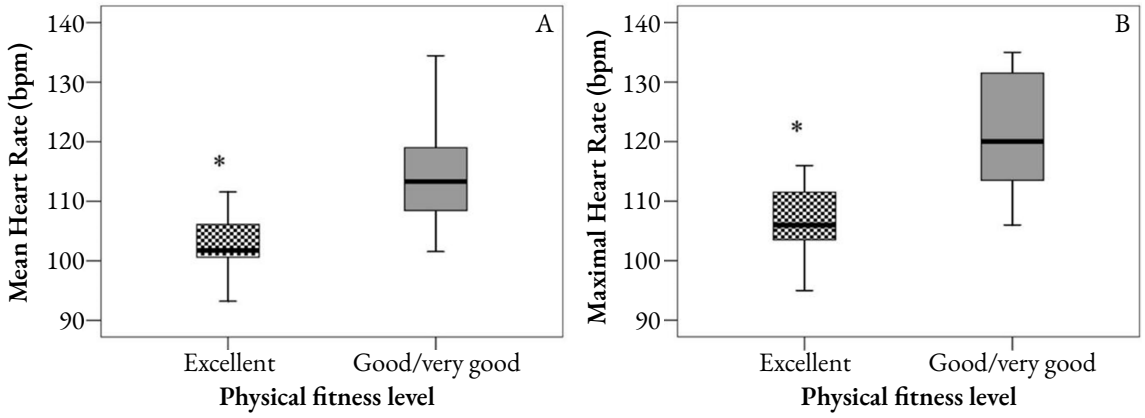
EX: group with excellent PFL (n = 11). GVG: group with good or very good PFL (n = 11).

ML: medial-lateral direction. SPL: sway path length. * p< 0.05

Source: prepared by the authors

Regarding cardiac behavior, according to PFL, the difference was statistically significant between the groups. Participants with excellent PFL showed less cardiac effort than participants with good or very good PFL, with lower mean and maximal HR values (Figure 2).

Figure 2 – Boxplots (minimum, 1st quartile, median, 3rd quartile, and maximal values) for mean heart rate (A) and maximal heart rate (B).
***Statistical difference between the groups (t-test for independent samples)**



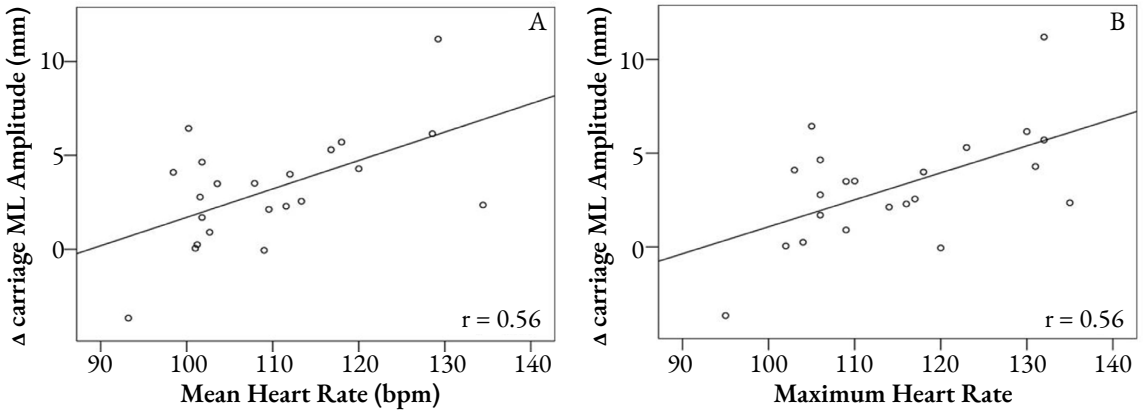
Maximal Heart Rate = Maximum heart rate

Source: prepared by the authors

Despite the difference found for heart rate, RPE showed no difference between the EX and GVG groups for both mean and max RPE. The analysis of mean RPE values for the EX group showed that seven participants reported score 2 and four reported score 3. In the GVG group, four participants reported 2 and seven reported 3. Fisher's exact test showed no statistical difference for mean RPE ($p = 0.40$). Regarding max RPE, six participants in the EX group reported 2, four reported 3, and one reported 4. In the GVG group, two participants reported 2, eight reported 3, and one reported 4. Similarly to mean RPE, max RPE showed no statistical difference in Fisher's exact test ($p = 0.19$).

Finally, cardiac variables showed a significant, positive, and regular correlation with Δ carriage ML standard deviation (mean HR: $r = 0.50$, $p = 0.019$; max HR: $r = 0.46$, $p = 0.033$) and Δ carriage ML amplitude (mean HR: $r = 0.56$, $p = 0.007$; max HR: $r = 0.56$, $p = 0.007$) (Figure 3). Another significant correlation was found between mean HR and Δ carriage sway Area ($r = 0.45$, $p = 0.038$). The correlation between max HR and Δ carriage sway Area showed no significant results ($r = 0.38$, $p = 0.083$).

Figure 3 – Scatter plots for Δ carriage ML amplitude vs. mean heart rate (A) and maximum heart rate (B)
r: Pearson correlation coefficient



Source: prepared by the authors

4 DISCUSSION

This study aimed to identify the effects of 4 km load carriage (with about 22 kg) on postural balance and cardiac responses, comparing individuals with different physical fitness levels. The results showed that: (i) carrying the personal equipment for 4 km changed sway area, ML amplitude, and ML standard deviation; (ii) PFL was associated with HR during treadmill walking, but not with changes in postural control; and (iii) postural and physiological changes resulting from load carriage have a positive correlation.

4.1 Postural balance and load carriage

The changes observed in postural balance after load carriage may be due to a possible fatigue caused by the task. In prolonged military exercises, carrying personal equipment seems to lead to significant lower limb muscle fatigue, which affects body balance, increasing the challenge and changing proprioception (ARLIANI et al., 2013; MARCHETTI; ORSELLI; DUARTE, 2013). Maintaining postural balance after minor disturbances is difficult due to changes in position sense (ALLEN; PROSKE, 2006) and ankle joint stability (YAGGIE; MCGREGOR, 2002), and the impaired synergy of hip and knee muscles to react to these disturbances (GRIBBLE; HERTEL, 2004). Moreover, fatigue affects neuromuscular function itself, worsening the ability to contract muscles quickly and appropriately for postural adjustments.

Many studies point to fatigue as a factor that impairs postural balance (ALLEN; LEUNG; PROSKE, 2010; NARDONE et al., 1997; RAHNAMA et al., 2003). For example, Baroni et al. (2011) confirmed the direct dependency relationship between fatigue and

postural balance (in which increased fatigue leads to greater imbalance), but their study used a cycle ergometer fatigue protocol, unlike our study. Other authors found similar results using isokinetic dynamometry of isolated muscles (GRIBBLE; HERTEL, 2004; YAGGIE; MCGREGOR, 2002). Our study shows that postural balance is modulated by a previous load carriage task and the positive correlations observed between postural and physiological changes enhance this discussion, highlighting that the higher the cardiac effort during the task, the worse the body balance. Since this is an observational cross-sectional study, this correlation does not guarantee a cause and effect relationship, but considering all these results, the integrated view (biomechanical, neurological, and physiological behavior) mentioned in the introduction section seems to make sense.

Our results showed significant changes in ML postural adjustments after load carriage, which could be due to a possible load asymmetry in the limbs (ZULTOWSKI; ARUIN, 2008). During the 4 km walk, participants were allowed to carry the rifle in the position they considered most comfortable, but they alternated the weapon between the two hands, which may have caused the differences observed mainly in the ML axis. The human body has postural strategies to maintain balance in relation to the axes of movement. Studies observe more ankle and hip strategies for the AP axis (HORAK; NASHNER, 1986) and the load-unload strategy for the ML axis (WINTER, 1995), which shows a certain postural asymmetry. Thus, unsurprisingly, the ML axis had the greatest effect on stabilometric parameters after physical demand in this study.

To our knowledge, this study was the first to assess postural balance after a long-distance walk with load carriage. The only study that addressed static postures after load carriage assessed postural alignment after a six-minute walk. Dahl et al. (2016) found an increase in neck hyperextension after the walk, but did not analyze postural balance.

4.2 Physical fitness level relationship with heart rate and stabilometric changes

Our results showed that the physical fitness level was associated with cardiac behavior in the load carriage task. Participants with better APFT scores performed the 4 km walking with lesser cardiac effort, reflected in lower mean and maximal HR values. In addition, the increase in post-walking stabilometric parameters was not the same for all individuals in the sample. Those who presented more changes in postural balance after the 4 km walk are those who also showed greater cardiovascular effort. Participants who showed better physical fitness were probably more adapted to the task, which may have contributed to less HR adjustments during low physical effort.

Although the association between cardiac behavior in a long-distance load carriage task and fitness levels has never been investigated, the results corroborated the traditional findings of exercise physiology studies. Individuals with better fitness levels would present better efficiency/

economy of movement, demanding less of their cardiovascular system in a given physical task (LITLESKARE et al., 2020). Although physical fitness level was found to have influence on the HR behavior, no impact on body balance was observed. The high level of experience of the participants and the low difficulty level of the balance assessment (60 s keeping upright position with personal equipment) may explain this result.

4.3 Limitations and highlights

No tests were made to specifically assess muscle peripheral fatigue associated with the 4 km walking, which is one of the limitations of the present study. Another important limitation was the use of a treadmill to simulate a road march in a controlled environment, when actual load carriage tasks are usually carried out by the troops on uneven terrain, with steep slopes, and under the most varied weather conditions. However, as this was the first study examining the effects of long-distance load carriage on postural balance, we opted to work in a controlled environment to allow a comprehensive and individualized follow-up.

Using the RPE scale with military service members is not an easy task. Since these individuals are usually physically fit (due to their military training), they commonly underestimate the perceived effort in most tasks. Thus, being familiar with the meaning of each of the scale's values is essential, which was employed in the present study. Finally, we note that among the studies issuing load carriage and support, a sample of 22 individuals is larger than many of them, further increasing the relevance of our findings.

5 CONCLUSIONS AND FUTURE PERSPECTIVES

Carrying 22 kg for 4 km worsened the body balance with modifications in the sway area, medial-lateral standard deviation and amplitude. Participants with better physical fitness level performed this task with less cardiac effort but no influence was observed on body sway. Finally, participants performing the 4 km load carriage with less cardiac effort also presented less postural balance variations, in function of load carriage.

Further research on this topic could evaluate heart rate behavior after the performance of the load carriage task in order to identify for how long military personnel are able to maintain conditions close to the pre-effort, which would improve the ability to accomplish assigned missions. Another suggestion is assessing the effects on postural balance of symmetrical load carriage and verifying whether these effects disappear, as usually occurs in load support tasks. Furthermore, verifying the modifications after load carriage under field conditions and for longer distances would also be valuable.

AUTHORSHIP AND CONTRIBUTIONS

Miriam Raquel Meira Mainenti, Ricardo Alexandre Falcão, Luis Aureliano Imbiriba – study conception and design; data collection, analysis, and interpretation; critical revision of the article for important intellectual content; final approval of the version submitted to *Coleção Meira Mattos*.

Jonathan Vieira da Silva, Victor Vinícius Ribeiro Lima – data collecttion, analysis, and interpretation; writing of the article; final approval of the version submitted to *Coleção Meira Mattos*.

Fabio Alves Machado – data interpretation; critical revision of the article for important intellectual content; final approval of the version submitted to the *Coleção Meira Mattos*.

Adriane Mara de Souza Muniz – data analysis and interpretation; critical revision of the article for important intellectual content; final approval of the version submitted to *Coleção Meira Mattos*.

REFERENCES

ALLEN, T. J.; PROSKE, U. Effect of muscle fatigue on the sense of limb position and movement. **Experimental Brain Research**, Bethesda, v. 170, n. 1, p. 30-38, 2006. Available from: https://pubmed.ncbi.nlm.nih.gov/16328298/. Access: April 20, 2023.

ALLEN, T. J.; LEUNG, M.; PROSKE, U. The effect of fatigue from exercise on human limb position sense. **Journal of Physiology**, Bethesda, v. 588, n. 8, p. 1369-1377, 2010. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2872740/. Access: April 20, 2023.

ARLIANI, G. G.; ALMEIDA, G. P. L.; SANTOS, C. V.; VENTURINI, A. M.; ASTUR, D. C.; COHEN, M. O efeito do esforço na estabilidade postural em jovens jogadores de futebol. **Acta Ortopédica Brasileira**, São Paulo, v. 21, n. 3, p. 155-158, 2013. Available from: https://www.scielo.br/j/aob/a/TTs4rXhkqgDbMqtDcDhQLfw/?lang=pt. Access: April 20, 2023.

BARONI, B. M.; WIEST, M. J.; GENEROSI, R. A.; VAZ, M. A.; LEAR JUNIOR, E. C. P. Efeito da fadiga muscular sobre o controle postural durante o movimento do passe em atletas de futebol. **Revista Brasileira de Cineantropometria & Desempenho Humano**, Santa Catarina, v. 13, n. 5, p. 348-353, 2011. Available from: https://www.scielo.br/j/rbcdh/a/gxZPZRjTt65QTPKz9MMHXqH/?lang=pt. Access: April 20, 2023.

BORG, G. A. Psychophysical bases of perceived exertion. **Medicine and Science in Sports and Exercise**, Bethesda, v. 14, n. 5, p. 377-381, 1982. Available from: https://pubmed.ncbi.nlm.nih.gov/7154893/. Access: April 20, 2023.

BORG, G. **Escalas de Borg para a dor e o esforço percebido**. São Paulo: Manole, 2000.

BRASIL. Ministério da Defesa. Exército Brasileiro. **Portaria nº 850-EME, de 31 de agosto de 2022**. Aprova diretriz para a avaliação física do Exército Brasileiro EB20-D-03.053. Brasília, DF: Ministério da Defesa, 2022. Available from: http://www.sgex.eb.mil.br/sg8/006_outras_publicacoes/01_diretrizes/04_estado-maior_do_exercito/port_n_850_eme_31ago2022.html. Access: April 20, 2023.

BRASIL. Ministério da Defesa. Exército Brasileiro. **Portaria nº 041-COTER, de 4 de abril de 2019**. Manual de Campanha EB70-MC-10.304. Marchas a Pé. Brasília, DF: Ministério da Defesa, 2019.

CALLEGARI-JACQUES, S. M. **Bioestatística**: Princípios e Aplicações. Porto Alegre: Artmed, 2003.

CARROLL, J. P.; FREEDMAN, W. Nonstationary properties of postural sway. **Journal of Biomechanics**, Bethesda, v. 26, n. 4-5, p. 409-416, 1993. Available from: https://pubmed.ncbi.nlm.nih.gov/8478345/. Access: April 20, 2023.

DAHL, K. D.; WANG. H.; POPP, J. K.; DICKIN, D. C. Load distribution and postural changes in young adults when wearing a traditional backpack versus the BackTpack. **Gait Posture**, Bethesda, v. 45, p. 90–96, 2016. Available from: https://pubmed.ncbi.nlm.nih.gov/26979888/. Access: April 20, 2023.

DU, N. *et al*. Heart rate recovery after exercise and neural regulation of heart rate variability in 30-40 year old female marathon runners. **Journal of Sports Science & Medicine**, Bethesda, v. 4, n. 1, p. 9-17, 2005. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3880089/. Access: April 20, 2023.

DUARTE, M.; FREITAS, S. M. S. Revisão sobre posturografia baseada em plataforma de força para avaliação do equilíbrio. **Revista Brasileira de Fisioterapia**, São Carlos, v. 14, n. 3, p. 183-192, 2010. Available from: https://www.scielo.br/j/rbfis/a/hFQTppgw4q3jGBCDKV9fdCH/. Access: April 20, 2023.

ESTON, R. Use of ratings of perceived exertion in sports. **International Journal of Sports Physiology and Performance**, Bethesda, v. 7, n. 2, p. 175-182, 2012. Available from: https://pubmed.ncbi.nlm.nih.gov/22634967/. Access: April 20, 2023.

FERREIRA, L. L.; SOUZA, N. M.; BERNARDO, A. F. B.; VITOR, A. L. R.; VALENTI, V. E.; VANDERLEI, L. C. M. Variabilidade da frequência cardíaca como recurso em fisioterapia: análise de periódicos nacionais. **Fisioterapia & Movimento**, Curitiba, v. 26, n. 1, p. 25-36, 2017. Available from: https://www.scielo.br/j/fm/a/wtXh958WvNYsP37scpDtDgP/?lang=pt. Access: April 20, 2023.

FREITAS, D. S.; MIRANDA, R.; BARA FILHO, M. Marcadores psicológico, fisiológico e bioquímico para determinação dos efeitos da carga de treino e do overtraining. **Revista Brasileira de Cineantropometria e Desempenho Humano**, Santa Catarina, v. 11, n. 4, p. 457-465, 2009. Available from: https://periodicos.ufsc.br/index.php/rbcdh/article/view/1980-0037.2009v11n4p457. Access: April 20, 2023.

GILES, G. E.; HASSELQUIST, L.; CARUSO, C. M.; EDDY, M. D. Load carriage and physical exertion influence cognitive control in military scenarios. **Medicine and Science in Sports and Exercise**, Bethesda, v. 51, n. 12, p. 2540-2546, 2019. Available from: https://pubmed.ncbi.nlm.nih.gov/31274685/. Access: April 20, 2023.

GOLRIZ, S.; HEBERT, J. J.; FOREMAN, K. B.; WALKER, B. F. The effect of hip belt use and load placement in a backpack on postural stability and perceived exertion: a within-subjects trial. **Ergonomics**, Bethesda, v. 58, n. 1, p. 140-147, 2015. Available from: https://pubmed.ncbi.nlm.nih.gov/25265931/. Access: April 20, 2023.

GRENIER, J. G. *et al*. Effects of Extreme-Duration Heavy Load Carriage on Neuromuscular Function and Locomotion: A Military-Based Study. **PLoS ONE**, San Francisco, v. 7, n. 8, p. 1-11, 2012. Available from: https://pubmed.ncbi.nlm.nih.gov/22927995/. Access: April 20, 2023.

GRIBBLE, P. A.; HERTEL, J. Effect of lower-extremity muscle fatigue on postural balance. **Archives of Physical Medicine and Rehabilitation**, Bethesda, v. 85, n. 4, p. 589-592, 2004. Available from: https://pubmed.ncbi.nlm.nih.gov/15083434/. Access: April 20, 2023.

HELLER, M. F.; CHALLIS, J. H.; SHARKEY, N. A. Changes in postural sway as a consequence of wearing a military backpack. **Gait Posture**, Bethesda, v. 30, n. 1, p. 115-117, 2009. Available from: https://pubmed.ncbi.nlm.nih.gov/19403310/. Access: April 20, 2023.

HORAK, F. B.; NASHNER, L. M. Central programming of postural movements: adaptation to altered support-surface configurations. **Journal of Neurophysiology**, Bethesda, v. 55, n. 6, p. 1369-1381, 1986. Available from: https://pubmed.ncbi.nlm.nih.gov/3734861/. Access: April 20, 2023.

KLEINER, A. F. R.; SCHLITTLER, R. D. C.; SÁNCHEZ-ARIAS, M. D. R. O papel dos sistemas visual, vestibular, somatosensorial e auditivo para o controle postural. **Revista Neurociências**, São Paulo, v. 19, n. 2, p. 349-357, 2011. Available from: https://repositorio.unesp.br/handle/11449/72584. Access: April 20, 2023.

KNAPIK, J. J.; REYNOLDS, K. L.; HARMAN, E. Soldier Load Carriage: Historical, Physiological, Biomechanical, and Medical Aspects. **Military Medicine**, Bethesda, v. 169, p. 45-56, 2004. Available from: https://pubmed.ncbi.nlm.nih.gov/14964502/. Access: April 20, 2023.

LIN, D.; SEOL, H.; NUSSBAUM, M. A.; MADIGAN, M. L. Reliability of COP-based postural sway measures and age-related differences. **Gait Posture**, Bethesda, v. 28, n. 2, p. 337-342, 2008. Available from: https://pubmed.ncbi.nlm.nih.gov/18316191/. Access: April 20, 2023.

LITLESKARE, S.; ENOKSEN, E.; SANDVEI, M.; STØEN, L.; STENSRUD, T.; JOHANSEN, E.; JENSEN, J. Sprint Interval Running and Continuous Running Produce Training Specific Adaptations, Despite a Similar Improvement of Aerobic Endurance Capacity—A Randomized Trial of Healthy Adults. **International Journal of Environmental Research and Public Health**, Bethesda, v. 17, n. 11, p. 3865, 2020. Disponível: https://pubmed.ncbi.nlm.nih.gov/32485945/. Access: April 20, 2023.

LOPES, R. F.; OSIECKI, R.; RAMA, L. M. P. L. Resposta da frequência cardíaca e da concentração de lactato após cada segmento do triathlon olímpico. **Revista Brasileira de Medicina do Esporte**, São Paulo, v. 18, n. 3, p. 158-160, 2012. Available from: https://www.scielo.br/j/rbme/a/Y6tMwmCXy6NZVRZQ4NBMBvN/abstract/?lang=pt. Access: April 20, 2023.

MALA, J. *et al*. The role of strength and power during performance of high intensity military tasks under heavy load carriage. **US Army Medical Department Journal**, Bethesda, p. 3-11, 2015. Available from: https://pubmed.ncbi.nlm.nih.gov/26101902/. Access: April 20, 2023.

MARCHETTI, P. H.; ORSELLI, M. I. V.; DUARTE, M. The effects of uni- and bilateral fatigue on postural and power tasks. **Journal of Applied Biomechanics**, Bethesda, v. 29, n. 1, p. 44-48, 2013. Available from: https://pubmed.ncbi.nlm.nih.gov/22814245/. Access: April 20, 2023.

NARDONE, A.; TARANTOLA, J.; GIORDANO, A.; SCHIEPPATI, M. Fatigue effects on body balance. **Electroencephalography and Clinical Neurophysiology**, Bethesda, v. 105, n. 5, p. 309-320, 1997. Available from: https://pubmed.ncbi.nlm.nih.gov/9284239/. Access: April 20, 2023.

PIHLAINEN, K.; SANTTIIA, M.; HÄKKINEN. K.; LINDHOLM, H.; KYRÖLÄINEN, H. Cardiorespiratory Responses Induced by Various Military Field Tasks. **Military Medicine**, Bethesda, v. 179, n. 2, p. 218-224, 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/24491620/. Access: April 20, 2023.

PRIETO, T. E.; MYKLEBUST, J. B.; HOFFMANN, R. G.; LOVETT, E. G.; MYKLEBUST, B. M. Measures of postural steadiness: differences between healthy young and elderly adults. **IEEE Transactions on Bio-medical Engineering**, Bethesda, v. 43, n. 9, p. 956-966, 1996. Available from: https://pubmed.ncbi.nlm.nih.gov/9214811/. Access: April 20, 2023.

RAHNAMA, N., REILLY, T., LEES, A., GRAHAM-SMITH, P. Muscle fatigue induced by exercise simulating the work rate of competitive soccer. **Journal of Sports Sciences**, Bethesda, v. 21, n. 11, p. 933-942, 2003. Available from: https://pubmed.ncbi.nlm.nih.gov/14626373/. Access: April 20, 2023.

RUGELJ, D.; SEVŠEK, F. The effect of load mass and its placement on postural sway. **Applied Ergonomics**, Bethesda, v. 42, n. 6, p. 860-866, 2011. Available from: https://pubmed.ncbi.nlm.nih.gov/21356532/. Access: April 20, 2023.

RUHE, A.; FEJER, R.; WALKER, B. The test–retest reliability of centre of pressure measures in bipedal static task conditions – A systematic review of the literature. **Gait Posture**, Bethesda, v. 32, n. 4, p. 436-445, 2010. Available from: https://pubmed.ncbi.nlm.nih.gov/20947353/. Access: April 20, 2023.

SHUMWAY-COOK, A.; WOOLLACOTT, M. H. **Motor control**: translating research in clinical practice. 5. ed. Philadelphia: Lippincott, 2016.

WINTER, D. A. **A.B.C. of Balance During Standing and Walking**. Ontario: Waterloo Biomechanics, 1995.

YAGGIE, J. A.; MCGREGOR, S. J. Effects of isokinetic ankle fatigue on the maintenance of balance and postural limits. **Archives of Physical Medicine and Rehabilitation**, Bethesda, v. 83, n. 2, p. 224-228, 2002. Available from: https://pubmed.ncbi.nlm.nih.gov/11833026/. Access: April 20, 2023.

ZULTOWSKI, I.; ARUIN. A. Carrying loads and postural sway in standing: the effect of load placement and magnitude. **Work**, Bethesda, v. 30, n. 3, p. 359-368, 2008. Available from: https://pubmed.ncbi.nlm.nih.gov/18725699/. Access: April 20, 2023.


ECEME

DOI 10.52781/cmm.a107

Analysis of the Metabolic and Cardiorespiratory Profiles of Female Military Personnel Belonging to Operative and Non-operative Military Organizations of the Brazilian Army

Análisis del perfil metabólico y cardiorrespiratorio de mujeres militares pertenecientes a organizaciones militares operativas y no operativas del ejército brasileño

Abstract: The metabolic and cardiorespiratory profiles of 301 female soldiers from Non-Operative Military Organizations (OMNOP) and Operative Organizations (OMOP) of the Brazilian Army were compared. This is an analytical cross-sectional study, which analyzed the following variables:cardiorespiratory fitness, biochemical markers and body composition. In the difference of VO_{2max} averages, the OMOP military had statistically higher scores (M = 36.2 ± 4.4 ml/kg/min) than the OMNOP (M = 34.2 ± 5.7 ml/kg/min). VO_{2max} correlated positively with HDL cholesterol and negatively with triglyceride and BMI. On the other hand, BMI correlated negatively with HDL cholesterol and positively with triglyceride and glucose. Glucose correlated with HDL cholesterol. The results of the study corroborated the evidence in the literature regarding productive, positive and negative associations between VO_{2max} and indicators of cardiovascular health.

Keywords: cardiorespiratory fitness; metabolic profile; body composition.

Resumen: Se compararon los perfiles metabólicos y cardiorrespiratorios de 301 mujeres militares, integrantes de Organizaciones Militares No Operativas (OMNOP) y Organizaciones Militares Operativas (OMOP) del Ejército Brasileño. Se trata de un estudio transversal analítico, en el que se analizaron las siguientes variables: aptitud cardiorrespiratoria, marcadores bioquímicos y composición corporal. En la diferencia de medias de $VO_{2máx}$, las militares de OMOP tuvieron puntuaciones estadísticamente más altas (M = 36,2 ± 4,4 ml/kg/min) que las de OMNOP (M = 34,2 ± 5,7 ml/kg/min). El $VO_{2máx}$, se correlacionó positivamente con el colesterol HDL (lipoproteína de alta densidad) y negativamente con los triglicéridos y el índice de masa corporal (IMC). El IMC se correlacionó negativamente con HDL y positivamente con triglicéridos y glucosa. La glucosa, a su vez, se correlacionó negativamente con HDL. Los resultados de este artículo corroboran las evidencias halladas en la bibliografía sobre las asociaciones significativas entre el $VO_{2máx}$, y los indicadores de salud cardiovascular.

Palabras clave: aptitud cardiorrespiratoria; perfil metabólico; composición corporal.

Paula Fernandez Ferreira
Exército Brasileiro. Instituto de Pesquisa da Capacitação Física do Exército. Rio de Janeiro, RJ, Brasil.
bioquimica.ipcfex@gmail.com

Marcio Antonio de Barros Sena
Exército Brasileiro. Instituto de Pesquisa da Capacitação Física do Exército. Rio de Janeiro, RJ, Brasil.
mabsmarcio@gmail.com

Aline Tito Barbosa Silva
Exército Brasileiro. Instituto de Pesquisa da Capacitação Física do Exército. Rio de Janeiro, RJ, Brasil.
aline.tito@yahoo.com

Runer Augusto Marson
Exército Brasileiro. Instituto de Pesquisa da Capacitação Física do Exército. Rio de Janeiro, RJ, Brasil.
runer.marson@gmail.com

Marcos de Sá Rego Fortes
Exército Brasileiro. Instituto de Pesquisa da Capacitação Física do Exército. Rio de Janeiro, RJ, Brasil.
msrfortes@gmail.com

Received: Oct. 6, 2022
Approved: Apr. 25, 2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

The inclusion of women in the Brazilian Armed Forces dates back to the late 1980s and early 1990s. In the Brazilian Army (EB), the pioneering military women, who entered the career through public tender, recently completed the cycle of 30 years of service provision and, in 2017, the first group of women joined the Army Cadet Preparatory School, in the line of military education. Brazil is part of the agreements included in the United Nations' Women, Peace and Security program, which aims to increase women's participation in peacekeeping missions. According to the guideline on increasing EB participation in UN Peacekeeping Operations (BRAZIL, 2022), minimum percentages of female soldiers must be met for the deployment in peacekeeping operations, as recommended in the UN Uniformed Gender Parity Strategy 2018-2028. In this context, the importance of maintaining the health and physical fitness of military women is emphasized for the fulfillment of the various functions of the craft, at the national and international levels (FIELDHOUSE; O'LEARY, 2020; JONES *et al*., 2019; MACGREGOR *et al*., 2021).

The Armed Forces around the world strive to maintain their personnel in conditions of physical health for combat (NINDL *et al*., 2012; OJANEN *et al*., 2018; OJANEN; JALANKO; KYRÖLÄINEN, 2018).

Nevertheless, there is a growth in cardiometabolic diseases, for example, obesity and type 2 diabetes mellitus. Within the scope of the military career, some factors can contribute to this risk, such as stress, reduced physical activity, decreased sleep time and poor food choices.

In view of the necessary adjustments for the full integration of the military during their training, the Department of Education and Culture of the Army (DECEx) structured the Project for the Insertion of the Female Sex in the War Teaching Line (PISFLEMB), and the Army Physical Training Research Institute (IPCFEx) is responsible for actions regarding the physical training and monitoring of the health status of the combatant military. With regard to the female military, there are few scientific studies dedicated to this segment, considering its physiological particularities and life stages and, allied to these, the relationship with military activity, a gap that this article proposes to fill (O'LEARY; WARDLY; GREEVES, 2020; SCHRAM *et al*., 2022). Thus, this article intends to make a comparative analysis of the biochemical and cardiorespiratory profiles of female military personnel, in Non-Operative Military Organizations (OMNOP) and Operative Organizations (OMOP) of the EB, as well as to verify the association between the biochemical variables BMI and VO_{2max}. Therefore, this research is based on data collected in field surveys carried out by IPCFEx in 2018, with a sample of military personnel, representative of EB. The answers provided in this study will allow for the adoption of strategies to contribute to the improvement of the health and quality of life of the female military personnel of both types of OM, in addition to assuming that the military physical training (TFM) carried out in preparation for the physical assessment test (TAF) is consistent with the purpose of achieving better health indicators.

2 THEORETICAL REVIEW

In a survey carried out between 2014 and 2016 among EB military personnel and members of the UN peacekeeping mission contingents, the prevalence of metabolic syndrome (MS)

was 15% (ROSA *et al*., 2018). Another study, with 2,719 EB military personnel, found a prevalence of 12.2% (FORTES *et al*., 2019). It is noteworthy that both surveys included only male soldiers in the samples, although epidemiological data demonstrate that military training and operational environments induce greater damage in females when compared to males (NINDL *et al*., 2016).

Biochemical variables considered as MS risk factors, namely blood glucose (GLU), HDL-cholesterol (high-density lipoprotein) and triglycerides (TRIG), are related to an increased risk of developing cardiovascular diseases (LEE *et al*., 2021; TOTH *et al*., 2013). In relation to blood glucose, the decrease in the sensitivity of insulin receptors in the target tissues causes a condition of insulin resistance (IR) and elevation of blood glucose (YARIBEYGI *et al*., 2019), being related to the development of type 2 *diabetes mellitus*. In this sense, several studies have already been carried out to understand the effects of IR on metabolism in different tissues, for example, liver, muscle and fat, in addition to inflammation and other important biological processes (BÓDIS; RODEN, 2018; PETERSEN; SHULMAN, 2018; YANG; VIJAYAKUMAR; KAHN, 2018). As for HDL-cholesterol, studies show an inverse relationship between its systemic levels and cardiovascular risk (CVR) (NICHOLLS; NELSON, 2019). In addition to its key role in the reverse transport of cholesterol, HDL-c has a range of functional properties, which may exert a protective influence on inflammation, oxidative stress, angiogenesis and glucose homeostasis. Regarding TRIG levels, epidemiological analyzes have shown that high levels, even within the reference range, are related to higher CVR (BUDOFF, 2016; VALLEJO-VAZ *et al*, 2020). The desirable value of TRIG measured in the fasted state for adult subjects is less than 150 milligrams per deciliter (mg/dL).

Physical training is an important, effective and recommended non-pharmacological intervention for improving health and treating metabolic diseases such as obesity (KHALAFI *et al*., 2021). Recent data suggest that cardiorespiratory fitness (ACR) plays an important role in reducing not only cardiovascular mortality, but also myocardial infarction, hypertension, diabetes, atrial fibrillation, heart failure, and stroke (AL-MALLAH; SAKR; AL-QUNAIBET, 2018; SEALS; NAGY; MOREAU, 2019). Regarding the differences in physical performance between the sexes, it can be explained, according to literature review, due to the physiological and morphofunctional differences of men and women (FORTES *et al*., 2015). In military personnel, when the treadmill walk with progressive load (0%, 20% and 40% of body mass) was analyzed, the physiological demands increased with heavier loads, however, there was no difference between the sexes when compared to the relative VO_{2max}. In addition, in all load conditions, women worked with a higher relative intensity than men. (VICKERY-HOWE*et al*., 2020).

3 METHODOLOGY

This is an analytical cross-sectional study carried out in a convenience sample with 301 female military personnel, with a mean age of 34.6 ± 6.9 years and a mean BMI of 24.6 ± 4.1 kg/m^2. The sample was selected from a group of volunteer military personnel from all military regions of Brazil, participating in the Physical Assessment Test Project,

which was carried out by IPCFEx in 2018. The sample was divided into two groups: 62 military operative OM (OMOP) and 239 military non-operative OM (OMNOP). The OMOP are those organized and trained for use in military operations, while the OMNOP refer to the units that perform activities, mainly administrative, teaching, health and research. Female active-duty EB military personnel who were under health conditions considered fit to perform the physical evaluation test (TAF) and who delivered the results of laboratory tests (GLUC, TRIG, HDL-c) were included. This research was approved by the Ethics Council of the Marcílio Dias Naval Hospital, No. 1,551,242, CAAE No. 47835615.5.0000.5256, on July 11, 2019.

Cooper's test (COOPER, 1968) was performed in a straight plane with distance markings every 50 meters, between seven and half and nine o'clock in the morning, being applied by physical education professionals. From the result, VO_{2max} was calculated using the formula: (D - 504.9) / 44.73, in which D is the distance reached in meters (COOPER, 1968). In the assessment of body composition, mass and height were measured to estimate BMI, according to international standards (NORTON, 1996).

As for statistical analysis, according to the Central Limit Theorem, if a sample is large enough (greater than 30), whatever the distribution of the sample mean, it will be approximately normal. In this sense, in descriptive statistics, the measures of central tendency used were dispersion (mean and standard deviation) for continuous variables. In the statistical inference, to evaluate the differences in means between the two groups (OMOP and OMNOP), a parametric analysis was used with the helpof Student's t-test (GLU, HDL-c and TRIG) or Welch's test (VO_{2max}), depending on the violation of the assumption of homogeneity of variances, verified with the help of Levene's test. In addition, Pearson's Correlation test was used to evaluate the level of association between continuous variables, with Pearson's correlation coefficient values categorized as follows: from 0 to 0.3 (weak correlation); from 0.3 to 0.6 (moderate correlation); and from 0.6 to 0.9 (strong correlation) (CALLEGARI-JACQUES, 2009). The significance level adopted was $p < 0.05$, and the JAMOVI program (version 2.3.9) was used for the statistical analysis.

4 RESULTS

The results of this research will be presented with the help of tables.

Table 1 – Mean (M) and Standard Deviation (SD) values of the variables: Age, Body Mass, Height and BMI of the military women of the sample

	OMOP	OMNOP
Age (years)	32.9 ± 6.5	35.1 ± 7.0
Body mass (kg)	64.2 ± 9.3	66.3 ± 10.9
Height (cm)	164.3 ± 7.1	163.8 ± 7.1
BMI (kg/m^2)	23.9 ± 3.7	24.8 ± 4.2

OMOP = Military Operative Organization; OMNOP = Military Non-Operative Organization; BMI = Body Mass Index. Data were expressed as means and standard deviations

Source: Prepared by the author, 2023.

Table 2 – *T-test* for independent samples in military women of OMNOP and OMOP

	GROUP	M	DP	p-value
VO_{2max} (mL/Kg/min)	**OMNOP**	34.2	5.7	0.002*
	OMOP	36.2	4.4	
GLU (mg/dL)	**OMNOP**	87.7	8.6	0.375
	OMOP	86.6	7.8	
HDL-c (mg/dL)	**OMNOP**	62.3	14.5	0.821
	OMOP	62.8	15.1	
TRIG (mg/dL)	**OMNOP**	89.8	39.3	0.730
	OMOP	91.7	33.6	

VO_{2max} = Maximum Oxygen Consumption; GLU = glucose; HDL-c = high-density lipoprotein;
TRIG = triglycerides; OMOP = Military Operative Organization; OMNOP = Military Non-Operative Organization.
* = significant difference. Data were expressed as means and standard deviations.
Source: Prepared by the author, 2023.

So, to investigate the extent to which VO_{2max} levels were different between OMNOP and OMOP, Welch's t-test for independent samples was performed, since the assumption of homogeneity of variance, evaluated by Levene's test, was violated ($p < 0.05$). For biochemical markers, Student's t-test was performed. The result obtained shows there were significant differences only in the variable VO_{2max}, in which the OMOP military obtained a statistically higher result (M = 36.2 ± 4.4 ml/Kg/min) than the military of OMNOP (M = 34.2 ± 5.71 ml/Kg/min). In the other variables, however, no significant results were found. One should note the percentage of military personnel of OMOP with blood glucose, HDL-c, and triglycerides levels within the reference values, according to the Brazilian Society of Dyslipidemias and the Brazilian Society of Diabetes, was 99%, 95.4% and 98.7%, respectively. In relation to the military of OMNOP, the percentages were: 96.4%, 81.1% and 95%, respectively.

Table 3 – Correlation Matrix between all variables of the study of female military of the EB

		TRIG	GLU	HDL-c	BMI	VO_{2max}
TRIG	Pearson r	—				
	p-value	—				
GLU	Pearson r	0.089$^{n.s}$	—			
	p-value	0.123$^{n.s}$	—			
HDL-c	Pearson r	-0.030$^{n.s}$	**-0.194*****	—		
	p-value	0.604	<0.001	—		
BMI	Pearson r	**0.129***	**0.154****	**-0.224*****	—	
	p-value	0.026	0.007	< 0.001	—	
VO_{2max}	Pearson r	**-0.168****	-0.051$^{n.s}$	**0.123***	**-0.288*****	—
	p-value	0.004	0.380	0.033	<0.001	—

BMI = Body Mass Index; GLU = glucose; HDL-c = high-densitylipoprotein;
TRIG = triglycerides; VO_{2max} = Maximum Oxygen Consumption.
Note. * p <05, ** p <.01, *** p <.001,
n.s. = non-significant relationship
Source: Prepared by the author, 2023.

In the matrix above, one can observe that VO_{2max} correlated significantly and positively with HDL-c (r =0.123; p=0.03) and negatively with both TRIG (r=-0.168; p=0.004) and BMI (r = -0.288; p < 0.001). BMI, in addition to VO_{2max}, correlated with all variables of the analysis, namely: negatively with HDL-c (r = -0.224; p < 0.001); and positively with TRIG (r = 0.129; p=0.026) and GLU (r = 0.154; p = 0.007). GLU, in addition to BMI, was statistically negatively correlated with HDL-c (r = -0.194; p < 0.001).

5 DISCUSSION

Since military physical training is compulsorily inserted into the routines of corporations, the results of this article point to the positive effects of its practice on the metabolic profile and body composition, regardless of the end activity of the OM in which the military woman performs its job. This inference is consistent with studies that examined long training programs, for example, a six-month study that examined a mixed sample of both healthy and sedentary men and women, and demonstrated significantly positive changes in total cholesterol and HDL-c (DUNN, 1997). In relation to cardiopulmonary capacity, female military personnel from OMOP presented higher values compared to military personnel from OMNOP. This result can be explained by the higher physical demand required in OMOP to perform imediate missions, which leads to improved aerobic conditioning.

The mean BMI in both types of OM considered as normal (BMI ≤ 25) and the favorable metabolic profile were evidenced, with all averages of biomarkers concentrations within the reference values (RV) (GLU RV < 100 mg/dL, HDL-c RV > 50 mg/dL and TRIG RV < 150 mg/dL). In these lipid and glycemic profile variables, no significant difference was found between the OMOP and OMNOP groups. These results are consistent with those presented in the literature, according to research by Lemura (2000), which exclusively examined women under the effects of 16 weeks of resistance exercises, with a significant increase in HDL-c and a decrease in TRIG concentration. Another study should be highlighted, in which women underwent 24 weeks of functional training, showing an increase in the strength variable, which directly contributed to improved metabolism and, therefore, better expression of biomarkers (NINDL *et al*., 2017).

Regardless of the training programs (aerobic and neuromuscular) used by both types of military organizations, favorable metabolic profiles are observed (AHMETI *et al*., 2020; MOGHARNASI *et al*., 2017). In the study by Schroeder *et al*. (2019), it was observed that the changes induced by three distinct training programs for 8 weeks in fasting lipids and glycemia were small and did not vary between the training groups and the control without training. Another study with women from two different countries, despite cultural and socioeconomic differences that led to a different involvement in physical training programs, reported differences in cardiometabolic parameters, HDL-c and total cholesterol; however, no difference in TRIG levels was observed between the groups. In the case of this study, women with a higher age group and BMI (Age: 50 years; BMI: 29.5 Kg/m^2) were evaluated than in that study.

Cardiorespiratory fitness (ACR) refers to the ability of the circulatory and respiratory systems to deliver oxygen to the mitochondria of skeletal muscle for the production of energy required during a physical activity (ROSS *et al*., 2016). Namely, OMOPs are those that, due to their functional characteristic, of operational activities, are employed in combat situations; therefore, it becomes interesting that this group presents an optimal ACR. In this context, the OMOP group had a significantly higher mean compared to OMNOP. According to the American Society of Sports Medicine, the VO_{2max} results of OMOP and OMNOP are classified as excellent and good, respectively (RIEBE *et al*., 2018). In addition, the positive association between HDL levels and VO_{2max} in this research corroborates the results that point to the fact that women with better cardiorespiratory fitness had higher levels of HDL-c (APARICIO, 2012). In this scenario, we list this result as satisfactory, as individuals with a better VO_{2max} have positive associations with health indicators and are associated with a lower prevalence of metabolic syndrome (KELLEY *et al*., 2018). This article therefore found an association between ACR and the biochemical markers TRIG and HDL-c, which corroborates studies that demonstrate that aerobic training and higher levels of ACR are related to lower cardiometabolic risks (AHMETI *et al*., 2020; HAAPALA *et al*., 2022).

Despite the limitations found, particularly regarding the control of temperature, humidity and the phase of the menstrual cycle, which can interfere with physical performance, we highlight, with the help of the results found, the positive effects of the practice of TFM on the glycemic lipid panel and on the cardiopulmonary capacity of female soldiers from the various OM of the EB. However, no differences were evidenced between the biochemical and body composition parameters of the military from OMOP and OMNOP, probably because these markers present positive results in the physically active sample of this research. Another limitation refers to laboratory tests having been performed in different laboratories, which may lead to possible differences in the analysis methodologies.

It is worth mentioning the importance of monitoring the health status of military personnel who perform different missions within the EB, as the increase in the prevalence of cardiovascular risk factors in the civilian and military population is alarming (FORTES *et al*., 2019). In this context, this article, which involved physically active female participants, apparently healthy and with BMI within the normal range, contributes with knowledge to outline the profile of the EB military and association between the physical parameter and biochemical and morphological markers.

6 CONCLUSION

This article involved healthy female participants with BMI within the normal range, however, due to the alarming trends of increasing cardiovascular risk factors in the civilian and military population, it is of paramount importance to monitor the health status of officers of military units in different missions.

A good metabolic profile was observed, with no difference between the groups studied; however, there was a difference in the cardiopulmonary fitness of the groups. Although a weak association was found between BMI and biochemical variables and VO_{2max} with TRIG and

HDL-c, these data are in agreement with the established literature, since body composition and cardiopulmonary fitness are related to better indicators of cardiovascular health.

Finally, this research provides a profile of the female population of the EB, thus contributing to advances in management strategies to control chronic non-communicable diseases and improve the physical and operative capacity of the ground troops.

ACKNOWLEDGMENTS

The authors thank the Brazilian Army for the access to the data of the military personnel who carried out the Physical Assessment Test Project in 2018.

AUTHORS' CONTRIBUTIONS

1 – Paula Fernandez Ferreira: study planning, data collection and analysis, writing and review of the article.

2 – Marcio Antonio de Barros Sena: data collection, writing and review of the article.

3 – Aline Tito Barbosa: writing and reviewing the article.

4 – Runer Augusto Marson: study planning and data analysis.

5 – Marcos de Sá Rego Fortes: study planning, writing, data analysis and article review.

All authors read and approved the final article.

REFERENCES

AHMETI G. B.; IDRIZOVIC, K.; ELEZI, A.; ZENIC, N.; OSTOJIC, L. Endurance Training vs. Circuit Resistance Training: Effects on Lipid Profile and Anthropometric/Body Composition Status in Healthy Young Adult Women. **International Journal of Environmental Research and Public Health**, Basel, v. 17, n. 4, p. 1-15, 2020. Available from: https://www.mdpi.com/1660-4601/17/4/1222. Access: April 27, 2023.

AL-MALLAH, M. H.; SAKR, S.; AL-QUNAIBET, A. Cardiorespiratory Fitness and Cardiovascular Disease Prevention: an Update. **Current Atherosclerosis Reports**, New York, v. 20, n. 1, 2018. Available from: https://link.springer.com/article/10.1007/s11883-018-0711-4. Access: April 27, 2023.

APARICIO, V. A.; ORTEGA, F. B.; CARBONELL-BAEZA, A.; FERNÁNDEZ, M.; SENHAJI, M.; RUIZ, J. R.; ERRAMI, M.; DELGADO-FERNÁNDEZ, M.; ARANDA, P. Fitness, fatness and cardiovascular profile in South Spanish and North Moroccan women. **Nutricion Hospitalaria**, Madrid, v. 27, n. 1, p. 227-231, 2012. Available from: https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0212-16112012000100029&lng=es&nrm=iso&tlng=en. Access: April 27, 2023.

BÓDIS, K.; RODEN, M. Energy metabolism of white adipose tissue and insulin resistance in humans. **European Journal of Clinical Investigation**, Hoboken, v. 48, n. 11, 2018. Available from: https://onlinelibrary.wiley.com/doi/10.1111/eci.13017. Access: April 27, 2023.

BRASIL. Ministério da Defesa. Exército Brasileiro. Estado-Maior do Exército. **Portaria nº 1.771-EME, de 14 de junho de 2022**. Aprova a Diretriz para o incremento da participação do Exército Brasileiro em Operações de Paz da Organização das Nações Unidas (ONU) e na sede da ONU, em Nova Iorque – (EB10-D-01.039). Brasília, DF: Ministério da Defesa, 2022. Available from: http://www.sgex.eb.mil.br/sg8/006_outras_publicacoes/01_diretrizes/01_comando_do_exercito/port_n_1771_cmdo_eb_14jun2022.html. Acesso em April 27, 2023.

BUDOFF, M. Triglycerides and Triglyceride-Rich Lipoproteins in the Causal Pathway of Cardiovascular Disease. **The American Journal of Cardiology**, Amsterdam, v. 118, n. 1, p 138-145, 2016. Available from: https://www.ajconline.org/article/S0002-9149(16)30484-2/fulltext. Access: April 27, 2023.

CALLEGARI-JACQUES, S. M. **Bioestatística**: princípios e aplicações. Porto Alegre: Artmed, 2009.

DUNN, A. L.; MARCUS, B. H.; KAMPERT, J. B.; GARCIA, M. E.; KOHL, H. W.; BLAIR, S. N. Reduction in cardiovascular disease risk factors: 6-month results from Project Active. **Preventive Medicine**, Amsterdam, v. 26, n. 6, p. 883–892, 2017. Available from: https://www.sciencedirect.com/science/article/pii/S0091743597902188?via%3Dihub. Access: April 27, 2023.

FIELDHOUSE, A.; O'LEARY, T. J. Integrating women into combat roles: Comparing the UK Armed Forces and Israeli Defense Forces to understand where lessons can be learnt. **BMJ Military Health**, London, v. 169, n. 1, p. 78-80, 2020. Available from: https://militaryhealth.bmj.com/content/169/1/78.long. Access: April 27, 2023.

FORTES, M. S. R.; MARSON, R. A.; MARTINEZ, E. C. Comparação de Desempenho entre Homens e Mulheres: Revisão de Literatura. **Revista Mineira de Educação Física**, Viçosa, v. 23, p. 54, 2015. Available from: https://periodicos.ufv.br/revminef/article/view/9964. Access: April 27, 2023.

FORTES, M. S. R.; DA ROSA, S. E.; COUTINHO, W.; NEVES, E. B. Epidemiological study of metabolic syndrome in Brazilian soldiers. **Archives of Endocrinology and Metabolism**, São Paulo, v. 63, n. 4, p. 345-350, 2019. Available from: https://www.scielo.br/j/aem/a/R5TxygTTb96CsMtwRWYwtHQ/?lang=en. Access: April 27, 2023.

HAAPALA, E. A.; TOMPURI, T.; LINTU, N.; VIITASALO, A.; SAVONEN, K.; LAKKA, T. A.; LAUKKANEN, J. A. Is low cardiorespiratory fitness a feature of metabolic syndrome in children and adults? **Journal of Science and Medicine in Sport**, London, v. 25, n. 1, p. 923-929, 2022. Available from: https://www.jsams.org/article/S1440-2440(22)00213-4/fulltext. Access: April 27, 2023.

JONES, N.; GREENBERG, N.; PHILLIPS, A.; SIMMS, A.; WESSELY, S. British military women: Combat exposure, deployment and mental health. **Occupational Medicine**, Oxford, v. 69, n. 8-9, p. 549-558, 2019. Available from: https://academic.oup.com/occmed/article/69/8-9/549/5548904?login=false. Access: April 27, 2023.

KELLEY, E.; IMBODEN, M. T.; HARBER, M. P.; FINCH, H.; KAMINSKY, L. A.; WHALEY, M. H. Cardiorespiratory Fitness Is Inversely Associated with Clustering of Metabolic Syndrome Risk Factors: The Ball State Adult Fitness Program Longitudinal Lifestyle Study. **Mayo Clinic Proceedings**: Innovations, Quality & Outcomes, Scottsdale, v. 2, n. 2, p. 155-164, 2018. Available from: https://www.mcpiqojournal.org/article/S2542-4548(18)30023-7/fulltext. Access: April 27, 2023.

KHALAFI, M.; MALANDISH, A.; ROSENKRANZ, S. K.; RAVASI, A. A. Effect of resistance training with and without caloric restriction on visceral fat: A systemic review and meta-analysis. **Obesity Reviews**, Hoboken, v. 22, n. 9, 2021. Available from: https://onlinelibrary.wiley.com/doi/10.1111/obr.13275. Access: April 27, 2023.

LEE, H. R.; KIM, J. K.; KIM, J. H.; CHUNG, T. H. Compared to serum triglyceride alone, the association between serum triglyceride to high-density lipoprotein cholesterol ratio and 10-year cardiovascular disease risk as determined by Framingham risk scores in a large Korean cohort. **ClinicaChimica Acta**, Amsterdam, v. 520, p. 29-33, 2021. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0009898121001856?via%3Dihub. Access: April 27, 2023.

MACGREGOR, A.; ZOURIS, J.; DOUGHERTY, A.; DYE, J. Health Profiles of Military Women and the Impact of Combat-Related Injury. **Women's Health Issues**, Oxford, v. 31, n. 4, p. 392-398, 2021. Available from: https://www.whijournal.com/article/S1049-3867(21)00032-3/fulltext. Access: April 27, 2023.

MOGHARNASI, M.; CHERAGH-BIRJANDI, K.; CHERAGH-BIRJANDI, S.; TAHERICHADORNESHIN, H. The effects of resistance and endurance training on risk factors of vascular inflammation and atherogenesis in non-athlete men. **Interventional Medicine and Applied Science**, Budapest, v. 9, n. 4, p. 185-190, 2017. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6016202/. Access: April 27, 2023.

NICHOLLS, S. J.; NELSON, A. J. HDL and cardiovascular disease. **Pathology**, Amsterdam, v. 51, n. 2, p. 142-147, 2019. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0031302518305129. Access: April 27, 2023.

NINDL, B. C.; EAGLE, S. R.; FRYKMAN, P. N.; PALMER, C.; LAMMI, E.; REYNOLDS, K.; ALLISON, K.; HARMAN, E. Functional physical training improves women's military occupational performance. **Journal of Science and Medicine in Sport**, London v. 20, n. 4, p. 91-97, 2017. Available from: https://www.jsams.org/article/S1440-2440(17)30953-2/fulltext. Access: April 27, 2023.

NINDL, B. C.; JONES, B. H.; VAN ARSDALE, S. J.; KELLY, K.; KRAEMER, W. J. Operational physical performance and fitness in military women: Physiological, musculoskeletal injury, and optimized physical training considerations for successfully integrating women into combat-centric military occupations. **Military Medicine**, Oxford, v. 181, n. 1, p. 50-62, 2016. Available from: https://academic.oup.com/milmed/article/181/suppl_1/50/4209407?login=false. Access: April 27, 2023.

NINDL, B.; SCOFIELD, D.; STROHBACH, C.; CENTI, A.; EVANS, R.; YANOVICH, R.; MORAN, D. IGF-I, IGFBPs, and inflammatory cytokine responses during gender-integrated Israeli Army basic combat training. **The Journal of Strength and Conditioning Research**, Philadelphia, v. 26, n. 2, p. 73-81, 2012. Available from: https://journals.lww.com/nsca-jscr/Abstract/2012/07002/IGF_I,_IGFBPs,_and_Inflammatory_Cytokine_Responses.10.aspx. Access: April 27, 2023.

OJANEN, T.; JALANKO, P.; KYRÖLÄINEN, H. Physical fitness, hormonal, and immunological responses during prolonged military field training. **Physiological Reports**, London, v. 6, n. 17, p. 1-10, 2018. Available from: https://physoc.onlinelibrary.wiley.com/doi/10.14814/phy2.13850. Access: April 27, 2023.

OJANEN, T.; KYRÖLÄINEN, H.; IGENDIA, M.; HÄKKINEN, K. Effect of Prolonged Military Field Training on Neuromuscular and Hormonal Responses and Shooting Performance in Warfighters. **Military Medicine**, Oxford, v. 183, n. 11-12, p. 705-712, 2018. Available from: https://academic.oup.com/milmed/article/183/11-12/e705/5025890?login=false. Access: April 27, 2023.

O'LEARY, T. J.; WARDLE, S. L.; GREEVES, J. P. Energy Deficiency in Soldiers: The Risk of the Athlete Triad and Relative Energy Deficiency in Sport Syndromes in the Military. **Frontiers in Nutrition**, London, v. 7, p. 1-18, 2020. Available from: https://www.frontiersin.org/articles/10.3389/fnut.2020.00142/full. Access: April 27, 2023.

PETERSEN, M. C.; SHULMAN, G. I. Mechanisms of Insulin Action and Insulin Resistance. **Physiological Reviews**, Bethesda, v. 98, n. 4, p. 2133-2223, 2018. Available from: https://pubmed.ncbi.nlm.nih.gov/30067154/. Access: April 27, 2023.

RIEBE, D.; EHRMAN, J.; LIGUORI, G.; MAGAL, M. **ACSM's guidelines for exercise testing and prescription**. Philadelphia: Lippincott Williams & Wilkins, 2018.

ROSA, S. E.; LIPPERT, M. A.; MARSON, R. A.; FORTES, M. S. R.; RODRIGUES, L. C.; FERNANDES FILHO, J. Desempenho físico, composição corporal e síndrome metabólica em militares brasileiros. **Revista Brasileira de Medicina do Esporte**, São Paulo, v. 24, n. 6, p. 422-425, 2018. Available from: https://www.scielo.br/j/rbme/a/8R9f7gbKbFy7vgPts47MCDn/?lang=en. Access: April 27, 2023.

ROSS, R. *et al*. Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: a Case for Fitness as a Clinical Vital Sign: A Scientific Statement From the American Heart Association. **Circulation**, Dallas, v. 134, n. 24, p. 653-699, 2016. Available from: https://www.ahajournals.org/doi/10.1161/CIR.0000000000000461?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed. Access: April 27, 2023.

SCHRAM, B.; CANETTI, E.; ORR, R.; POPE, R. Injury rates in female and male military personnel: a systematic review and meta-analysis. **BMC Women's Health**, New York, v. 22, n. 1, p. 1-14, 2022. Available from: https://bmcwomenshealth.biomedcentral.com/articles/10.1186/s12905-022-01899-4. Access: April 27, 2023.

SCHROEDER, E. C.; FRANKE, W. D.; SHARP, R. L.; LEE, D. C. Comparative effectiveness of aerobic, resistance, and combined training on cardiovascular disease risk factors: A randomized controlled trial. **PLoSOne**, San Francisco, v. 147, n. 1, p. 1-14, 2019. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0210292. Access: April 27, 2023.

SEALS, D. R.; NAGY, E. E.; MOREAU, K. L. Aerobic exercise training and vascular function with ageing in healthy men and women. **The Journal of Physiology**, London, v. 597, n. 19, p. 4901–4914, 2019. Available from: https://physoc.onlinelibrary.wiley.com/doi/10.1113/JP277764. Access: April 27, 2023.

TOTH, P. P. *et al*. High-density lipoproteins: A consensus statement from the National Lipid Association. **Journal of Clinical Lipidology**, Philadelphia, v. 7, n. 5, p. 484-225, 2013. Available from: https://www.lipidjournal.com/article/S1933-2874(13)00249-3/fulltext. Access: April 27, 2023.

VALLEJO-VAZ, A. J.; CORRAL, P.; SCHREIER, L.; RAY, K. K. Triglycerides and residual risk. **Current Opinion in Endocrinology, Diabetes and Obesity**, London, v. 27, n. 2, p. 95-103, 2020. Available from: https://europepmc.org/article/med/32073428. Access: April 27, 2023.

VICKERY-HOWE, D. M.; DRAIN, J. R.; CLARKE, A. C.; DASCOMBE, B. J.; MCWILLIAM, J. T.; MIDDLETON, K. J. Treadmill load carriage overestimates energy expenditure of overground load carriage. **Ergonomics**, Abingdon, v. 64, n. 4, p. 521-531, 2020. Available from: https://www.tandfonline.com/doi/abs/10.1080/00140139.2020.1839675. Access: April 27, 2023.

YANG, Q.; VIJAYAKUMAR, A.; KAHN, B. B. Metabolites as regulators of insulin sensitivity and metabolism. **Nature Reviews Molecular Cell Biology**, New York, v. 19, n. 10, p. 654-672, 2018. Available from: https://www.nature.com/articles/s41580-018-0044-8. Access: April 27, 2023.

YARIBEYGI, H.; FARROKHI, F. R.; BUTLER, A. E.; SAHEBKAR, A. Insulin resistance: Review of the underlying molecular mechanisms. **Journal of Cellular Physiology**, Hoboken, v. 234, n. 6, p. 8152-8161, 2019. Available from: https://onlinelibrary.wiley.com/doi/10.1002/jcp.27603. Access: April 27, 2023.


ECEME

ARTICLE DOI 10.52781/cmm.a108

Operational medicine and mine action: theoretical essay and experience in the Republic of Colombia

Medicina operativa y acción contra minas: ensayo teórico y experiencia en la República de Colombia

Abstract: Humanitarian demining is one of the activities of peace and assistance missions that involve, even with the preparations, risks in their execution. Since the enhancement during the Civil War in the United States, landmines have been a part of virtually every conflict. The lifespan of an anti-personnel mine can be up to 30 years, which poses a long-term threat and the ongoing conflict makes it almost impossible to identify all mined areas. Operational medicine is the integrated and comprehensive medical care, consultation and management of medical information in tactical operations, which contributes to the security and success of a mission that is primarily military. This study shows the need to expand knowledge of injuries caused by explosives, especially for members of Humanitarian Demining missions, reducing mortality and loss of limbs.

Keywords: mine action; humanitarian demining; medic corps; military medicine; traumatic amputation.

Resumen: El desminado humanitario es una de las actividades de las misiones de paz y asistencia militar que implican, incluso con precauciones, riesgos en su ejecución. Desde su perfeccionamiento durante la Guerra de Secesión en Estados Unidos, las minas terrestres han formado parte de casi todos los conflictos. La vida útil de una mina antipersonal puede ser de hasta 30 años, lo que supone una amenaza duradera y, con los conflictos en curso, resulta casi imposible identificar todas las zonas minadas. La medicina operativa es la atención médica integrada y completa, la consulta y la administración de información médica en operaciones tácticas, que contribuyen a la seguridad y al éxito de una misión esencialmente militar. Este estudio muestra la necesidad de ampliar el conocimiento de las lesiones por explosivos, especialmente para aquellos en misiones de desminado humanitario, disminuyendo la mortalidad y la pérdida de miembros.

Palabras Clave: acción contra minas; desminado humanitario; apoyo sanitario; medicina militar; amputación traumática.

Rogério Santos Silva
Exército Brasileiro,
Comando da 12ª Região Militar.
Manaus, AM, Brasil.
rssvascular@gmail.com

Received: Oct. 29, 2022
Accepted: Mar. 21, 2023

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 INTRODUCTION

Mines, particularly anti-personnel mines, are a danger to human life and an impeding factor to the free movement of people and goods, hindering national reconstruction in the post-war period.

The Brazilian Armed Forces have extensive experience in humanitarian demining. Since 1993, within the scope of multilateral organizations, Brazil has collaborated in *Ação contra Minas na Missão de Assistência à Remoção de Minas na América Central* (Marminca – Mine Action with the Assistance Mission for Mine Clearance in Central America); the *Missão de Assistência para a Remoção de Minas na América do Sul* (Marminas – Assistance Mission for Mine Clearance in South America); and currently with the *Grupo de Monitores Interamericanos na Colômbia* (GMI-CO – Group of Inter-American Monitors in Colombia), as well as with the *Grupos de Assessores Técnicos Interamericanos na Colômbia* (GATI-CO – Group of Inter-American Technical Advisors in Colombia), providing specialists for programs linked to the *Junta Interamericana de Defesa* (JID – Inter-American Defense Junta), in addition to missions in Benin and Angola. It is noteworthy that Marminca pioneered the development of techniques and operational procedures, forming the basis for international standards on humanitarian demining (DA CÁS, 2018). In the documents generated by the missions mentioned, there is no presentation of an objective and efficient health support plan.

In a civilian environment, the recommendation is that pre-hospital care be given within ten minutes (platinum minutes) at the most. In addition, the recommendation is that the injured person receive hospital care within one hour (golden hour) (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017). Because of the geographical difficulty of demining areas, the transportation time (medical evacuation) often exceeds the above recommendation. However, according to international protocols (INTERNATIONAL MINE ACTION STANDARDS – Imas), medical evacuation from the accident area to a hospital with surgical capability should not exceed three hours. If this is not possible in the emergency process, the humanitarian demining organization should have an additional health care structure in place to stabilize the injured person before the medical evacuation to a higher level of care place.

Humanitarian demining is one of the activities of peace and assistance missions involving, even with all the preparations and precautions, risks in its execution. To reduce the consequences of accidents or incidents in these activities, we have to worry about health support in several stages: technical study; victim assistance; and, especially, minefield clearance.

Most undergraduate and graduate health and trauma care courses have little or no content for explosives injuries. Health professionals, doctors, nurses, nursing technicians and assistants need specific training on the effects of explosives on the human body, especially if they are going to work as health support in humanitarian demining operations and in primary care in conflict areas.

Therefore, it is necessary to increase the knowledge about explosives injuries and to train the members of the demining missions so that, in case of an accident, they can provide the best possible health care, reducing mortality and loss of limbs.

This article consists of a theoretical essay supported by bibliographic research on issues related to the historical evolution of mine action, humanitarian demining, and health support in these actions, in books, manuals and articles from a broad scope, including those provided by the web. We complemented the study with the experience in the mission of the *Grupo de Monitores Interamericanos na Colômbia* (Inter-American Monitors Group in Colombia), assuming, therefore, a qualitative and exploratory approach.

2 THE FIGHT AGAINST ANTI-PERSONNEL MINES

Since their enhancement in the American War of Secession in the American summer of 1862, landmines have been part of almost every major armed conflict, resulting in millions of victims. However, due to their nature as an insidious weapon hidden under the ground, mines continue to kill and maim for decades after conflicts have ended. When wars are over, the victims are no longer mostly military, but civilians. By blurring the distinction between civilian and military targets and causing damage disproportionate to the military objective, mines violate some of the most important principles of international humanitarian law and the Geneva Convention (ROMERO; GARCIA, 2017).

In October 1992, the Non-Governmental Organizations (NGO) Handicap International, Human Rights Watch, Medico International, Mines Advisory Group, Physicians for Human Rights, and Vietnam Veteran of America Foundation founded the International Campaign to Ban Landmines – ICBL. Four years later (1996), Canadian Foreign Minister Lloyd Axworthy makes a public challenge to governments and NGO to sign a definitive treaty banning the use of anti-personnel mines within one year. On December 3, 1997, in Canada, the first member states sign the Convention on the Prohibition of the Use, Stockpiling, Prohibition and Transfer of Anti-Personnel Mines and on their Destruction, which becomes known as the Ottawa Treaty. In addition to the duties expressed in its title, the treaty also provides for an obligation on the part of member states (currently 156 countries and territory) (Figure 1) to provide assistance to mine victims. The treaty initiative awarded the ICBL and its coordinator, Jody Williams, the 1997 Nobel Peace Prize (INTERNATIONAL CAMPAIGN TO BAN LANDMINES, 2020).

Figure 1 – Countries that ratified the Ottawa treaty

Source: INTERNATIONAL CAMPAIGN TO BAN LANDMINES, 2020

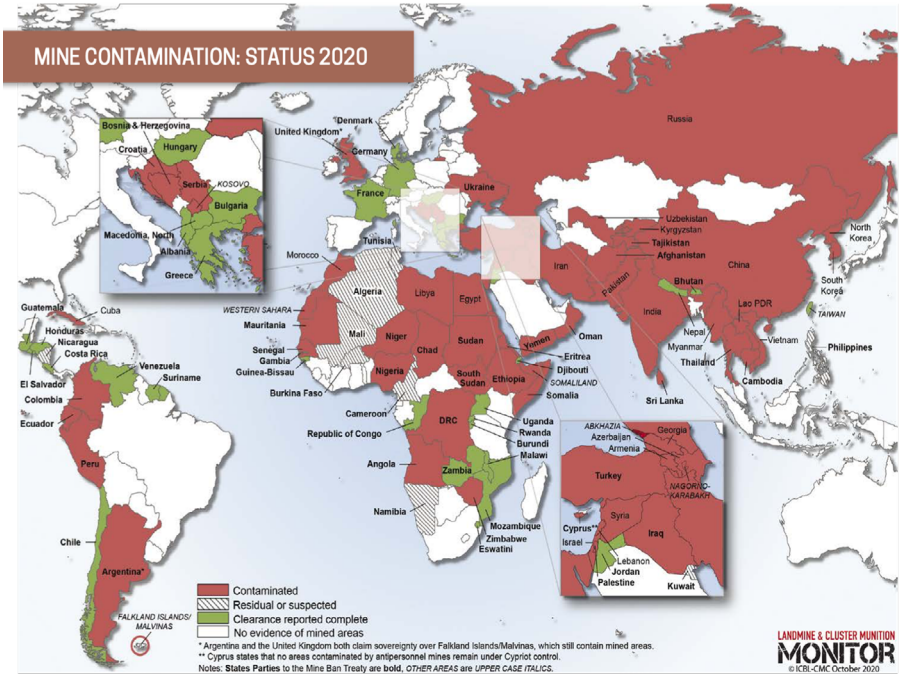
3 THE USE OF ANTI-PERSONNEL MINES

In Colombia, Law No. 759 of 2002 (COLOMBIA, 2002) defines Anti-Personnel Mine (APM) as one that has the potential to incapacitate, injure or kill one or more persons by presence, proximity or contact. It is estimated that there are more than 100,000 mines laid in Colombia (Figure 2) and close to residential, school, agricultural, business and military areas, with the majority of the affected territory being rural (ROMERO; GARCIA, 2017).

The lifespan of an anti-personnel mine can be up to 30 years, which poses a long-lasting threat. Added to this, the ongoing conflict makes it almost impossible to identify all mined areas with complete certainty, so suspicion alone turns large territories into unusable zones and clearing these areas is a long, dangerous and expensive process (INTERNATIONAL CAMPAIGN TO BAN LANDMINES, 2020).

The problem with APM is more complex because it is possible to use any object to make an explosive artifact, making them more difficult to detect. For example, the *quiebrapatas* type mine, which is activated by pressure or pressure relief, is made of ammonium nitrate (80%), sawdust (15%) and aluminum powder (5%), that is, cheap materials that are easy to buy and can be added to batteries, wires, tubes, bags, nails. Thus, it is possible to camouflage a mine in inoffensive objects such as household appliances, toys and even food (ROMERO; GARCIA, 2017).

Figure 2 – Countries affected by anti-personnel mines



Source: INTERNATIONAL CAMPAIGN TO BAN LANDMINES, 2020

4 TYPES OF EXPLOSIVES INJURIES

Blast injuries are multi-systemic with life-threatening and caused by various types of disasters. Victims of this type of injury tend to suffer more traumatic damage in varying anatomical locations, as well as higher severity scores compared to other trauma victims. The predominant post-blast injuries among survivors involve conventional penetrating and blunt traumatic injuries (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

Explosions are physical, chemical or nuclear reactions that result in the almost instantaneous release of large amounts of energy in the form of heat and highly compressed gas, which expands violently, becoming capable of projecting fragments at very high velocities (FELICIANO; MATTOX; MOORE, 2021).

The static component (expansive overpressure) envelops the objects in the flow field of the explosion and charges them on all sides with a discontinuous increase in pressure called the shock front or shock wave, up to a peak overpressure value (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

The dynamic component (dynamic pressure) is directional and experienced as wind. The main importance of wind is that it propels fragments with velocities exceeding several thousand meters per second (faster than standard ballistic weapons such as bullets and warheads) (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

Although the effective range of static and dynamic pressures is measured in tens of feet, fragments accelerated by dynamic pressure will quickly overcome the shock wave to become the predominant cause of damage in ranges of thousands of feet (FELICIANO; MATTOX; MOORE, 2021).

There are five types of injuries in an explosion: primary, blast shock wave; secondary, projectiles (the most common source of blast injury); tertiary, propulsion of the body toward another object; quaternary, heat and flame; quinquennial, radiation, chemicals, bacteria (FELICIANO; MATTOX; MOORE, 2021; NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

4.1 Primary Blast Injury

Primary blast injuries result from the direct effect of the blast wave (traveling at supersonic speeds) on the body. They affect the organs that contain gas, such as, the lung, the ear, and the gastrointestinal tract. The most common lung injury is a pulmonary contusion. Other lung injuries range from pneumothorax/hemothorax to arteriovenous fistulas (source of air emboli). Abdominal blast injuries are a significant cause of mortality and morbidity. Abdominal blast injuries can be hidden and difficult to diagnose and vary from hemorrhage to mucosal ischemia, bowel necrosis, and perforations. The middle ear is particularly sensitive to blast injuries, and rupture of the tympanic membrane (eardrum) can be a useful marker for blast injuries. However, isolated rupture of the tympanic membranes without other symptoms is not a high risk marker for associated blast injuries (FELICIANO; MATTOX; MOORE, 2021).

4.2 Secondary Blast Injury

Secondary blast injuries are caused by debris in flight generated by the blast. A common practice in bombings is to pack an Improvised Explosive Device (IED) with screws, nuts, and other small sharp objects. Significant soft tissue trauma, internal and orthopedic trauma often occurs from propelled projectiles (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

4.3 Tertiary Blast Injury

Tertiary blast injuries are caused by the body being propelled by the shock wave into solid objects (for example, walls). Victims of tertiary blast injuries suffer great damage from blunt trauma, for example, traumatic brain injuries, solid organ injuries, and complex orthopedic injuries. Penetrating injuries are not uncommon, causing impaling victims on objects present in the environment (FELICIANO; MATTOX; MOORE, 2021).

4.4 Quaternary Blast Injury

Various blast injuries encompass all other blast injuries, including burns, crushing, compartmental syndromes, and toxic inhalations (carbon monoxide, dust, hot gases).

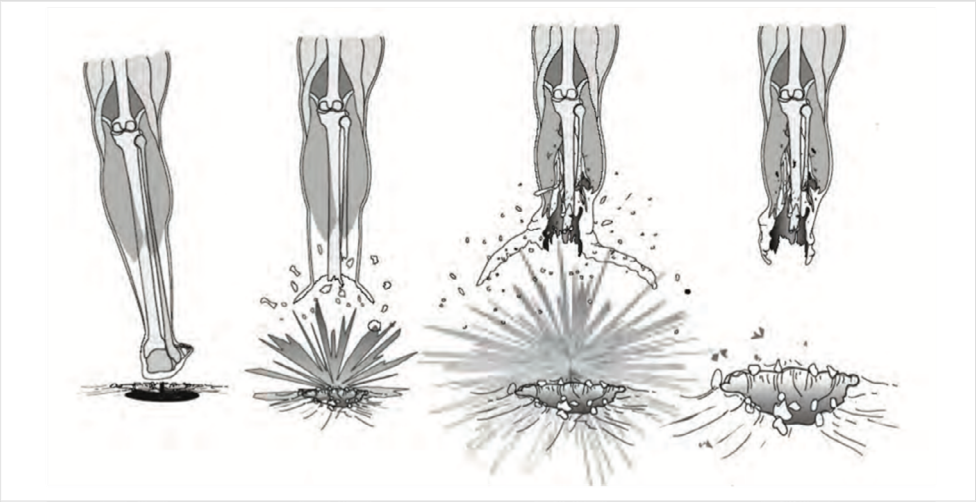
4.5 Quinary Blast Injury

Various blast injuries cover injuries caused by the blast in association with radiation, chemicals, and bacteria (GIANNOU; BALDAN, 2010).

4.6 Umbrella-type injury

In addition to the injuries mentioned, anti-personnel mines have a type of lower limb injury known as an *umbrella-type* injury. At the same time, the leg muscles are pushed up and outward in what can be described as the operation of an umbrella. The localized shockwave from the blast gases separates the periosteum and the attached muscles from the remaining bone: the umbrella opens. All muscles then fall away: the umbrella closes (Figure 3). The superficial muscles (gastrocnemius) are projected outward more and suffer less damage than the deeper muscle layers of the anterolateral compartment and the soleus muscle. The fascial planes are separated proximally causing irregular and variable skin loss (GIANNOU; BALDAN, 2010).

Figure 3 – Mechanism of Umbrella Blast Injury



Source: Giannou; Baldan, 2010

The surgeon should remember the pathology of the umbrella effect: the deeper muscle layers suffer greater damage than the more superficial ones, and the distal skin is still viable. Thus, a level of amputation based on knowledge of civil trauma would be too radical with respect to superficial tissues and not radical enough with respect to deeper tissues (Figure 4). In addition, the effects of the primary blast can produce tissue edema and compartment syndrome near the open injury (GIANNOU; BALDAN, 2010).

Figure 4 – Anti-personnel mine injury demonstrating the umbrella injury

Source: Giannou; Baldan, 2010

5 TRAUMATIC AMPUTATIONS

Traumatic amputations mainly affect adolescents and young adults, who are more exposed to accidents at work and in transportation. Armed conflicts and anti-personnel mines cause traumatic amputations in several countries (STARNES, 2006).

The second most common indication for amputation is trauma, and in adults under 50 years old it is the main indication. An acute injury is an indication for amputation when the blood supply to the limb is irreparably destroyed or when the limb is so badly injured that reasonable reconstruction is impossible. About 20% of all amputations are due to trauma, usually vehicle accidents, burns, explosions, and crush injuries from tools or machines, and they occur in men. These data are valid for countries without armed conflict (DÍAZ, 2010).

The prevalence of arterial extremity injury among contemporary war injuries is around 7% and extremity bleeding is the leading cause of preventable death in war. Special training of health care teams in conflicts after World War II resulted in improved management of massive hemorrhage with increased survival rates, as well as a substantial reduction in amputation rates. The use of the tourniquet, practically abolished in the civilian environment, can be an important tool for saving lives in the chaotic environment of war (SADAUSKAS, 2003).

Technical and doctrinal changes in the U.S. Army contributed to the decline in amputation rates after arterial wounding from 50% to 72% in World War II (1939-1945) to about 10% to 13% in the Korean (1951-1953) and Vietnam Wars (1964-1973), even with the increased destructive power of small arms (STARNES, 2006).

Fox *et al*. (2005) published a review of the wounded evacuees from the Iraq-Afghan conflict to an upper echelon hospital – Walter Reed Army Medical Center – and they found known or suspected vascular injury in 107 of 1524 war wounds, or a prevalence of 7%. Most of the injuries (64%) were due to explosives, including grenades, anti-personnel mines, mortars and improvised explosive devices. As for the anatomical distribution of injuries, 51% were located in the lower limbs, 39% in the upper limbs, 7% in the neck, and 3% in the pelvis.

Stannard *et al*. (2009) evaluated the experience in treating vascular injuries in British Armed Forces combatants in Iraq-Afghanistan war operations. In 1203 war injuries, 121 (9.9%) were direct injuries to medium or large caliber vessels. Of the 121 patients, 77 died before any opportunity for surgical treatment. All who had vascular lesions in the abdomen or chest died. Of 87 patients with extremity vascular injuries, 37 underwent surgery and two died postoperatively. Among the interventions for 38 extremities (of the 37 patients), they included 15 primary amputations, four ligatures, and 19 revascularizations resulting in 15 successes (limbs saved) and three late amputations.

The growth in the number of improvised explosives injuries in warfare is an observation reported by Fox *et al.* (2005) and reflects the modern predominance of urban guerrilla tactics. Included therein are elements of surprise against troops investing in the locality, such as defensive weapons in unpredictable locations, the employment of mines, traps, and prepared demolitions (SADAUSKAS,2003).

6 PRE-HOSPITAL CARE

Prehospital care (PHC) began in the late 18th century with Baron Dominique Jean Larrey, Napoleon Bonaparte's chief military surgeon. Larrey developed the flying ambulances because he noticed the need for quick removal of combatants acting at the battle front. This surgeon further noted that the men working in these ambulances should be trained in medical care to assist the victims at the scene of the incident and in transporting them to their final treatment. (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

Demands of war caused an evolution in military medical care, such as innovations in equipment. Lessons learned during the American Civil War, 1861-1865, were later applied in the civilian environment for pre-hospital care (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

Health support in tactical emergencies formally began in 1989, with the first formal course in medical support to special law enforcement operations, with a team from Swat (Special Weapons And Tactics), nos Estados Unidos (FELICIANO; MATTOX; MOORE, 2021).

7 OPERATIONAL MEDICINE

Operational medicine is the integrated and comprehensive medical care, consultation, and medical information management in tactical operations contributing to the safety and success of a primarily military mission (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

It is emergency medical support to tactical operations, such as, providing emergency medical service to military special operations, and providing comprehensive health care to members of tactical units on an ongoing basis, maintaining their physical and mental health to enhance tactical team performance (Figure 5).

Tactical emergency medicine is a rapidly expanding medical specialty that requires and utilizes a wide range of physician skills. It is medicine performed together with or in response to military operations, defined as a subspecialty of emergency medicine (FELICIANO; MATTOX; MOORE, 2021). Tactical combat victim care is a system of pre-hospital trauma care specifically designed, with all its particularities, for the tactical environment (TIEN *et al*., 2009).

Medical care generally did not occur during combat throughout most of history, so wounded soldiers were left to their own devices and waited until the end of combat to receive proper health care. It was only with Napoleon Bonaparte's French Army that this problem found a first solution (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

The concepts of quick evacuation from the battlefield and quick transport of the wounded to field hospitals emerged with the French army, and were widespread during the American Civil War. Nevertheless, in the early stages of the War of Secession, wounded soldiers

stayed up to five days on the battlefield waiting for help (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

Figure 5 – A soldier wounded by an anti-personnel mine in Colombia.

Source: Record made by the author, 2013

During the Vietnam War in the 1960s, military doctors began to provide first aid where combatants had been shot, that is, on the battlefield, and to quickly evacuate soldiers to trauma hospitals (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2017).

The support of the health teams to the tactical emergencies allows, besides an adequate and agile assistance to those who need it, a quick post-incident medical triage and the execution of small treatments (FELICIANO; MATTOX; MOORE, 2021). However, the potentially volatile and dangerous atmosphere surrounding tactical operations can cause serious injuries to those involved in the operation, whether they are officers, hostages, suspects, or even passersby. Given the particularity and dangerousness of these situations, a traditional Emergency Medical Services (EMS) approach can expose the PHC team to great risks, and even disrupt and/or interrupt the military mission. To meet these needs, the EMS must be specialized and trained to work together and provide support to the tactical teams (FELICIANO *et al*., 2021). In addition, they also warn that tactical medicine varies from ATLS (Advanced Trauma Life Support), in which the safety of the team is advocated and the means necessary for the initial and definitive care of the patient are presented.

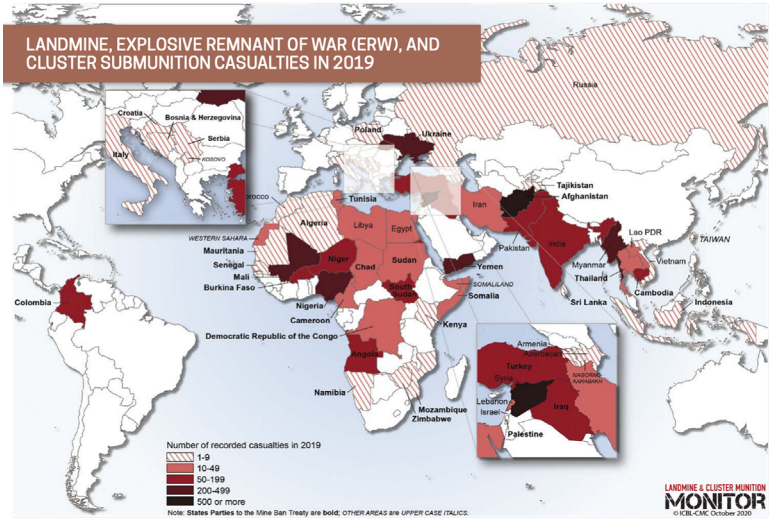
The primary role of the health support team is to provide the link between the site of injury and the appropriate admission of the patient to the health care system (NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS, 2007). The presence of

these teams on the scene decreases morbidity and mortality from injuries incurred during operations, contributing to the success of the mission and the safety and health of the tactical team (FELICIANO; MATTOX; MOORE, 2021).

8 THE ANTI-PERSONNEL MINE PROBLEM IN COLOMBIA

Colombia ranks second in the world, after Afghanistan, in the number of victims of APM and Explosive Remnants of War (ERW), as well as first in the number of victims in the Public Force due to these explosive artifacts (Figure 6). It is the only country in America where guerrillas use these weapons, despite the ban since 1992 by the Ottawa Convention under IHL (International Humanitarian Law). "Anti-personnel Mines do not distinguish between a combatant and someone who is not" (ROMERO; GARCIA, 2017, p. 20) and that is why their victimization is indiscriminate. The victims are not only the combatants, but also boys, girls and adolescents, women and men who live in the rural areas of the country.

Figure 6 – Countries affected by anti-personnel mines



Source: INTERNATIONAL CAMPAIGN TO BAN LANDMINES, 2020

9 HEALTH SUPPORT IN MINE ACTION

Imas 10.10 (INTERNATIONAL MINE ACTION STANDARDS, 2020) describes the responsibilities of the National Mine Action Authority (NMAA), employers and employees for providing and maintaining a safe working environment. This goal is achieved with the help of developing safe work practices and operating procedures, effective supervision and control, adequate education and training for men and women, safe equipment, and the provision of effective and appropriate personal protective equipment (PPE).

Developing a capability to provide an adequate response to a mine accident requires good planning, well-trained staff, and the availability of medical services capable of providing effective emergency treatment. Notwithstanding the legal and moral obligations placed on managers to provide the best possible medical support, particularly in the mine clearance workplace, planning must recognize the realities of field operations.

Table 1 – Types of Injuries Occurring in anti-personnel Mines Accidents with the Public Forces in Colombia

Lower limbs, abdomen, thorax and genitals	51%
Polytrauma	14%
Upper limbs and thorax	11%
Eye, face and neck injuries	5%
Superficial wounds and burns	4%
Amputation	31%

Source: Colombian National Army/AICMA, 2021

Health support in humanitarian demining operations is guided by Imas 10.40 (INTERNATIONAL MINE ACTION STANDARDS, 2014), which defines, in a generic way, the capabilities, attributions and minimum structure to develop the activities, especially the cleaning of the mined area. In this framework there is a request that each country affected by anti-personnel mines has its own protocol for health support, making this document more feasible given the realities of each country.

It is also mandatory for each organization, coordinated by IMAS 10.40, to submit its protocols for supporting humanitarian demining operations with details of the health conditions of each member of that organization, capabilities and training (especially of health professionals), techniques and forms of medical evacuation in the work area, and finally, the health plan and medical insurance.

Many countries, especially the poorest ones, which are the most affected by the anti-personnel mine problem, do not have a health structure that can adequately support humanitarian demining operations. Generally, because of the problems mentioned, these countries do not have a national protocol for health support to humanitarian demining operations and are subject to this standardization by Imas and the organization's mandatory humanitarian demining protocol.

Motivated by the lack of national protocols and the need for the standardization of health support, protocols have been developed by some humanitarian demining entities because of the importance of the subject. For example, we have the protocol in support of humanitarian demining operations of the JID and the protocol for Marminas operations – which guided preparations in health matters all the way to techniques and forms of evacuation in the clearance areas.

Therefore, the Mine Action Course was created at CCOPAB, which aims to prepare the military in humanitarian demining missions under the scope of international organizations. This center is a reference in the preparation of military personnel on an international level, and may be an opportunity to expand cooperation in this area by providing courses for participants in the many demining programs (DA CÁS, 2018).

This course also trains its members in the administrative issues of health support (need for ODH protocols, medical evacuation plans, and care in a hospital environment) and notions of basic explosives casualty care (Figure 7), with special focus during humanitarian demining (area clearance).

Figure 7 – Mine Action Course at CCOPAB – First Aid Instruction

Source: Record made by the author, 2017

10 HEALTH SUPPORT IN THE ACTIONS OF THE GMI-CO

In mine action, no work site, scenario or safety situation is identical, preventing the general use of established procedures and schedules. That said, Humanitarian Demining Organizations (HDO) have a responsibility to provide or ensure access to appropriate medical support for their staff. Imas 10.40 provides specifications and guidelines for the development of medical support for mine clearance operations. It identifies the minimum requirements for medical emergency preparation, including the planning necessary before the team mobilizes on mine clearance operations. In addition, it provides training for mine clearance and for the medical support of men and women teams.

Health support for humanitarian demining actions in Colombia, in the form of training, was provided by doctors from the Marminas mission until 2012 with training courses (first aid to the injured) for members of demining organizations, which until then was the responsibility of Bides – Colombian Army.

On March 1, 2011, the Organization of American States (OAS) requested the JID, through document GS/SMS/DPS/OHMA-017/11 (Mar. 1, 2011), the support of a medical monitor for the mission, with the following objectives:

- Objective 1: Strengthen the education, training or update needs in Pre Hospital Trauma Life Support (PHTLS) and Advanced Trauma Life Support (ATLS)

program standards to physicians and paramedics supporting humanitarian demining operations in remote areas of Colombia Programs.

- Objective 2: Promote in the teams the concept of trauma, combining the two main (independent and interdependent) trauma education programs, for paramedics who initiate the attention at the scene where the accident happened.
- Objective 3: Demonstrate to physicians and paramedics the roles, duties, and responsibilities of each of them.
- Objective 4: Determine how groups can work together to provide the best care for patients (doctors, paramedics, and deminers).
- Objective 5: To deliver a certificate, in the standards of the PHTLS and ATLS course, to the physicians and paramedics who pass the courses, according to the standards of the National Association of Emergency Medical Technicians (NAEMT).
- Objective 6: Conduct visits to observe medical procedures and medical evacuation in work areas and offer recommendations.

Figure 8 – Training Colombian military personnel for health support

Source: Record made by the author, 2014

10.1 Training course for health support to humanitarian demining actions in Colombia

The planning of the course for the training of the members of the civilian and military HDO followed the needs and requests of the AICMA-CO. The topics, subjects, and disciplines cover initial care of the injured, care of multiple victims, and medical evacuation. Accidents caused by anti-personnel mines and other explosives have their own characteristics, which were highlighted in the various levels of training offered. After approval of the content, focus, and target audience by JID and AICMA-CO, the GMI-CO began activities to structure and conduct the training course for health support in humanitarian demining operations.

The course is designed on the established PHTLS and ATLS frameworks with focus on the changes resulting from explosives injuries and the social, economic, and geographic characteristics of Colombia. At the beginning of the course, presentations of the Imas and current health support protocols are introduced, and the course ends with the current plans carried out in each region where the course is offered. The first training event took place in Bogotá, the Colombian capital, after which courses were held in Río Negro, Medellin, and in Nariño, in Antioquia state – one of the cities most affected by the armed conflict in Colombia.

10.2 Proposed Protocol for Health Support to Humanitarian Demining Operations for Colombia (General Notions)

This protocol provides the specifications and guidelines for the implementation of medical support techniques for humanitarian demining in the Colombian territory. Likewise, this protocol provides details on the responsibilities and obligations of the actors involved in the execution of the medical support.

Civilian Humanitarian Demining Organizations (CHDO) accredited by the National Government to conduct Humanitarian Demining activities must comply with the provisions of this standard; and implement their plans, programs, projects and operations in a coordinated manner with the Presidential Program of Comprehensive Action against Anti-Personnel Mines.

Medical care varies depending on where it is performed, the complexity of the situation, and its duration. However, in all cases, these general principles should be applied:

1. All medical support should be provided by the Humanitarian Demining Organization (HDO) accredited by the National Government and in coordination with the *Programa Presidencial de Ação Integral contra as Minas Antipessoal* (AICMA - Presidential Program for Comprehensive Action against Anti-Personnel Mines).
2. All medical support must be performed in accordance with a Standard Operating Procedure approved by the Inter-Institutional Humanitarian Demining Agency (IHD) and must be subject to quality assurance and quality control.
3. All information collected or developed (data, documents, etc.) during medical care must be sent to the President's Comprehensive Anti-Personnel Mine Action Program.

During the medical care, the community of the intervention area and other stakeholders must be consulted and informed, in order to ensure the best health structure and medical evacuation routes in case of accident or incident with Anti-Personnel Mine / Improvised Explosive Device / Unexploded ordnance (APM/IED/UXO).

Medical care must be performed in accordance with the provisions of the other National Humanitarian Demining Standards and will always be a mandatory requirement for the removal of APM/IED/UXO.

There are no APM/IED/UXO release operations without an acceptable level of medical care and a casualty evacuation plan. Everyone involved must fully understand and practice a medical evacuation plan.

If the medical support provided in this national protocol was eliminated or is not available, the authorization will cease immediately until it is restored.

Demining teams should conduct victim evacuation training at least once a month and when changing work sites. These drills will be recorded in the authorization task log.

Each demining activity will provide adequate medical support and evacuation of the injured. Humanitarian demining organizations (HDO) need to define precisely what kind of support is provided at each demining work site.

In each work area, the demining organization will have an equipped nursing assistant capable of performing victim rescue and Advanced Life Support (ALS) within five minutes of the accident. Each nursing assistant should have up to 15 minutes access to an emergency vehicle and the driver, which, during working hours, will not be used for any other purpose. The vehicle must be adequate to transport the victim quickly and safely to the nearest medical center, heliport, or landing strip.

For the Non-Technical and Technical Study Teams, a nurse's aide must be available and the investigation team must maintain proper communications, regarding the removal operations of APM/IED/UXO.

Medical support should be sufficient to stabilize large scale shrapnel wounds, traumatic amputation and multiple wounds and administer saline solution within 15 minutes of the accident or incident caused by APM/IED/UXO.

Organizations are responsible for ensuring that a properly equipped hospital with qualified surgical and medical equipment is available within 60 minutes of the transfer of any removal team of APM/IED /UXO. All organizations must clearly indicate in their Operating Procedure the implementation plans and the means provided for the evacuation of the injured.

The method of evacuation of victims should always be specified and understood by everyone. The primary method of evacuation is overland to the nearest hospital with operating capability.

Medical support and evacuation should contribute to the following goal: rapid and effective response to any accident or incident related to APM/IED /UXO for humanitarian demining activities.

11 CONCLUSION

Health support in non-warfare area clearance operations is not yet supported by Brazilian Army manuals, but the initial methodology can be found in the International Mine Action Standards (Imas).

In line with the issues raised, there is a need to develop a doctrine for the use of the health service in actions against mines, especially in the area clearance operation in a non-war situation (humanitarian demining), aiming first to provide support for these activities and then evolve into a guideline in a war situation.

The long period of conflict motivated the indiscriminate use of mines, causing serious effects for 31 states of the 32 existing in Colombia. Today Colombia is one of the countries most afflicted by this evil. In addition, despite great efforts to clear mined

areas, new contaminations by landmines or improvised explosive devices, particularly those launched by non-state actors who disregard the international legislation prohibiting their use, have emerged.

By supporting Colombia in the solution of its intrinsic problems, in the field of humanitarian actions and peace missions, Brazil strengthens its diplomacy and increases its influence in its strategic environment. The expansion of multilateral relations and cooperation actions will favor the reduction of humanitarian problems, as well as demonstrate Brazil's capacity to help and support international security efforts, increasing the country's legitimacy to the principles of world peace, as mentioned by Borlina (2015) and Geraldo (2020). The participation of Brazilian military personnel in humanitarian demining is a relevant support to the integration processes being developed in South America, especially in Colombia, by promoting dialogue, trust, and military cooperation for mutual defense.

CCOPAB is a reference center for training military personnel on humanitarian demining in association with the Engineering Instruction Center, in the city of Araguari, Minas Gerais. These two structures are in tune with the most modern techniques and equipment in use, but we still need a doctrine for humanitarian demining in its various phases, in addition to the health support offered for these activities. At the CCOPAB, training in the area of health was structured for Brazilian and foreign military and auxiliary forces, which would act in the various humanitarian demining missions. The participants of these trainings were also presented with a proposed protocol for Colombia for health support to humanitarian demining, demonstrating the need to specify and detail this health support for each region, area, or country in which the actions against mines would be carried out.

Army Planning, at the strategic and sectoral levels, must be oriented towards the acquisition of land military capabilities and operational capabilities that will enable the Brazilian Army to fulfill its mission and achieve its vision of the future (BRASIL, 2015). There is a need for these health operational capabilities to support humanitarian demining activities, with future application in military demining.

This paper, therefore, aims to stimulate debate about the topic, as well as to raise the interest and importance of health support about the activities involved in mine action.

REFERENCES

BORLINA, M. F. A desminagem humanitária como instrumento político da diplomacia brasileira. **Coleção Meira Mattos**: Revista das Ciências Militares, Rio de Janeiro, v. 9, n. 34, p. 9-31, 2015. Available from: http://www.ebrevistas.eb.mil.br/RMM/article/view/499. Access: April 3, 2023.

BRASIL. Exército Brasileiro. **Catálogo de Capacidades do Exército 2015-2035 (EB 20-C- 07,001)**. Brasília, DF: Ministério da Defesa, 2015.

COLOMBIA. **Ley No. 759 de 2002**. Dictan normas para dar cumplimiento a la Convención sobre la Prohibición el Empleo, Almacenamiento, Producción y Transferencia de minas antipersonal y sobre su destrucción se fijan disposiciones con el fin de erradicar en Colombia el uso de las minas antipersonal. Bogotá: Congreso de Colombia, 2002. Available from: https://www.refworld.org/docid/4ffea6762.html. Access: April 3, 2022.

DA CÁS, F. H. **A atuação de militares do Exército Brasileiro em missões de desminagem humanitária no continente africano**. 2018. Dissertação (Especialização em Ciências Militares) – Escola de Comando e Estado-Maior do Exército, Rio de Janeiro, 2018.

DÍAZ, O. Necesidades de cuidado de enfermería en soldados amputados por minas antipersona. **Revista Colombiana de Enfermería**, Bogotá, v. 5, n. 1, p. 53-66, 2010. Available from: https://revistacolombianadeenfermeria.unbosque.edu.co/index.php/RCE/article/view/1424. Access: April 3, 2023.

FELICIANO, D. V.; MATTOX, K. L.; MOORE, E. E. **Trauma**. 9. ed. New York: McGraw-Hill, 2021.

FOX, C. J. *et al*. Contemporary management of wartime vascular trauma. **Journal of Vascular Surgery**, Bethesda, v. 41, n. 4, p. 638-644, 2005. Available from: https://pubmed.ncbi.nlm.nih.gov/15874928/. Access: April 3, 2023.

GERALDO, A. F. A ação contra minas no contexto da construção da paz. **Revista Silva**, Rio de Janeiro, v. 4, p. 41-62, 2020. Available from: http://www.ebrevistas.eb.mil.br/silva/article/view/6689. Access: April 3, 2023.

GIANNOU, C.; BALDAN, M. **War surgery**: Working with limited resources in armed conflict and other situations of violence. Geneva: International Committee of the Red Cross, 2010.

INTERNATIONAL CAMPAIGN TO BAN LANDMINES. Cluster Munition Coalition. **Landmine Monitor 2020**. Monitoring and Research Committee, Geneva, International Campaign to Ban Landmines – Cluster Munition Coalition, 2020.

INTERNATIONAL MINE ACTION STANDARDS. Glossary of mine action terms, definitions and abbreviations. **IMAS**, Geneva, 2014. Available from: https://www.mineactionstandards.org/en/standards/document-detail/?tx_imas_document%5Bdocument%5D=264&tx_imas_document%5Baction%5D=show&tx_imas_document%5Bcontroller%5D=Document&cHash=611e82a6d46b2fe28da138e248a187ab. Access: March 21, 2021.

INTERNATIONAL MINE ACTION STANDARDS. Medical support to demining operation. **IMAS**, Geneva, 2020. Available from: https://www.mineactionstandards.org/en/standards/document-detail/?tx_imas_document%5Bdocument%5D=300&tx_imas_document%5Baction%5D=show&tx_imas_document%5Bcontroller%5D=Document&cHash=11413cdd3a284129491b182bd147672c. Access: March 21, 2021.

NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS. **PHTLS – Prehospital Trauma Life Support**. 8. ed. Amsterdam: Elsevier, 2017.

ORGANIZATION OF AMERICAN STATES. **Programa Presidencial para la Acción Integral Contra Minas Antipersonal (Aicma)**. Organization of American States, Washington, DC, 2023. Available from: http://www.oas.org/csh/spanish/desmaicma.asp#:~:text=El%20Programa%20de%20Acci%C3%B3n%20Integral,entre%20las%20que%20se%20incluyen%3A&text=Apoyo%20para%20actividades%20para%20desminado,marcado%20y%20limpieza%20de%20minas.&text=Educaci%C3%B3n%20preventiva%20para%20la%20gente%20que%20vive%20en%20las%20zonas%20afectadas. Access: March 21, 2021.

ROMERO, G. A. R.; GARCIA, M. E. P. **La guerra escondida**: Minas antipersonal y remanentes explosivos en Colombia (Relator e investigador). Bogotá: Centro Nacional de Memoria Histórica, 2017.

SADAUSKAS, P. S. **Fundamentos Doutrinários do Apoio Logístico de Saúde no Combate em Localidade**. 2003. Trabalho de Conclusão de Curso (Especialização em Ciências Militares) – Escola de Comando e Estado-Maior do Exército, Rio de Janeiro, 2003.

STANNARD, A. *et al*. Vascular trauma: survivability and surgical outcome in a deployed military trauma system. **British Journal of Surgery**, Oxford, v. 96, p. 1-15, 2009. Available from: https://academic.oup.com/bjs/article/96/Supplement_1/6/6179744. Access: April 3, 2023.

STARNES, B. W.; BEEKLEY, A. C.; SEBESTA, J. A.; ANDERSEN, C. A.; RUSH, R. M. Extremity vascular injuries on the battlefield: tips for surgeons deploying to war. **Journal of Trauma**, Bethesda, v. 60, p. 432-442, 2006. Available from: https://pubmed.ncbi.nlm.nih.gov/16508513/. Access: April 3, 2023.

TIEN, H. C.; JUNG, V.; RIZOLI, S. B.; ACHARYA, S. V.; MACDONALD, J. C. An evaluation of tactical combat casualty care interventions in a combat environment. **Journals of the American College of Cardiology**, Bethesda, v. 9, n. 1, p. 65-68, 2009. Available from: https://pubmed.ncbi.nlm.nih.gov/18656043/. Access: April 3, 2023.


ECEME

AUTHOR GUIDELINES AND ADDITIONAL INFORMATION

The entire submission process should be performed through our editorial management system, available at:

http://ebrevistas.eb.mil.br/index.php/RMM/index (Short URL: bit.ly/cmmbr)

In case of doubts or technical difficulties, please contact us by email: info.cmm@eceme.eb.mil.br

The manuscript:

1) It must be original and unpublished;
2) It must not have been published or be in assessment process by another journal, and an eventual submission to another journal will only occur after the assessment return;
3) A substantially similar version must not have been published in annals of events.

Guidelines for Authors

The following guidelines are essential to good editorial flow. Please, read the instructions carefully to be sure that your article meets all requirements. Complete regulatory requirements must be accessed directly in our system.

Article submissions are open in a continuous flow. Other publications such as interviews or technical reports will be selected directly by the editorial team.

Focus and Scope

The *Coleção Meira Mattos* is an interdisciplinary journal that publishes scientific articles related to Security, Defense and Military Sciences, promoting a dialogue between academics and professionals and integrating questions about Armed Forces and Society. It publishes peer-reviewed articles and, occasionally, interviews and selected technical reports on current issues of interest to the area.

Formatting

The papers should be submitted in Word or RTF format.

Structure

Language: articles may be submitted in Portuguese, English or Spanish.

Title: The title should be brief, limited to 22 words (including, if any, the subtitle).

Abstract: with a maximum of 150 words in the language of the text and in English (when submitted in Portuguese or Spanish). It must describe the objectives, methodology and results.

Keywords: at least three and at most five.

Tables, graphics and images: Use editable formats whenever possible so that translations can occur directly in the image. The quality of the images should be 300dpi when they are not from Word/Excel (tables and graphics). The graphic content should be included only if they provide indispensable information for the article's understanding.

Word limit: The article should have between 6000 and 8000 words, including pre-text and references. However, major or minor articles may be published as long as justified by the content of the contribution.

Footnotes: Notes should be included as little as possible and only for essential information. They should be included on the same page as the note, do not use endnote. Avoid using notes to reference, privilege the use of author-date citations directly in the text. For notes of informative texts available on the Internet that are of interest to the reader and which are not direct or indirect citations, such as news, institutional or corporate websites, electronic documents, tables or statistical data, the link and access date must be indicated, as following example:

[Explanatory text]. Available at: [website]. Access on: [month abbr. Day, year].

More information available on the Brazilian Army website. Available at: www.eb.mil.br. Access on: Jul. 2, 2019.

Other Recommendations

Indication of financing: it should be indicated as a footnote of the title if the research is financed and who financed it. Also indicate, when available, the process number. According to the following structure:

Study/Research project financed by the [funding body], through [project/program], [notice/process].

Example:

Study funded by the Brazilian Ministry of Defense and the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES), through the Program of Support for Teaching and Scientific and Technological Research in National Defense (*Pró-Defesa*), notice 27/2018.

Data about the author(s): they must be informed only in the metadata filled in the system when submitting the article. Only the full name, institutional association and e-mail address will be published.

Example:

Tássio Franchi

Exército Brasileiro, Escola de Comando e Estado-Maior do Exército, Instituto Meira Mattos. Rio de Janeiro, RJ, Brasil.

editor.cmm@eceme.eb.mil.br

We will not accept articles with more than 4 (four) authors/co-authors.

The authors should have at least a masters or similar degree and, preferably, one of them should have a doctorate degree.

Additional documents: Other documents may be inserted during submission to assist reviewers in the article assessment process. However, only the article will be published and made available in the journal.

Citations and References

CMM adopts the Brazilian standards for references and citations, respectively ABNT 6023:2018 and 10520:2002.

For authors not familiar with the ABNT standard, we ask that you adapt your citations and references as much as possible according to the following examples. All references and citations will be reviewed by experts, ensuring their uniformity. However, articles standardized in other presentation standards will not be accepted.

See the full standard requirements and examples of references and citations on our website.

Copyright Statement

Acknowledgements
Volume 17, number 59, 2023

Our acknowledgment for the the financial and administrative support from the following institutions and their related agencies. As well as all staff who get involved directly and indirectly with the Coleção Meira Mattos.

Ministério da Defesa

Departamento de Ensino

Divisão de Cooperação Acadêmica

Departamento de Educação e Cultura do Exército

Diretoria de Educação Superior Militar

Dir. do Patrimônio Histórico e Cultural do Exército

Escola de Comando e Estado-Maior do Exército

Coordenadoria de Avaliação e Desenvolvimento da Educação Superior Militar no Exército

EB Conhecer


ECEME

Coleção Meira Mattos

revista das ciências militares

Publication

EXÉRCITO BRASILEIRO
Braço Forte - Mão Amiga

ECEME

Edition

INSTITUTO MEIRA MATTOS
ESCOLA DE COMANDO E ESTADO-MAIOR DO EXÉRCITO

PPGCM