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Fatigue assessment through non-invasive physiological monitoring in military performance: Protocol for a Systematic Review

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Abstract

During military operations, soldiers often encounter extreme environmental, metabolic and neuropsychiatric conditions, which combined lead to a fatigue status that can cause serious physiological impairments, decreasing military performance on the battlefield. Comprehensive studies in realistically stressful environments are essential to expand the knowledge regarding the consequences of real-life stress exposure, facilitate the development of operationally-useful techniques and promote the conception of improved treatments. Therefore, a systematic review is proposed to obtain relevant information about fatigue assessment through multiple physiological parameters in the military context, to focus on determining the associations between fatigue and physiological response in order to plan in the future adequate interventions to prevent related negative consequences. Thus, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) Statement, this systematic review protocol was elaborated in order to present adequate guidelines to develop a research that can provide appropriate results to fulfill the sought objective. Five databases will be accessed (SCOPUS, PubMed, Science Direct, Medline and Web of Science) and a total of 9 combinations of keywords will be used. This protocol is registered in PROSPERO under the code of PROSPERO CRD42018105833.

1. INTRODUCTION

1.1. Background

Fatigue is a complex and multifaceted phenomenon. One of its most common definitions states it as a "failure to maintain the required or expected force" (Edwars 1983). A more descriptive concept explains it as a subjective, unpleasant symptom which incorporates total body feelings ranging from tiredness to exhaustion creating an unrelenting overall condition which interferes with individuals' ability to function to their normal capacity (Ream and Richardson 1996).

In general, fatigue can be understood as a condition involving the decreased ability of individuals to perform activities at the desired level due to lassitude or exhaustion of mental and/or physical strength (Ream and Richardson 1996, Hallowell 2010).

Fatigue degrades performance and well-being leading to error, incident, and accident in operational settings. An operational setting is one in which effective human performance is crucial to a successful outcome. If the human fails, the system fails. Technological advances are enabling 24/7 (twenty-four hours a day, seven days a week) operations and the integration of

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human activity around the globe, thus increasing exposure to the factors creating fatigue (Belenky et al. 2014). And military operations are not exempt from this phenomenon. New technological complexity, the lethality of weapons systems, and rapid worldwide response capabilities make the performance of the individual soldier more critical to mission success than ever before. The near- and long-term health of individual soldiers is also potentially at risk from military technologies that can surpass operator capabilities and safety (Friedl 2012).

What is more, the physical demands of combat impose unique stresses on soldiers not seen in any type of civilian occupations. Besides typical operational stressors, soldiers, are exposed to extreme environments, heavy workload, inadequate sleep, information overload, dehydration and impaired nutritional status. The combination of these stressors can cause serious physiological impairments, decreasing physical and military performance on the battlefield (Henning, Park, and Kim 2011, Lieberman et al. 2005).

As physiological stressors compromise health and performance, human performance optimization involves strategies to sustain both in the face of these stressors. Physiological modeling defining human tolerance limits and the effect of moderating factors provide scientifically based strategies for interventions that ultimately involve the way individuals and teams eat, rest, train, and are equipped. Thus, it is important to consider models that combine multiple stressors because individuals are rarely subjected to only one stressor at a time (Friedl 2012).

Additionally, as Taylor et al.(2007) empathizes, comprehensive studies in realistically stressful environments are essential to expand the knowledge regarding the consequences of real-life stress exposure, facilitate development of operationally-useful techniques and promote the conception of improved treatments as they differ greatly from more controlled settings in terms of environment, activity, equipment, and subject motivation (Taylor et al. 2007).

However, collecting the necessary physiological data in mission environments and activities has historically been hindered by lack of access to in-theatre warfighters and difficulties associated with measuring parameters such as heart rate and core temperature in the field. It is only with the development of non-invasive physiological status monitoring systems, that such data can be collected effectively during military activities.

To date, no systematic review has been conducted on the results obtained from these non-invasive physiological monitoring systems during military operations. Therefore, a systematic review is proposed in order to search for relevant information about fatigue assessment through multiple non-invasive physiological parameters in the military context, to focus on determining the associations between fatigue and physiological response in order to plan in the future adequate interventions to prevent related negative consequences.

1.2. Objectives

The purpose of this systematic review is twofold and, hence, will be conducted in two stages.

- The first objective is to identify fatigue assessment methods performed during military operational scenarios and that involve measurement of multiple physiological parameters, with focus on non-invasive procedures, to determine the associations between fatigue and physiological response that could lead to planning future adequate interventions.

- The second objective is to analyze the reliability of results provided by those assessment methods, along with the additional considered parameters, used software and equipment and the conclusions derived from the developed studies.

Specifically, the proposed systematic review will attempt to sequentially answer the following questions:

1. What are the fatigue assessment methods applied in military operational scenarios?

2. From the identified methods, which involve the measurement of multiple physiological parameters?

3. Are non-invasive procedures applied? Which parameters do they consider?

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4. How conclusive are the results obtained by these non-invasive procedures?

5. Which software and equipment are used within these identified non-invasive physiological monitoring methods?

6. What are the conclusions derived from developed studies?

2. METHODS

2.1. Research Framework

This systematic review protocol follows the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) Statement (Shamseer et al. 2015, Moher et al. 2015).

2.2. Eligibility criteria

Type of studies

Primarily, only research published articles and articles in press will be considered.

Since the aim of the review is to find relevant information in military operational settings, theoretical studies such as literature reviews and conference papers will be excluded.

Context

Eligible publications will include those presenting investigations developed in field, combat or training military conditions.

Type of participants

The research will focus on healthy active military personnel. The study will include both, female and male samples, with no age limits. Additional restrictions will not be considered since the emphasis will be on the applied assessment parameters.

Methods of assessment

Studies will be included if they apply a non-invasive objective physiological assessment method.

Language

The review will only consider articles written in English.

2.3. Information sources

The research will include the following electronic databases: SCOPUS, PubMed, Science Direct, Medline and Web of Science. It will be conducted on journal articles from 2013 to 2018. The year range is set in order to obtain relevant outcomes on currently available physiological monitoring methods used on present military practices.

Additionally, the study will also look through the references of the collected articles to search for any additional record relevant to the goals of the review. This process will be repeated until no more related outcomes can be found.

2.4. Search strategy

The intended systematic review will aim to focus on literature that addresses fatigue assessment and military performance. Thus, selected keywords are categorized in two groups, referring to each of those topics: group (A) with 'Fatigue', 'Physical exertion' and 'Monitoring'; and group (B) with 'Military training', 'Military performance' and 'Military operations'.

Combinations of keywords from both groups will be formed as follows:

1. Fatigue + Military training

2. Fatigue + Military performance

3. Fatigue + Military operations

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4. Physical exertion + Military training

5. Physical exertion + Military performance

6. Physical exertion + Military operations

7. Monitoring + Military training

8. Monitoring + Military performance

9. Monitoring + Military operations

In every database, the search will be performed inserting each combination (separated by the operator "AND") and selecting, when possible, "Article title, Abstract, Keywords".

On a second stage, as the selected articles are analyzed, potential new keywords will be identified, and a new search will be conducted. Similarly, references will also be checked in order to find older articles that could provide complementary information. This procedure will be repeated in the new identified articles until no more relevant outcomes are obtained. Furthermore, other works developed by the authors of the primary studies included in the review will be consulted in order to find related investigations that fulfill the established inclusion criteria.

Lastly, in a third stage of research, additional sources referenced in the analyzed articles will be identified and accessed. Since this review aims to focus on studies developed in the military context, those additional sources will primarily include military sites and associated research institutions.

2.5. Study records

Data management

After finishing the search and recording the number of collected articles in Table 1 (see Annex 1), selected articles from each database will be exported for screening and removing duplicates. Both title and abstracts are going to be analyzed. Then, after taking in consideration the established selection criteria, full-text from the resultant studies will be retrieved and assessed.

The number of articles resulting from every filter stage will be registered in the aforementioned table (see Annex 1). This will allow keeping track of every study from the first identified articles to the final selected publications along with the number of excluded articles from every applied criterion.

Records management will be performed with the "EndNote" software.

Selection process

As each combination is inserted, three phases of exclusion will be applied:

- Through search filters, the following criteria will be considered:

  - Date: Articles published between January 2013 and January 2018. However, for the previously mentioned second and third stages of the search process, no date restrictions will be applied.

  - Type of article: Articles and Articles in Press.

  - Source type: Journals.

  - Language: English.

  - Source Title: related to Military, Physiology, Sports, Medicine and Ergonomics.

- Repeated articles will be removed.

- Articles will be excluded if any of the next conditions are met:

  - Studies are not applied in a military sample.

  - Studies only consider subjective methods of assessment.

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Subsequently, full-texts will be collected with the objective of extracting the needed information to determine the fulfillment of the inclusion criteria. In that regarding, studies will be included if both of the following conditions are met:

- They objectively assess physiological parameters through non-invasive methods.
- Assessments are developed in field, combat or training military conditions.

The removal of any article after a full-text consideration will be justified and recorded.

Data collection process

From the final selected studies, full-text will be retrieved with the objective of collecting information of interest.

Extracted information will include:

1. Study general information: authors, year of publication, country.

2. Sample characteristics: size, gender distribution, mean age.

3. Context: in field, combat and/or training conditions; associated risks and stressors.

4. Study characteristics: goals, considered physiological parameters, other assessed parameters, procedures/methods, conclusions, equipment, and software.

5. Major study limitations.

6. Quality assessment: possible risks of bias (risk of selection bias, precision, risk of information bias, risk of investigator bias), reporting (assessment of the overall study quality), external validity (assessment of whether the study results are generalizable), internal validity (assessment of bias due to study sample selection and/or confounding), power (assessment of whether study results could be obtained by chance).

2.6. Data items

Summary tables will be elaborated with information compiling the topics presented in the above section, mainly: reference and country, sample size, gender distribution and mean age range, study goals, conclusions, measured parameters and equipment, and software.

2.7. Outcomes and prioritization

From this proposed research, the following primary outcomes are expected:

1. To identify physiological variables measured during military operations.

2. To determine the methods and equipment of measurement.

3. To evaluate the reliability of results from non-invasive physiological monitoring methods in field conditions.

4. To stablish possible relationships between fatigue and physiological response.

Additionally, as a secondary outcome, other assessed parameters will be observed and the correspondence of results with previously identified variables will be determined. Finally, the most frequently evaluated parameters will be identified and comparison of outcomes from different studies will be made.

2.8. Risk of bias in individual studies

The risk of bias will be assessed individually for this review. Two phases will take place along the assessment. First, the general characteristics of each study will be identified and analyzed in accordance with the sought goals of this review. Considered parameters will include aims and objectives, assessed variables, applied methods and equipment, assessment procedure, time of measurement.

Later, taking as a reference the Cochrane Collaboration's Tool for assessing the risk of bias (Table 2 in Annex 1), methodological issues will be addressed; ethical standards fulfillment, sample justification, clear description of the experimental procedure and practical difficulties.

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Each of the determined topics will be ranged by 'yes', 'no' or 'unclear', this last one indicating that there is not sufficient information to determine the fulfillment of the criteria.

Studies presenting more positive answers to the established criteria will be the ones considered as the most suitable and reliable to the objectives of this review.

2.9. Data Synthesis

If obtained data allows it, a meta-analysis will be conducted. Otherwise, it is planned to conduct a narrative synthesis, based on assembled data tables (with information from the selected publications), in which the main objective will be to present the physiological parameters assessed and the relevance of their outcomes. Bias will also be evaluated when analyzing the data.

The checklist of The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Statement will delimitate this process (Moher et al. 2009).

2.10.   Meta-bias (es)

If the extracted articles permit the formulation of a meta-analysis, a meta-bias will be conducted later.

2.11.   Confidence in cumulative evidence

This parameter is not applicable to the proposed review.

2.12.   Protocol registration

This protocol is registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the code CRD42018105833.

AUTHORS' CONTRIBUTIONS

Study design and development: DB, JCG, JTC.

Title and abstract screening: DB, JCG.

Full-text screening: DB.

Data extraction: DB, JCG, JTC.

Critical appraisal: DB, JCG, JTC.

Data analysis and interpretation: DB, JCG, JTC.

Draft of the protocol: DB.

Support in draft's development: DB, JCG, JTC.

All authors read and approved the final version.

SUPPORT

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ANNEX 1

Table 1 – Form sheet summarizing the proposed rejection criteria

Summary of collected articles	Summary of selected articles	Summary of rejected articles	Summary of Total Rejected Items						Database	Keyword Group A + Keyword Group B							
			Date	Type of document	Source type	Language	Other	Out of topic		nº of selected articles	nº of collected articles	nº of articles included after criteria					
												Date	Type of document	Source type	Language	Other	Out of topic
0	0	0	0	0	0	0	0	0	Total	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	**SCOPUS**	0							
0	0	0	0	0	0	0	0	0	**PUBMED**	0							
0	0	0	0	0	0	0	0	0	**SCIENCE DIRECT**	0							
0	0	0	0	0	0	0	0	0	**MEDLINE**	0							
0	0	0	0	0	0	0	0	0	**WEB OF SCIENCE**	0							

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Table 2 – The Cochrane Collaboration's tool for assessing risk of bias.

Domain	Support for judgement	Review authors' judgement
Selection bias.		
Random sequence generation.	Describe the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.	Selection bias (biased allocation to interventions) due to inadequate generation of a randomized sequence.
Allocation concealment.	Describe the method used to conceal the allocation sequence in sufficient detail to determine whether intervention allocations could have been foreseen in advance of, or during, enrolment.	Selection bias (biased allocation to interventions) due to inadequate concealment of allocations prior to assignment.
Performance bias.		
Blinding of participants and personnel *Assessments should be made for each main outcome (or class of outcomes).*	Describe all measures used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.	Performance bias due to knowledge of the allocated interventions by participants and personnel during the study.
Detection bias.		
Blinding of outcome assessment *Assessments should be made for each main outcome (or class of outcomes).*	Describe all measures used, if any, to blind outcome assessors from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.	Detection bias due to knowledge of the allocated interventions by outcome assessors.
Attrition bias.		
Incomplete outcome data *Assessments should be made for each main outcome (or class of outcomes).*	Describe the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. State whether attrition and exclusions were reported, the numbers in each intervention group (compared with total randomized participants), reasons for attrition/exclusions where reported, and any re-inclusions in analyses performed by the review authors.	Attrition bias due to amount, nature or handling of incomplete outcome data.
Reporting bias.		
Selective reporting.	State how the possibility of selective outcome reporting was examined by the review authors, and what was found.	Reporting bias due to selective outcome reporting.
Other bias.		
Other sources of bias.	State any important concerns about bias not addressed in the other domains in the tool. If questions/entries were pre-specified in the review's protocol, responses should be provided for each question/entry.	Bias due to problems not covered elsewhere in the table.