ASSESSING THE IMPACT OF ERGONOMIC INTERVENTIONS IN MILITARY SETTINGS: A SCIENTOMETRIC AND SCOPING APPROACH

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A B S T R A C T

This study explores the effects of ergonomic interventions in military settings through a dual approach: scientometric analysis and a scoping review. The scientometric analysis highlights growing interest and advancements in military ergonomics, with increasing research publications. Top keywords include military ergonomics, low back pain, and ergonomic design. Key findings show that ergonomic interventions reduce musculoskeletal injuries and enhance military personnel's well-being and performance. Notable interventions like Equine-Facilitated Therapy (EFT) and High-Density Surface Electromyography (HD-sEMG) improve physical performance and pain management. The scoping review stresses the need for tailored ergonomic strategies for military-specific challenges, such as body armor optimization and injury prevention during high-impact events. Gaps in long-term studies and the integration of ergonomic principles into military training are identified for future research.

1. INTRODUCTION

Ergonomic interventions hold significant importance in military environments due to their contributions to performance improvement, injury reduction, and overall well-being enhancement. Several studies have highlighted the adverse effects of inadequate ergonomics on healthcare professionals, including dermatological surgeons, resulting in musculoskeletal injuries (Rajan et al., 2021). Conversely, it has been established that the implementation of ergonomic modifications can effectively alleviate chronic musculoskeletal pain in rural and remote populations (Fontaine et al., 2019). Moreover, the adoption of ergonomic practices in the workplace helps prevent surgical fatigue, errors, and enhances productivity (Anderson et al., 2022). Additionally, a workplace-based trial comparing ergonomic interventions emphasized the significance of proper implementation and adherence to these measures for long-term effectiveness and maintenance (Kelly et al., 2023). Therefore, in military settings characterized by demanding physical requirements and critical performance, ergonomic interventions are essential. They optimize operational efficiency, mitigate injury risks, and enhance the overall health and well-being of military personnel.

Numerous studies have confirmed the crucial role that ergonomic interventions play in influencing the

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performance of military personnel. These interventions have been shown to reduce musculoskeletal injuries and improve the overall well-being of military personnel (Konradt et al., 2022). Equine-Facilitated Therapy (EFT) is one such intervention that has demonstrated positive effects on physical performance, pain acceptance, and quality of life for individuals with chronic low back pain (Wilkerson et al., 2023). Furthermore, research into the post-rehabilitation experiences of UK military personnel with persistent pain or fatigue has highlighted the effectiveness of strategies such as mindfulness, activity pacing, and symptom education in improving occupational capacity and overall outcomes. These findings underscore the significance of tailored ergonomic interventions in optimizing performance and sustaining military employment (Kelly et al., 2023).

Ergonomics is an applied science that focuses on the interaction between humans and technology. Derived from the Greek words for work and laws, its goal is to ensure compatibility between operators' capabilities and task demands (Rinaldho et al., 2022). In military settings, ergonomics plays a crucial role in various aspects, including the design of weaponry, the selection and training of military officers, combat command management, and the transportation of personnel and equipment in vehicles like Armoured Personnel Carriers (Donthu et al., 2021). Specifically, in the design of military platforms such as soldiers' backpacks, ergonomics is essential for reducing injuries. Factors such as load-bearing capacity and sizing based on body dimensions are taken into consideration to prevent musculoskeletal disorders (Muslim et al., 2019). Overall, military ergonomics is vital for enhancing operational efficiency, safety, and performance in diverse military environments.

Significant progress has been made in the history of ergonomic interventions in the military, with a focus on improving performance, reducing injuries, and enhancing overall well-being. The development of ergonomics as a scientific discipline, encompassing physical, cognitive, and organizational aspects (Pouyakian, 2022), has paved the way for the use of advanced technologies such as High-Density Surface Electromyography (HD-sEMG) to evaluate muscle activation during rehabilitation exercises in horses (Gamucci et al., 2022). These advancements emphasize the importance of assessing workplace ergonomics to prevent injuries and improve productivity (Kelly et al., 2023). Research has also shown that training interventions effectively improve performance in both limbs, highlighting the need to include female participants and skilled tasks in cross-education studies (Pearcey et al., 2022). Additionally, efforts have been made to develop interventions and facilitate discussions among clinicians and veterans, aiming to prevent firearm-related deaths, particularly within the veteran population (Radzi et al., 2024b; Reger et al., 2023).

The implementation of ergonomic interventions for military personnel faces numerous challenges related to physical and psychological demands, as well as environmental and operational constraints. Kettlewell et al. (2022) conducted a study that emphasizes the importance of addressing the specific needs of trauma survivors through tailored interventions. Additionally, Hassan et al. (2020) highlight the significance of training practitioners in both cardiovascular disease risk prevention and severe mental illness to enhance their knowledge and confidence in engaging with individuals with mental health conditions. This training can help reduce the stigma surrounding mental health. Bonnechère et al. (2023) conducted research on the environmental and operational constraints involved in validating rehabilitation interventions, including ergonomic interventions. These constraints include difficulties in conducting high-quality randomized controlled trials and securing funding, which ultimately impact the level of evidence supporting such interventions. These challenges highlight the complexity of implementing ergonomic interventions in military settings and emphasize the need for tailored approaches to address the diverse needs and constraints present. By employing a scientometric and scoping approach, this study aims to investigate the trends and patterns in ergonomic research and their implications for effective ergonomic interventions in military settings.

The main goal of this article is to evaluate the impact of such interventions in military contexts through a dual methodological approach consisting of scientometric analysis and a scoping review. This comprehensive analysis entails the examination of publication trends to ascertain the development of research in this area, as well as the assessment of the effectiveness of diverse ergonomic interventions. Consequently, this study seeks to present a holistic overview of current practices in military ergonomics, thereby informing future directions in this field.

2. METHOD AND ANALYSIS DESIGN

2.1 Scientometric Analysis

Scientometric analysis is widely accepted in academic circles as an approach for analyzing and comprehending extensive scientific data. This method enables a thorough understanding of the evolution of a specific field (Donthu et al., 2021). The use of scientometric parameters to assess the quality of research output is steadily gaining momentum. Researchers employ scientometric analysis for various purposes, including identifying emerging trends and evaluating journal performance (Struck et al., 2021). Furthermore, it is used to explore collaboration patterns and research components (Wachsmann et al., 2019), examine publication trends within a specific research domain (Abd Aziz et al., 2021), and delve into the intellectual structure of a particular area as depicted in published works (Simao et al., 2021). In this study, we utilize scientometric analysis to observe patterns in research publications on ergonomics in military settings, identify countries actively engaged in publishing, and

analyze the themes and subthemes conveyed through authors' keywords.

2.2 Scoping Analysis

The main goal of scoping reviews is to thoroughly collect and document a wide range of available evidence (Munn et al., 2018). Therefore, the purpose of this study is to comprehensively investigate the important aspects related to ergonomics in military publications and bring together the existing literature in this research area. This scoping review was carried out to identify areas that require further investigation and gaps in our knowledge. The study followed the five-step scoping review framework outlined by Arksey and O'Malley (2005):

1) Establishing the research question.
2) Identifying relevant studies.
3) Selecting studies.
4) Data charting.
5) Reporting results.

2.3 Establishing Research Question

The scoping analysis in this study is guided by the following research question:

1) According to the SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research Type) tool (Cooke et al., 2012), what are the main findings of previous studies on ergonomics in military environments?

2.4 Identifying Relevant Studies

2.4.1 Database

To gain access to scientific journal publications, institutional repositories, archives, and other collections of materials, databases and search engines must be used (Abdullah et al., 2020). For this study, we utilized the Scopus and WoS databases to analyze scientometric and scoping indicators. These databases were selected because they give more importance to document citations compared to other databases (Vieira & Gomes, 2009). Furthermore, we made efforts to enhance the validity of the coverage analysis by improving metadata accuracy, document categorization, and discipline assignment. Therefore, Scopus and WoS prioritize these factors (Stahlschmidt & Stephen, 2022).

2.4.2 Search Strategy

Once the keywords were identified, an encyclopedia was consulted in order to find synonymous terms.

Table 1. Search strategy for extracting data from the Web of Science and Scopus databases.

Database	Search Strategy	Records
Web of Science	Topic: ("ergonomic") AND ("military" OR "Army" OR "soldiers" OR "navy" OR "airforce" OR "soldier" OR "military personal" OR "armed forces")	151
Scopus	Article Title, Abstract, Keywords: ("ergonomic") AND ("military" OR "Army" OR "soldiers" OR "navy" OR "airforce" OR "soldier" OR "military personal" OR "armed forces")	314

Table 1 presents the search strings that were employed to retrieve publication lists from the Scopus and WoS databases. This search was conducted in June 2024, encompassing titles, abstracts, and keywords from both databases. No restrictions were imposed on the retrieved data, including limitations on date, publication type, or language.

2.4.3 Software

ScientoPy and VOSviewer are two widely used research tools in academic settings. ScientoPy is a Python script that extracts valuable information from research articles, such as main subjects, authors, countries, and associated documents. This tool utilizes author-provided keywords to generate insights, thereby reducing potential biases that may arise from independent investigations (Ruiz-Rosero et al., 2017). However, it is important to recognize the possibility of bias when analyzing studies that rely on author name analysis due to potential instances of name similarities (Ruiz-Rosero et al., 2017). VOSviewer, developed by Van Eck and Waltman (2010), is a software application that facilitates keyword co-occurrence analysis, particularly in the context of social security in the military domain. It employs advanced mapping techniques to transform CSV data into visually informative diagrams or clusters (Abdullah, 2022b). These mapping strategies provide significant advantages for researchers interested in analyzing specific data points, such as authors' keywords (Abd Aziz et al., 2021; Abdullah 2023, Abdullah & Sofyan 2023).

2.5 Selecting Studies

### 2.5.1 Publications Merge and Removal of Duplicates

The data from both databases was compiled and processed using ScientoPy, a widely employed tool in academic research. Throughout this stage, various standardization procedures were implemented to guarantee data consistency and accuracy. These procedures encompassed substituting commas in the author's name with semicolons, eliminating dots, commas, and any distinctive formatting from the author's name, and removing duplicate entries with identical titles and authors. This systematic approach was employed to enhance the precision and dependability of the datasets. Diagram 1 offers a visual depiction of the preprocessed data outcomes.

The preprocessing script utilized in ScientoPy assigns greater significance to Web of Science (WoS) documents in comparison to Scopus documents. Figure 1 presents an illustration of the preprocessing procedure for documents pertaining to ergonomic studies in the military context, sourced from two prominent databases: WoS and Scopus. The horizontal bars for each database indicate the total number of loaded documents, with a distinction made between retained documents and duplicate entries that have been eliminated.
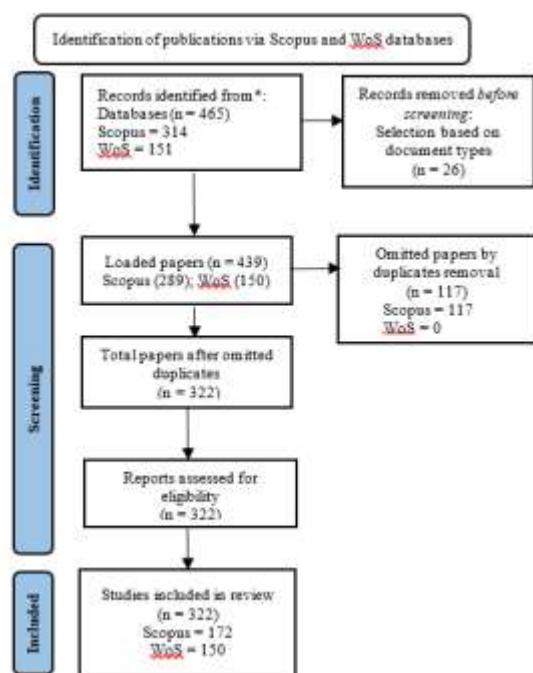
Diagram 1. Flow diagram of research of databases and registers

In the case of WoS, the blue bar signifies that all documents have been retained, with no duplicates removed, as evidenced by the 0% label for removed duplicates. Conversely, the bar for Scopus is divided into two sections, with the orange portion representing 40% of the total documents that have been eliminated as duplicates, while the remaining 60% in blue have been retained. This visual representation underscores the prevalence of duplicate entries across different databases and emphasizes the criticality of meticulous data cleaning and preprocessing to ensure the accuracy of scientometric analysis in ergonomic research conducted within military settings.
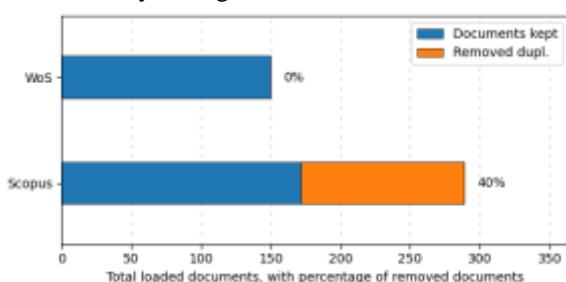
Figure 1: Data Combination and Duplicates Removal

Diagram 1 presents supplementary information regarding the source dataset, which encompasses 465 papers sourced from the WoS and Scopus databases. These publications have been categorized into various types, such as conference papers, articles, reviews, proceedings papers, and press pieces, utilizing ScientoPy. A total of 26 documents, including books, letters, and errata, have been excluded. Following data reconciliation, this study has utilized a combined total of 322 entries from both databases. Specifically, 150 papers were sourced from WoS, whereas 172 were obtained from Scopus.

Furthermore, 117 duplicate entries, found exclusively in Scopus, were eliminated.

2.5.2 Data Charting

The growth graph shown here depicts the progress of publishing in the Scopus and WoS databases. This data is crucial for comprehending the general trend in publications. To gain a more comprehensive understanding of the articles chosen in the previous phase, we analyze the evolution graph of the top 10 authors' keywords and examine the co-occurrence of these keywords.

2.5.3 Reporting Results

In accordance with the study's objectives, a concise summary and report of the findings were prepared. ScientoPy was used to analyze publication growth, identify active countries, and examine keywords. VOSviewer was employed as a descriptive metric to determine the co-occurrence of authors' keywords. It should be noted that a minimum of two keywords is required to generate co-occurrence results using VOSviewer. Furthermore, the thesaurus files were carefully reviewed and modified to avoid duplication of authors' keywords, following the recommendation by Abdullah (2022a).

The methodology used in this study, known as a scoping review, aims to provide a comprehensive overview of existing research in a specific field. One of the primary objectives of conducting a scoping study is to identify any gaps or deficiencies in the current research body. In this study, our goal was to thoroughly examine and describe the current state of research on ergonomic factors, as well as identify areas where the literature is lacking. To carry out this analysis, articles obtained from Scopus and WoS were preprocessed using ScientoPy. The specific inclusion criteria for this scoping review can be found in Table 2.

1) Written in English.
2) Publications from 2013 and later.
3) Describe primary research.
4) Use the keyword soldier in the authors keywords.

3. RESULTS

3.1 Scientometric Outcome

3.1.1 Publication Growth

Figure 2 illustrates the progression of publications on ergonomic studies in military contexts from 1992 to 2024, based on data from Scopus (represented by blue circles and lines) and WoS (represented by orange triangles and lines). The key findings reveal a consistent rise in the number of publications over time, indicating a growing interest in research in this field. There are notable fluctuations, particularly a significant increase around 2000 for Scopus, which suggests early interest or significant studies. Both databases display a steady

increase in publications from the mid-2000s, with prominent peaks around 2015 and 2020, highlighting periods of heightened research activity. These findings indicate that ergonomic research in military settings has gained significant attention in recent years, demonstrating its increasing importance and ongoing efforts to enhance military ergonomics through scientific investigation.

The increasing number of publications on ergonomic factors in military contexts indicates a growing interest among academics in the complexities involved in ensuring the health, safety, and performance optimization of military personnel. It is imperative to maintain a continuous dialogue between scholars, military subject matter experts (SMEs), and ergonomic professionals to ensure the development and implementation of effective ergonomic interventions that are both scientifically rigorous and practically feasible within the unique and demanding environments of military operations. Research conducted by Winkel and Westgaard (2019) underscores the necessity of expanding traditional intervention research paradigms to include considerations of organizational sustainability alongside the prevention of musculoskeletal disorders (MSDs), which necessitates collaboration with stakeholders responsible for the development of production systems. In addition, Lundsgaard-Hansen et al. (2024) emphasize the importance of worker participation in interventions, highlighting the significance of clearly defined roles, adequate resources, and managerial commitment.
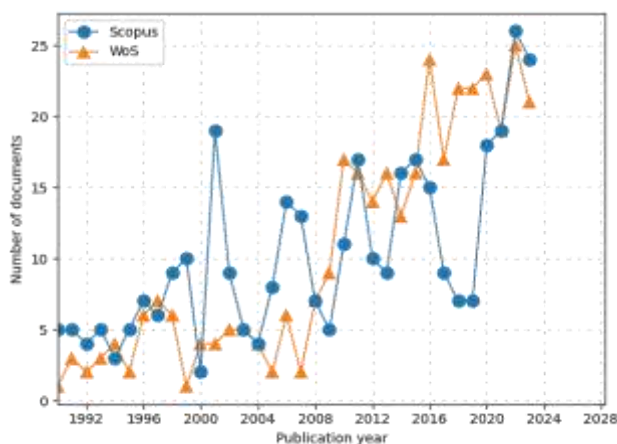

Figure 2: The evolution of publication growth (Source: Author, using ScientoPy 2.1.3)

By incorporating insights from these studies, as well as emphasizing the value of participatory approaches in workplace interventions, a multidisciplinary approach involving scholars, SMEs, and ergonomic professionals can ensure the implementation of scientifically rigorous and practically feasible interventions tailored to the specific challenges posed by military settings.

3.1.2 The Most Influential Academic Works
Figure 3 illustrates the scholarly contributions of different institutions to the field of ergonomics within

military contexts. It specifically focuses on the number of publications before and after 2022. The institutions that have made the largest number of contributions are the Center for Health Promotion and Preventive Medicine and the Department of Medicine and Clinical Psychology in the United States. It is worth noting that all of their publications were published before 2022. On the other hand, the Royal Center for Defense Medicine in the United Kingdom stands out with 25% of its publications occurring between 2022 and 2023, indicating recent research activity. Conversely, institutions such as the US Army, College Park, DRDO in India, Department of Preventive Medicine and Biometrics, HIA Percy in France, Medical Center, and Research Laboratory in the United States have not published any recent documents between 2022 and 2023. This data indicates a trend where the majority of influential academic works on ergonomics in military contexts were produced before 2022, with only a few institutions making recent contributions.
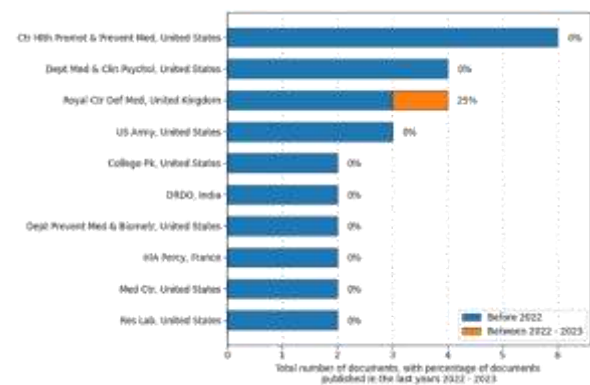

Figure 3: Institution Bar Trends Graph

The recent publications from the Royal Center for Defense Medicine suggest ongoing research interests and efforts to address current ergonomic challenges in military settings.

3.1.3 Authors' Keywords
Figure 4 presents the authors' keywords employed in academic research on ergonomics in a military context. It demonstrates the total number of related documents associated with each keyword and the percentage of those documents published between 2022 and 2023. Noteworthy findings reveal that "military ergonomics" is a relatively recent term experiencing rapid growth, as all of its associated documents were published within the aforementioned period. This indicates a rising research interest in the field. Keywords such as "soldier" and "aviation" also exhibit significant recent activity, with 67% of documents published during the same timeframe. "Ergonomics" emerges as the dominant keyword, boasting the highest number of documents. However, only 4% of these documents were published in the recent period, suggesting that this area is well-established with ongoing, yet stable, interest. Terms like "military," "ergonomic," and "ergonomic design" have also made

notable recent contributions, with 12%, 20%, and 20% of their respective documents published between 2022 and 2023. Conversely, keywords like "low back pain," "human factors," and "anthropometry" have not witnessed recent publications, signaling potential avenues for further exploration. This analysis underscores the evolving focus within military ergonomics, showcasing a shift towards more specific and applied research themes in recent years.
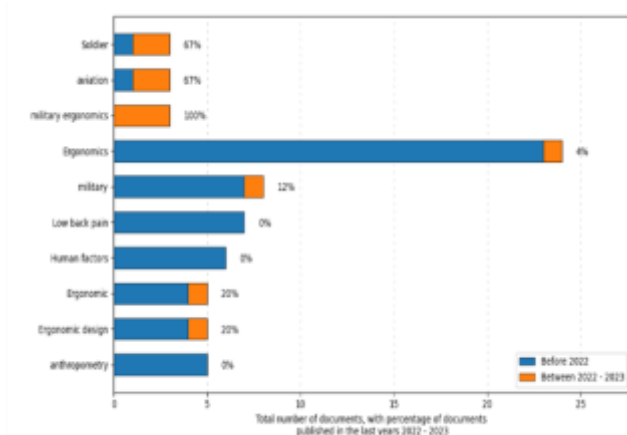
Figure 4: The bar-trend graph of research themes and topics emerging (Source: Author, using ScientoPy 2.1.3).

The network visualization of author keywords related to ergonomics in a military context reveals important trends and themes through interconnected nodes and colored links that indicate the average publication year. The central node, "ergonomics," stands out prominently and has strong connections to several keywords, highlighting its foundational role in the field. The keyword "military" forms a significant cluster with connections to "musculoskeletal," "training," and "low back pain," indicating a focus on physical health and training issues within military environments. Recent trends, represented by the orange and red nodes, include "ergonomic design," "wearable device," and "military ergonomics," indicating a growing interest in advanced ergonomic solutions and the integration of technology. Terms like "human factors" and "musculoskeletal disorders" are closely linked to both "ergonomics" and "military," underscoring their relevance in addressing comprehensive ergonomic challenges. Additionally, specific areas such as "aviation," "pilots," and "protective clothing" form distinct clusters that highlight specialized research themes. The color gradient of the timeline reveals that while foundational topics like "ergonomics" and "military" have been studied for a longer period (blue to green), newer themes (yellow to red) reflect current and evolving research interests, thus emphasizing the dynamic nature of ergonomic studies in military contexts. These findings suggest that ergonomic research within military contexts is both foundational and evolving, with

a central focus on improving health, safety, and performance of military personnel. The prominence of terms like "ergonomics" and "military" alongside emerging keywords such as "ergonomic design," "wearable device," and "military ergonomics" highlights a shift towards integrating advanced technologies and innovative solutions. Specialized areas like "aviation," "pilots," and "protective clothing" indicate targeted research efforts addressing unique challenges. The strong connections between "human factors" and ergonomic principles reflect an integrated approach to enhancing interactions between personnel and their environments (Figure 5).
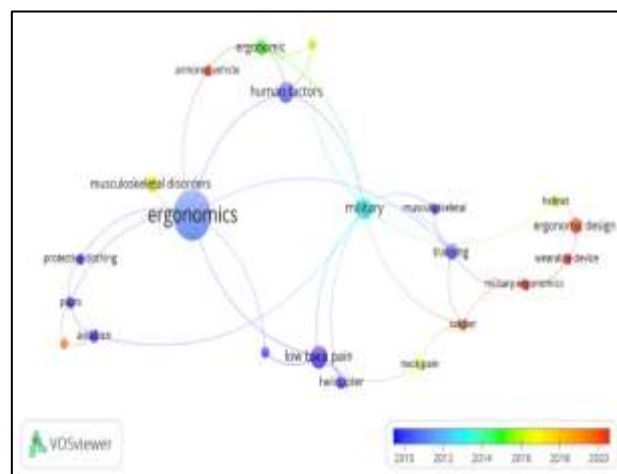
Figure 5: Co-occurrence of authors' keywords

Overall, this dynamic field continues to prioritize addressing both broad and specific ergonomic issues, emphasizing the importance of continuous innovation and technological integration.

3.2 Scoping Outcomes

This section provides a comprehensive examination of the manner in which military-related publications address ergonomic factors. Undertaking this analysis is a crucial preliminary step in identifying areas of knowledge insufficiency and guiding future research endeavors. Furthermore, it contributes to the existing knowledge base and establishes best practices. To carry out this analysis, qualitative research questions were formulated, and the SPIDER tool was employed as the search strategy. Table 3 presents a compilation of publications based on extended author keywords obtained from ScientoPy. Initially, the information in Table 3 was condensed from a total of 322 documents. It is important to note that this study specifically focuses on the scoping analysis of research articles. Consequently, the other 319 records that were not classified as research papers were excluded at this juncture.

Table 2: *List of Inclusive Publications*

No	Sources	Sample	Phenomenon of Interest	Design	Evaluation	Research Type
1.	Summers et al., (2023)	66 individuals, with an equal number of males and females (33 each), who participated in two separate studies to measure thoracoabdominal organ boundaries using MRI	Understanding the boundaries of essential and desirable thoracoabdominal organs in males and females to optimize body armour coverage and design	Involves a comparative analysis using MRI data to measure organ boundaries in different postures and breathing conditions for both male and female participants	Males generally have more laterally and inferiorly positioned organ boundaries compared to females, and existing body armour sizes do not fully cover all essential organs for both sexes	Quantitative
2.	Ojanen et al., (2023)	Soldiers who participated in a new advanced repeated simulated military task performance test (RSMT) designed to study the interrelationships between RSMT, body composition, and physical fitness	The performance changes during repeated military tasks under conditions of accumulating fatigue. The study specifically focuses on how physical fitness variables such as lower body maximal strength, anaerobic power, and upper body strength endurance affect performance in tasks like sprinting, crawling, load carriage, and casualty evacuation	Experimental. A new advanced repeated simulated military task performance test (RSMT) was constructed to assess the performance of soldiers in various combat-related tasks. The study involved performing strength and power tests in a specific order on the same day to ensure consistency . Included a linear regression model to analyze the data and identify significant predictors of performance	Highlights the importance of a balanced training program that includes both strength and endurance components, noting that lower body strength, anaerobic power, and upper body strength endurance are crucial for tasks in a recovered state, while military-specific aerobic endurance is vital under acute fatigue conditions	Quantitative
3.	Burkacki et al., (2017)	Soldiers inside a light armored vehicle, specifically focusing on their equipment and positioning during an IED explosion simulation conducted using the Madymo software program	The impact of soldiers' equipment, particularly the position of weapons, on the risk of head and neck injuries during an IED explosion under a light armored vehicle	A simulation-based approach using the Madymo software program, which models the effects of explosions on soldiers by analyzing various ergonomic factors and equipment positions	Indicates that holding weapons in hands increases the likelihood of head and neck injuries during an explosion, and using mounts for weapons can enhance soldiers' safety	Quantitative

4. DISCUSSION

Based on the keyword analysis, it is evident that notational analysis, multivariate analysis, and kinetics are closely intertwined with military ergonomics. Notational analysis has significantly impacted this field by bolstering the comprehensive evaluation of task performance, optimizing physical activities, improving training programs, and minimizing the likelihood of injuries among military personnel. This discovery underscores the vital role of notational analysis in enhancing the meticulous assessment and optimization of military tasks, amplifying training effectiveness, and safeguarding the safety and well-being of military personnel. By utilizing inertial sensors to analyze joint angles and model professional movements, as discussed in the research by Olivas-Padilla et al. (2021), military personnel's postural stability can be assessed effectively, contributing to injury risk mitigation (Read et al., 2021).

Additionally, understanding risk factors for musculoskeletal injuries in military populations, such as the impact of body mass index, prior injuries, and physical performance, as highlighted in the systematic review by Rhon et al. (2021), allows for targeted interventions and training programs to enhance soldiers' physical capabilities and reduce injury rates. Integrating notational analysis techniques with comprehensive risk factor assessments can significantly improve military readiness and overall operational effectiveness.

Soldiers play a crucial role in implementing ergonomic interventions in military contexts because of the high prevalence of musculoskeletal disorders among them (Souchet et al., 2023). These disorders are a significant cause of disability in armed forces, highlighting the importance of effective interventions aimed at improving working conditions and enhancing soldier performance. Additionally, involving soldiers in participatory ergonomics processes can help them better understand

ergonomics principles, identify problems, and implement cost-effective solutions to improve working conditions (Pleizier & Schuhmann, 2022). By actively engaging soldiers in ergonomic interventions, organizations can foster a culture of participation, enhance expertise in identifying and resolving ergonomic issues, and ultimately promote the overall health and well-being of military personnel.

Future research in military ergonomics should prioritize integrating notational analysis with advanced technologies, such as inertial sensors. This integration can enhance task performance evaluations and assess postural stability, thereby reducing the risk of injury (Huang et al., 2020; Johnston et al., 2019). Additionally, it is crucial to understand risk factors such as body mass index, prior injuries, and physical performance. This understanding will enable the development of targeted interventions and training programs to enhance soldiers' physical capabilities and reduce injury rates (Lim & D'Souza, 2020). Engaging soldiers in participatory ergonomics is also essential. This approach empowers them to comprehend ergonomic principles, identify problems, and implement solutions, fostering a culture of participation and expertise in ergonomic issues (Cort & Devries, 2019). Furthermore, research should investigate the long-term impact of ergonomic interventions on military readiness and operational effectiveness. It should also develop customized training programs based on comprehensive risk assessments and explore effective policy and implementation strategies to overcome barriers to adopting ergonomic practices (Maurer-Grubinger et al., 2021; Tang, 2020). These collective efforts will contribute to enhancing the health, safety, and performance of military personnel.

Based on a scoping analysis, three studies have been published in Scopus and WoS indexed journals since 2013. The main findings from the samples indicate that males have distinct anatomical boundaries that affect armor coverage. It is essential for military performance to have a balanced strength and endurance training. Additionally, weapon mounts reduce the risk of injury during explosions. These studies have demonstrated that the majority of research samples indicate a significant impact of military ergonomics on soldiers. The studies provide valuable insights into the impact of military ergonomics on soldiers. Research on body armor coverage (Breeze et al., 2021) and bulletproof vest design (Wen & Shih, 2021) highlight the importance of considering distinct anatomical boundaries, especially for males, to ensure optimal protection. Furthermore, a focus on balanced strength and endurance training is crucial for military performance, as shown by the benefits of nontraditional physical training on muscular endurance, power, and strength in military personnel (Schram, 2022). Moreover, the biomechanical analysis of in-service armors on females emphasizes the significance of equipment design in reducing injury risk and enhancing operational effectiveness, with specific attention to shoulder pressure as a predictor of discomfort and potential injury (Wendland et al., 2023). These findings collectively underscore the significant impact of military ergonomics on soldiers' well-being and performance.

The objective of this study is to examine the phenomenon of interest, which is the impact of ergonomic factors on the safety and performance of military personnel in various environments. Specifically, this research focuses on improving the coverage of body armor, analyzing the effect of physical fitness on task performance when fatigued, and assessing the potential risk of head and neck injuries resulting from IED explosions in relation to equipment placement. Previous studies have indicated that young, active-duty military personnel are at an increased risk for isolated posterior and combined-type shoulder instability. This emphasizes the importance of identifying instability in shoulder pain evaluations, even in the absence of clear diagnostic findings (Cooney et al., 2022). Furthermore, the high prevalence of chronic pain and fatigue among military personnel underscores the significance of implementing effective rehabilitation strategies such as mindfulness, activity pacing, and symptom education (Radzi et al., 2024a). These strategies can improve work capacity and outcomes, particularly in cases of persistent pain and fatigue (Green et al., 2023). These findings demonstrate the need for a comprehensive approach to optimizing ergonomics in military environments, with the ultimate goal of enhancing the well-being and performance of service members.

The impact of ergonomic interventions on military performance and injury reduction is evident from the reviewed literature. Physical ergonomics interventions, such as ergonomic backpacks and load carriage systems, have shown to decrease musculoskeletal injuries significantly. Cognitive ergonomics strategies, including simulation-based training, have enhanced decision-making skills and overall operational readiness.

However, gaps remain in the research, particularly in long-term studies and the integration of ergonomic principles into military training programs. Future research should focus on longitudinal studies to assess the sustainability of ergonomic benefits and explore the integration of advanced technologies, such as AI and machine learning, in developing adaptive ergonomic solutions.

5. CONCLUSION

The study examined the impact of ergonomic interventions in military settings using a dual methodological approach of scientometric and scoping analyses to provide a comprehensive evaluation. The scientometric analysis revealed a growing interest and significant progress in ergonomic research within military contexts, as evidenced by an increasing number of publications over the years. Key findings indicated that ergonomic interventions significantly contribute to reducing musculoskeletal injuries and improving overall well-being and performance among military personnel.

Specific interventions, such as Equine-Facilitated Therapy (EFT) and the integration of advanced technologies like High-Density Surface Electromyography (HD-sEMG), demonstrated positive effects on physical performance and pain management. The scoping analysis further emphasized the need for tailored ergonomic strategies to address unique challenges in military settings, such as optimizing body armor and mitigating injury risks during high-impact events like IED explosions. Studies highlighted the importance of comprehensive training programs that encompass both strength and endurance components to maintain operational efficiency when fatigued. Additionally, the analysis identified gaps in the existing literature, particularly in terms of long-term studies and the integration of ergonomic principles into military training.

In summary, the research highlighted the crucial role of ergonomic interventions in enhancing the health, safety, and performance of military personnel. Future endeavors should focus on conducting longitudinal studies to ensure the sustainability of these benefits and exploring the integration of advanced technologies to develop adaptable and effective ergonomic solutions tailored to the demanding environments of military operations.

5.1 Limitation of the Current Study

The inclusion of the list of publications is one of this study's most fundamental limits. The analysis of scientometrics and scoping in this study relies on the Scopus and WoS databases; however, future researchers would benefit from using Google Scholar, PubMed, and ERIC to enhance the existing findings based on this study.

5.2 Contribution to the Body of Knowledge and Practices

The article provides a significant contribution to our knowledge and understanding of the importance of ergonomic interventions in military settings. These interventions have the potential to enhance operational efficiency, decrease musculoskeletal injuries, and improve the overall well-being of military personnel. The article employs a comprehensive scientometric and scoping review to examine publication trends and the efficacy of different ergonomic strategies. One noteworthy discovery is that interventions such as Equine-Facilitated Therapy (EFT) and advanced technologies like High-Density Surface Electromyography (HD-sEMG) have a positive impact on physical performance and pain management. The study also emphasizes the necessity for tailored ergonomic solutions to address the unique challenges faced by the military. For instance, it discusses the significance of optimizing body armor coverage and mitigating injury risks during high-impact events.In conclusion, the findings underscore the importance of ongoing research, participatory ergonomics, and the integration of advanced technologies in the development of effective and adaptable ergonomic practices for military operations.

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