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Equipment and advances for measuring fatigue in office settings: systematic review protocol

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Abstract

Fatigue in humans is a state that reduces activity, ability to perform, or cognitive functions due to internal sensations such as tiredness, drowsiness, sleepiness, and burnout. It is directly influenced by mentally demanding or stressful tasks and indirectly by physical activities that reduce alertness, mental focus, motivation, and other psychological factors. While fatigue has been studied extensively in various settings such as transport and emergency responders and environments like hospitals, a clear and unified database of equipment to measure fatigue in office work quantitatively has yet to be presented. Considering the importance of fatigue-induced loss of productivity, the need for understanding fatigue in offices is clear. A database regarding what fatigue will cause, its effects on the human body with more precision, and how it is measured will be a good source for future research. A systematic review for fatigue measurement is proposed to determine the relationship between workers' exposure to sedentary status during their working days and fatigue-induced pains and cognitive function reductions. The objective of this systematic review protocol is to establish the criteria necessary for conducting research eventually aimed at mitigating the negative consequences. By doing so, it would enable the creation of programs and measures to minimize these effects. The protocol is founded on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) Statement and is registered on PROSPERO with ID number CRD42023408696.

1. INTRODUCTION

Studies have shown that fatigue can be considered a contributing factor to reducing human performance in different fields (Van Der Linden and Eling 2006; Williamson et al. 2005). In simple terms, fatigue, objective or subjective, is a state where a person's ability to carry out tasks at the usual level is reduced because they feel tired or exhausted both mentally and physically (Bustos et al. 2021). Fatigue encompasses both objective and subjective dimensions. Objective fatigue is characterized by mental, emotional, or physical exhaustion resulting from sustained involvement in a specific task, project, or objective. This occurs when an individual's cognitive resources and energy are depleted due to prolonged and demanding responsibilities. On the other hand, subjective fatigue pertains to an individual's personal experience and perception of tiredness, sleepiness, or drowsiness. It is a subjective state encompassing physical weariness, mental exhaustion, and a general lack of energy (Ream and Richardson 1996). As fatigue could affect and decrease response time and increase decision-making time, many jobs are subject to fatigue-induced human error (Pimenta et al. 2013). Some jobs are more prone to accidents that have perilous consequences, such as military soldiers, drivers, pilots, and offshore workers (Meijer, Robb, and Smit 2017; Sant'Anna and Hilal 2021; Williamson et al. 2005). However, there are less perilous environments

in which fatigue could still cause human error, among other issues, such as those from office work. While it could be argued that office environments are considered safe occupational spaces, it does not mean that the employees are fully risk-proof (Arezes et al. 2020).

From an individual point of view, office workers are prone to multiple musculoskeletal disorders, such as neck and back pain, and other physiological and psychological issues (Abdulameer, Finteel, and Flayyih 2020; Lima and Coelho 2018; Rizzo, Peresson, and Larese Filon 2012). From an organizational point of view, physiological and psychological issues amongst office workers could lead to indirect financial loss from health care and absence. Fatigue could exacerbate either aspect of an office worker's health, even if we neglect the human error role in making small mistakes and direct and indirect losses of a company (Knezevic et al. 2021; Lima and Coelho 2018). This highlights the importance of understanding fatigue among office workers to improve their health and increase their work efficiency.

There are methods to measure fatigue in objective and subjective ways, including but not limited to questionnaires for psychological subjective fatigue assessment, such as Nordic Musculoskeletal Questionnaire or Cornell Musculoskeletal Discomfort Questionnaires (Bazazan et al. 2019; Chaiklieng and Poochada 2021). There are various methods to measure fatigue objectively, such as Electroencephalography (Ramirez-Moreno et al. 2021) or surface Electromyography (Fu et al. 2022; Mota-Carmona et al. 2022), but most methods appear to be time-consuming, intrusive, and excessive (Pimenta et al. 2013). However, with the advances in software development and sensors engineering, fatigue measurement via non-intrusive methods using computers and machine learning seems to be a trend (Bustos et al. 2019; D. Bustos et al. 2021; Gonçalves, Guedes, and Santos Baptista 2015; Lee et al. 2021; Ramos et al. 2020). Machine learning is the study of algorithms with which a machine/computer can learn from experience and can improve automatically through more data and experience (Mitchell 1997). While the concept has existed since the late 90's, the applications are relatively new. The relevance of these new and innovative technologies for fatigue assessment among office workers should be explored. Such review of the available methodologies to assess fatigue in office work has not yet been performed to this date. This study acknowledges the lack of criticality of office work with respect to other professions, such as driving, in terms of being risk-prone yet recognizes the lack of attention given to this sector. Therefore, this study defines its objectives as stated in the following section.

The purpose of this systematic review protocol is to establish the criteria necessary for conducting research eventually aimed at mitigating the negative consequences. This inquiry will facilitate the development of initiatives and programs to understand the most feasible, precise and affordable technologies and methodologies for this purpose, with the final aim of optimizing such methods and/or developing a new methodology. To understand and perform a review of what methods are available to assess and measure fatigue among office workers via machine learning methods the following research questions have been identified:

(1) What are the feasible approaches to measuring fatigue in an office setting?

(2) What are the successful examples of machine learning applications in measuring fatigue within the specific office environment?

(3) What type of equipment have they used in their studies to collect and process raw data and features?

(4) What features were significant to estimating fatigue and how was the fatigue state identified through machine learning?

(5) What was the type of measured fatigue and what was considered when reporting the outcomes (for example, if accuracy or any performance metric were reported)?

2. METHODOLOGY

This plan for a systematic review follows the instructions set out in the PRISMA-P Statement, which provides guidelines for reporting systematic review protocols and meta-analyses (Shamseer et al. 2015).

2.1. Eligibility criteria

Type of Studies

Throughout this review, only published research articles will be selected. Theoretical or review studies will be excluded. Conference papers will be checked for quality and relevance. Inclusion criteria were determined as follows:

Office workers; at least 18 years of age with no prior incidents of metabolic disorders or diseases. Exclusion criteria: Home office and teleworking, non-sedentary workers, part-time or shift workers.

Context

Any publication using any methodologies, or equipment to indicate and measure fatigue in office settings will be selected.

Participants

The research will focus on studies developed within workers who are exposed to office work in a seated setting. It will include human samples regardless of gender and with an age restriction of at least 18 and at most 65, the average retirement age in most countries.

2.2 Information sources and search strategy

The databases used for this review will be Scopus, Web of Science, PubMed, and Science Direct. The search will include the articles published in the last five years to have an up-to-date collection of the methods. Furthermore, the references of the ultimately included articles will be checked for snowballing the accumulated articles in terms of richness and compiling. The first-time databases were accessed was on March 18, 2023, and the search is ongoing at the time of the writing. Using the search strategy worksheet available on the Western Libraries website, the following keywords were identified, as seen in Table 1.

Table 1. Search datasheet[1]: An example for a search on Scopus could be ((Fatigue OR Drowsiness OR Tiredness) AND (Detection OR Measurement) AND (office OR sedentary))

		AND	AND
	Group 1	Group 2	Group 3
OR	Fatigue	Detection	Office
OR	Drowsiness	Measurement	Sedentary
OR	Tiredness		

A spreadsheet was created in Excel to record relevant data regarding the title of each article and their presence in each database, with one sheet dedicated to why articles were excluded and another dedicated to preliminary inclusions. Each reviewer will read the abstract of an article, and if they have questions about whether it meets the criteria for inclusion, they will only look at the methodology section of the full article. This would be useful because some articles do not have all the necessary information in the abstract or title, like the job of the study participants. Articles that meet the criteria will be put in a separate collection for further examination, while excluded articles will be listed in the Excel file along with the reasons why they were excluded.

[1] https://guides.lib.uwo.ca/systematicreviews/searchtechniques

2.3 Study records

Data management

In addition to the spreadsheet mentioned before, Mendeley citation manager will be used to store all the records, and to help with the duplicated records removal. Additional literature sources, such as the references identified in the first articles, will also be added manually. At this stage, both the titles and abstracts of the records will be checked. After that, the number of records that passed each filter stage will be recorded to ensure that the review can be replicated and traced accurately.

Selection process

Two reviewers will screen the title and abstract based on the inclusion and exclusion criteria. The third reviewer will sort out any disagreement. The same approach for possible discrepancies regarding the inclusion and exclusion of articles between the two reviewers will be considered. After the combination of keywords is inserted, three phases of exclusion will take place:

1. Through search filters, the following criteria will be considered:
    - Date: Last five years, from 2019 to 2024
    - Type of articles: Articles
    - Source type: Journals or possibly conferences
    - Language: English
2. Duplicated articles will be removed with the help of the Mendeley desktop software.
3. Studies will be excluded if any of these two conditions is verified:
    - Teleworking or home office
    - Part-time workers or shift workers

Data collection process

Screened articles will be moved on to full-text reviews. All criteria must be met during this stage.

- General study information: authors, year, and geographic area of application
- Context: characteristics of the application of fatigue measurement method

2.4 Data items

Tables summarizing the topics mentioned in the previous section will be created: country, age and gender of the sample, fatigue levels, objectives, potential health outcomes, conclusions, and technologies used. Such technologies include the equipment for objective fatigue reading, various subjective fatigue measurement techniques, and specific machine learning methods. Additionally, regarding machine learning, extracted and processed features will be recorded, and the same will be done for any reported outcome. Potential subgroups could include:

- Time of day: Morning vs. afternoon vs. evening
- Duration of measurement: Short-term vs. long-term

2.5 Outcomes and prioritization

Changes in cognitive function based on cognitive screening measures (such as Mini-mental state examination, Montreal Cognitive Assessment), neuropsychological interview, informant/career responses to assessment tools, or mood changes. Secondary outcomes include changes in muscle activity, posture, work productivity, and pain development. Furthermore, authors' conclusions and suggestions regarding the utilization of the machine learning method will be sought.

2.6 Risk of bias in individual studies

Considering the inclusion of different study types, various tools shall be used for such assessment. The Cochrane Risk of Bias Tool (Higgins et al. 2011) will be used for randomized controlled trials (RCTs). The ROBINS-I Tool (Sterne et al. 2016) will be used

in non-randomized studies, including cohort studies, case-control studies, and quasi-experimental studies. The QUADAS-2 Tool (Whiting et al. 2011) shall be used for the risk of bias in diagnostic accuracy studies. Finally, the Newcastle-Ottawa Scale (Lo, Mertz, and Loeb 2014) assesses the risk of bias in observational studies, including cohort and case-control studies.

2.7 Data synthesis

The information gathered from every study incorporated will be compiled into predetermined spreadsheets for data extraction. The findings will be summarized in a descriptive format within the results and analyzed in the discussion sections. The feasibility of conducting a meta-analysis will be evaluated based on the variability of the data presented in the final collection of manuscripts.

2.8 Meta-bias(es)

If obtained results permit it, a meta-bias will be performed later.

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Conceptualization, S.I.P, J.S.B, and J.C.G.; methodology, S.I.P, J.S.B, and J.C.G.; research, S.I.P; draft writing preparation, S.I.P; drafting and editing revision, S.I.P, J.S.B and J.C.G.; project administration, J.S.B. and J.C.G.; All authors have read and agreed with the published version of the manuscript.

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