World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(REVIEW ARTICLE)

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Bibliometric analysis of physical workload

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World Journal of Advanced Research and Reviews, 2023, 20(02), 1133–1146

Publication history: Received on 14 October 2023; revised on 20 November 2023; accepted on 23 November 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.2.2400

Abstract

An analytical study was carried out on the development of research in the field of physical workload published from 2003 to 2023 which was indexed on Scopus by authors worldwide. The amalgamation keywords implement to ascertain articles relevant to workload are "physical workload," "workload," "environment," and "risk assessment". A review of these 33 documents shows that there is an increasing trend in the number of literature publications, number of artivles published each year, types of open access, publication sources, and major journals. Using VOS-viewer software, we will perform a bibliometric analysis to visualize how authors collaborate, how documents are cited, and how keywords co-occurance in these findings. This bibliometric analysis will use VOS-viewer software to describe patterns of co-authorship, documents citations, and co-occurrence of keywords in the findings. (1) Workload studies have developed in recent years, starting in 2004. Workload study articles have been published in 29 journals in 79 institutions and 17 countries. (2) This bibliometric analysis reveals that Det Nationale Forskningscenter for Arbejdsmiljø has the most research publications related to workload, namely four documents indexed in Scopus. Sweden has the most publications of 9 documents, the United States is the second Country with the most publications of 6 documents, and the Netherlands is the third Country with the most publications of 5 Scopus-indexed documents. (3) There are several differences between studies, which can be seen from the use of different methods and the use of tools used, such as Surface Electromyography (sEMG), Electromyography (EMG), and Electrocardiogram (EKG). Psychosocial factors from several studies include work tension and significant work demands felt by workers. (4) So that the author's research design can be drawn with several aspects, namely the use of the Biomechanics method, SNI 9011: 2021 Work-related muscle and skeletal disorders (GOTRAK), Ergonomic Risk Factor (ERF) and the use of tools in the form of a Heart rate monitor and 4in1 Environmentalmeter.

Keywords: Physical workload; Environment; Bibliometric analysis; VOSViewer

1. Introduction

The dominant influence of workload on human resource performance but also harms the safety and health of the workforce. Specifically, workload can be categorized into two namely physical workload and mental workload. Physical workload tends to be included in the burden received by workers in a job, which is related to their physiological conditions, such as noise, vibration, hygiene, and sanitation. Excessive work due to the limited number of employees indicates an excessive physical workload. Then, the perception of work incompatibility and the work environment causes stress, which indicates excessive mental workload.

Workload is measure of the demands a person experiences in various aspect of work, such as physical load, task requirements, effort expended, and performance. Knowing the expected workload level can help evaluate different system configurations, such as team structure, task assignment, and efficient team composition [1].

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Physical workload research is a complex and interdisciplinary field, and various fields need to work together to synthesize existing research, identify gaps in knowledge, and develop future research directions. This research will examine the bibliometric characteristics and publication trends of physical workload research that has been indexed by Scopus by authors from various countries. Publication of articles from 2003 to 2023 will be used as several research questions: 1. What has been the focus of recent research in the field of physical workload? 2. What is the productivity level of journal authors and publishers? 3. How do the workload models differ for each researcher? And 5. What shape will research take in the future?

2. Materials and methods

2.1. Definition of physical workload

In everyday life, we often face physical tasks, such as lifting, pulling, pushing, walking long distances, etc. A deep understanding of the concept of physical workload is fundamental, both in optimizing our performance and maintaining bodily health. Physical workload can be a serious ergonomic risk factor for workers, especially in difficult work environments. In work difficulties, physical workload is one of the main ergonomic risk factors among workers [2]. Excessive physical workload can have cumulative effects that are harmful to health, both physical and mental. This cumulative effect can cause musculoskeletal health problems, such as back pain, neck pain, and muscle pain [3]. This cumulative effect means that over time, accumulating a high physical workload can damage the musculoskeletal system and overall health. Physical workload is a combination of factors originating from within the worker and factors originating from the work environment. Factors that originate from within the worker are called internal factors, while factors that orifinate from the work environment are called external factors [4].

2.2. Definition of workload

Workload is an important determinant of productivity and turnover because if workload is below standard, it will create a feeling of laziness and provide opportunities for non-productive activities [5]. If the workload is excessive, it can cause stress fatigue and increase the risk of work-related injuries or illnesses. This can also lead to high turnover because workers feel unable to cope with excessive tasks and can look for other work that suits the worker's abilities and comfort. Workload is discomfort at a personal level when it exceeds a person's abilities and resources in handling a job [6].

2.3. Definition of work environment

Work Environment, in general, is critical because it emphasizes general working conditions, workplace settings, safety protocols, working hours, and the relationship that exists between work and employers [7]. Managing a good, healthy, and productive work environment is a shared responsibility for employers and workers. Good leadership and awareness of the importance of a good work environment can help create a work environment that supports company growth and employee welfare. Work Environment is the relationship that exists between workers and employers, and the environment where workers work includes the technical, human, and organizational environments [8].

2.4. Definition of risk assessment

Risk assessment in ergonomics is critical to identify work postures that are dangerous for a worker's health [9]. Therefore, ergonomic risk assessment plays an essential role in creating a safe work environment and supporting worker welfare, as well as helping to reduce long-term costs associated with avoidable work-related injuries or illnesses. Risk Assessment is nothing more than a careful examination of something in the work. This can cause harm to humans, so we can consider whether we have taken sufficient precautions or whether we should do more to prevent a hazard.[14].

2.5. Bibliometric analysis

The bibliometric method is the method used in this research. Bibliometrics is helpful in analyzing several trending research topics, developments in the number of studies, and various types of publications. Otlet first mentioned bibliometric analysis in his book “Trait’e Documentation” and used it by Alan Pritchard in 1969 as a way to analyze various academic parameters form the literature published by researches. [11]. In this research, two bibliometric map source analyses are used, the co-authorship analysis and the co-occurance analysis

3. Methodology

This section explains the research methodology. The steps in following sub-sections are explained:

3.1. Start by identifying sources of information. Define the criteria used to select research subjects

The research objective is to identify evaluate, and conclude relevant research. This research began the process of determining precise inclusion and exclusion criteria for the selection of databases for research and decades for article searches. The period of this research is 2003 to 2023, and the search is written in the form of books, conferences, and reviews.

3.2. Second keyword definition and article search

In looking for related articles that focus on workload, the database search starts with articles or abstracts or keywords that contain a combination of the words " physical workload " (TITLE ABS-KEY (" physical workload ")), the word " workload " (TITLE ABS - KEY (“ workload ”)), the word “ risk assessment ” (TITTLE ABS – KEY (“ risk assessment”)), and the word “ environment ” (TITLE ABS – KEY (“ environment ”)) to discuss the topic of physical workload in any combination . With the results found as many as 33 documents.

3.3. Third, the analysis and results of the article

At this stage, 33 documents, including 29 articles, will be analyzed and grouped based on their characteristics and content (such as number of articles published per year, type of publication, type of source, affiliation, author name, and keywords). The first phase of research was conducted to describe the increase in physical workload literature. This research analyzes the number of publications published each year, type of open access, publications per year, type of open access, publication sources and influential journals. The bibliometric study uses the software VOS-viewer to analyze author collaboration patterns, document citation patterns, and keyword co-occurrence patterns. Co-authorship analysis is used to determine the pattern of authors collaborations, and co-word analysis is used to determine the pattern of co-occurrence of keywords.

4. Results and discussion

4.1. General literary tendencies

Figure 1 shows the annual trend of publications related to physical workload. Based on Scopus data, the first article was published in 2003, and the number of publications related to physical workload has increased significantly since then.

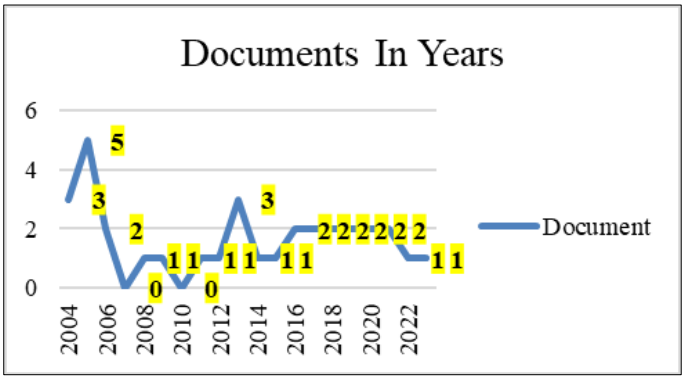

Figure 1 Annual trends in publications regarding physical workload

Based on the keywords that combine "physical workload," "workload," "risk assessment," and "environment," the type of literature is stated as "all types". The selection criteria were met by thirty-three article. Of the various types of open access avaible by journals, the majority of published versions or articles accepted are open access, namely 16 articles. Versions of publications or manuscripts accepted for publication are available in the green open-access repository for 14 articles. Hybrid gold for six documents. Gold open, documents in journals that only publish 5 open access articles. Bronze, published versions of notes or manuscripts are accepted to publish 1 article. The publisher has provided temporary or permanent free access to as many as 29 journals. Other types of documents include two book series and two conference proceedings.

4.2. Distribution institute for physical workload studies

Physical workload study, a total of 74 institutions were involved. Only the top 15 institutions are listed below.

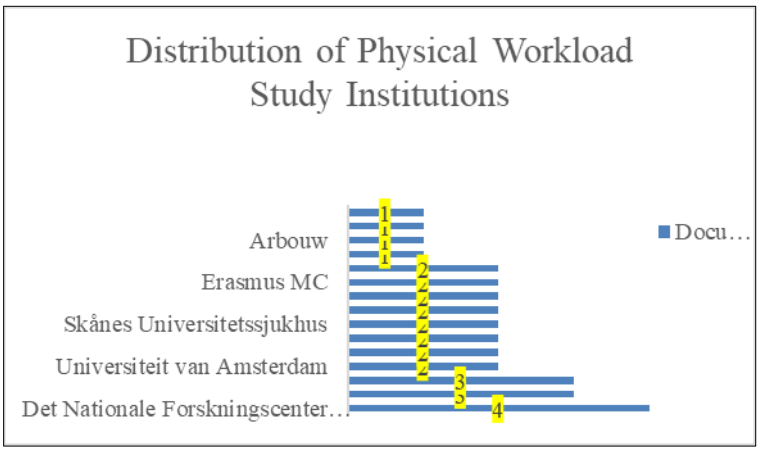

Figure 2 Distribution of institutions studying the physical workload

Of the 15 institutes, Det Nationale Forskningscenter for Arbejdsmiljø is the most productive institute in producing publications, with a total of 4 articles. Aalborg University and Vrijie Universiteit Amsterdam are in second place with the same number of publications, namely 3 articles.

4.3. Distribution of journal publications on physical workload studies

Thirty-three journals registered on Scopus that publish articles related to physical workload. The journal with the most publications on physical workload studies is the Scandinavian Journal of Work Environment and Health with 5 articles, Proceedings Of The Human Factors And Ergonomics Society with 2 articles, and the International Journal Of Industrial Ergonomics with 2 articles.

4.4. Country research and citation analysis

The 33 articles published in 17 different countries show that the top 15 regional distribution of articles among the authors is in descending order, as in Figure 3. Figure 3 shows a data visualization of the physical workload study paper in terms of countries related to co-authorship. The co-authored analysis between countries aims to identify the countries most active in physical workload research, as well as communication and collaboration patterns between countries. The size of the nodes indicates the significance of the country, while the linkages between nodes indicate the relationship between nodes indicate the relationship between countries. The thickness of the link and distance between nodes indicate the extent of cooperation between countries. The color of the node indicates the number of fields studied, which can be seen from the number of clusters formed.

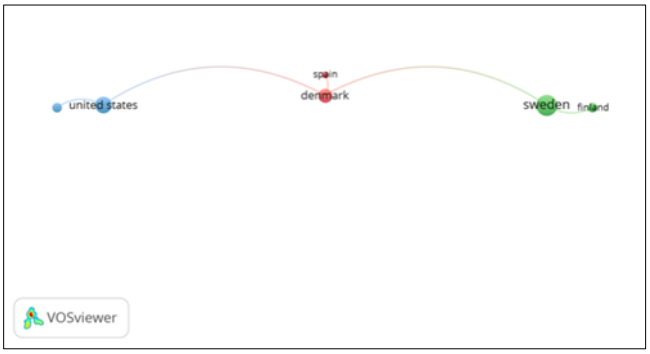

Figure 3 Co-authorship networks in state terms

The analyzed data shows that authors from Sweden are the most active in this field, with nine documents out of the total. The United States is second with six documents, followed by the Netherlands with five documents.

Based on data from Scopus, all documents are published by the author. The author with the highest number of citations is Andersen II, with 11 citations and a link strength of 5, followed by lotters f. with 140 citations and a link strength of 3.

Table 1 Number and analysis of citations by author

Writer	Quote	Total Link Power
Andersen ll	11	5
Blafoss br	0	5
Cedrasci c.	44	3
Leroux i.	90	3
Lotters f.	140	3
Gheldof elm	66	2
Klussmann a.	11	2
Nordander c.	96	2
Zeng p.	14	2
Ketola r.	6	1

In Figure 3, each tie represents an author or group of authors. Stronger writers are indicared by larger nodes. Andersen ll has the most significant total link strength value, namely 5, and Lotus f. is the author with the most significant influence because he has the most considerable quotation value of 140 quotations. The distance between nodes shows how close the relationship between researchers is. Authors in close proximity tend to cite the same publications.

4.5. Main research themes

There were 621 keywords identified in the physical workload study from 2003-2023. These are too many to fit in one table. Therefore, only the top 10 keywords are shown in Table 2. The normalization method used is fractionalization, and the visualization weights are events.

Table 2 Top keywords in physical workload studies

2003 - 2023	
Risk Assessment (30)	Female (15)
Human (26)	Risk Factors (13)
Workloads (23)	Work Environment (15)
Occupational Hazards (7)	Musculoskeletal diseases (6)
Ergonomics (13)	Low Back Pain (7)
Adult (17)	Biomechanics (5)
Male (15)	Physical Activity (5)

Figure 4 shows the essential keywords and their relationships. Closer keywords and thicker lines indicate that the two keywords appear together frequently. Bigger keywords have a higher weight. The keyword with the highest weight is “risk assessment.”

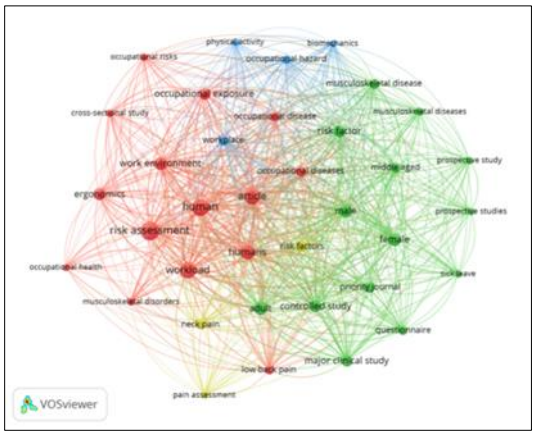

Figure 4 Keyword co-occurrence networks in documents

4.6. Previous research

The following are some that contain workload topics or use similar methodologies:

Table 3 Previous research in the field of physical workload

Writer	Research Title	Research purposes	Research variable	Research result	Further Research
[12]	Duration and intensity of occupational lifting and risk of long-term sickness absence: Prospective cohort study with registered follow-up among 45,000 workers	Investigating the prospective relationship between lifting duration and lifting load and risk long-term sickness absence (LTSA).	Independent Variable: factors for lifting the work object, especially the duration, and load of lifting the object while working Dependent Variable: risk of long-term sickness absence (LTSA)	Workers who lift weights at work for more than half or three-quarters of long-term sickness absence (LTSA). The risk increases are the lifting load increases. Workers over 50 years old have a higher risk of experiencing LTSA, both in terms of lifting duration and lifting load.	Further research in this paper could focus on exploring the effectiveness of interventions to reduce work-related factors and their impact on the risk of long-term sickness absence. Additionally, future research could investigate mediating or moderating factors that influence the relationship between work-enhancing factors and long-term sickness absence, such as individual characteristics, work-related psychosocial factors, or other occupational exposures.
[3]	Forest harvesting in	Examine whether forest	Independent variables: job characteristics that	This research shows that the	Further research on this topic could

	rural properties: Risks and worsening to the worker's health under the ergonomics approach	harvesting workers in rural areas have a higher risk of experiencing occupational deseasses (EOD) and their impacts.	may cause health and safety issues for workers, such as heacy physical load, strength required to perform tasks with the hands, workplace arrangement, body position, static activity, frequency of repetition of task, work organization, and tools used. Dependent Variable: Logging activities on rural land carry a high risk of repetitive strain injuries and work-related musculoskeletal disorders. (RSI/WMSDs).	physical workload in forest harvesting on rural land is very high and exceeds the cardiovascular load limit. This indicates the need for changes in work organization to reduce the risk of injury and health problems. All logging activities, based on evaluations, have a high potential for causing serious injuries to the spine and lower extremities, as well as repetitive strain injuries and work-related musculoskeletal disorders. These risks are caused by a combination of organizational work factors, such as lifting and handling heacy loads, and environmental factors, such as exposure to adverse weather, uneven terrain, excessive noise, and thermal overload.	focus on the development and implementation of ergonomic interventions to improve working conditions and reduce the possibility of injury and pain in muschles and bones caused by repetitive movements and heavy physical activity in forest harvesting activites on rural land.
[4]	Practical judgment of workload based on physical activity, work conditions, and worker's age in construction sites	Develop practical methods for estimating construction workers' individual the possibility of injury and illness due to workload caused by physical activity, working conditions and worker age. This research aims to develop a	Independent variables: Subject age, BMI, amount of physical activity (ACC), and wet bulb temperature (WBGT) in the field environment. Dependent Variable: Construction workers individual workload risks can be predicted based on the physical activity undertaken, working conditions on	The study showed that physical activity (ACC) has a relationship that is not too strong between these variables and the subjects age, wherease there was no relationship between body mass index (BMI) and wet bulb wet temperature (WBGT). Subject	Conducting longitudinal studies to track the long-term health impacts of workload risks in construction workers would provide valuable insight into the cumulative impacts over time. Explore the relationship between workload risk and

		tool that can be used to measure the health impacts of working conditions on construction sites. This tool can be used to identify factors that contribute to damage to worker health.	the construction site and the workers age.	BMI had a weak positive relationship with WBGT. The variance inflation factor (VIF) indicates that the possibility of multicollinearity between independent variable is low.	other factors such as job satisfaction, job stress, and mental health.
[13]	Estimation of physical workload of the low-back based on exposure variation analysis during a full working day among blue-collar male workers. Cross-sectional workplace study	Estimating lower back physical workload based on analysis of exposure variations over an entire workday in male blue-collar workers	Independent Variable: Lifting muscle load Dependent Variable: Workload	Reseacrh shows that operators experience higher exposure to lifting heavy loads in short durations, namely between 1-20 kg and 5-20 kg, compared to other occupational groups.	Focuses on the long-term impact of identified physical workload on low back pain among male blue-collar workers. This could involve conducting prospective cohort studies to determine high physical workloads can increase the risk of low back pain and injury over time. Additionally, explore specific work tasks within each occupational group that contribute to increased risk of injury and musculoskeletal disorders, using detailed time logs or video recordings documenting work activities performed during the workday.
[14]	Validation of newly developed and redesigned essential indicator methods for assessment of	Developed and validated a newly developed and redesigned Key Indicator Method (KIM) for the assessment of physical workload to	Independent variable: Age, body mass index, height, other types of physical workload, other occupational exposure, job satisfaction, quantitative demands, cognitive demands, insecurity at work,	This study involves documenting and analyzing the workplace through observations, applying KIMs, interviews, and	Future research could further validate the Leading Indicator Method (KIM) to assess work factors that can cause fatigue, injury or other

	different working conditions with physical workloads based on mixed-methods design: a study protocol	prevent work-related musculoskeletal disorders (WRMSDs)	influence on performance. Variable: Prevalence of musculoskeletal symptoms in various parts of the body (neck, shoulders, elbows/forearms, hands/wrists, upper back, lower back, hips/thighs, knees, ankle/foot joints), tentative medical conditions, diagnosis, and the body's reaction to certain exposures to the cardiovascular system can be described by perceived activity.	assessing environmental conditions. The validated KIM is intended to be published in 2018 and will be implemented in a real environment for practical use.	health problems, in addition to physical workload, such as manual lifting, holding and carrying laods, manual handling operations whole boddy strength, body posture awkwardness, and body movements.
[15]	The physical workload is associated with increased risk of rheumatoid arthritis: results from a Swedish population-based case-control study	To examine the association between physical stress at work and the risk of developing rheumatoid arthritis (RA), as well as to explore possible interactions between physical stress at work and shared epitope (SE) alleles in the development of RA.	Dependent Variable: Progression of rheumatoid arthritis (RA), especially overall RA or ACPA-positive RA or ACPA-negative RA Independent Variable: Physical stress due to work, exceptionally prolonged repetitive physical workload (PW), such as bending/twisting repeatedly, repetitive hand/finger movements, lifting or carrying loads of more than 10 kg, hands under knees, hands on over the shoulder. Level, and vibration.	The risk of developing RA increases with the amount of physical workload exposure, and there is a significant dose-response relationship. The association between physical workload and RA risk remained significant even after adjusting for potential confounders such as age, gender, and area of residence.	Investigating the specific mechanisms by which work-related physical stress contributes to the development of rheumatoid arthritis.
[16]	Exposure-response relationships for work-related neck and shoulder musculoskeletal disorder-analyses of pooled uniform data sets	Understand how exposure to occupational risk factors can cause neck and shoulder musculoskeletal disorder.	Independent Variable: The posture of the head, upper arms, and wrists, as well as speed, muscle activity in the trapezius and forearm extensor muscles, and psychosocial work environment factors (low job control, job tension, and isostrain) Dependent Variable:	This research found that exposure to occupational risk factors can increase the risk of musculoskeletal disorders of the neck and shoulders. Right-sided shoulder disorders occur more often in workers who make rapid head	

			Frequency of complaints/discomfort in the neck and right shoulder as well as medical conditions diagnosed in the neck and right shoulder.	and upper arm movements, and use the trapezius and forearm extensor muscles intensively. Women also had a higher risk of experiencing neck and shoulder complaints, even after adjusting for other factors such as posture, speed, muscle activity, or psychosocial exposure.	
[17]	Productivity and ergonomic risk in human-based production systems: A job-rotation scheduling model	Develop job rotation scheduling models that maximize production rates while manage human workload to remain within safe and limitation of the bodys ability to adapt to work environments characterized by repetitive manual tasks, such as assembly lines.	Independent Variable: production level. Dependent Variables: factors such as the nature of the task (manual tasks that are repetitive and don't require a lot of effort), the level of automation in the production system, the level of skill and training of workers, and the associated ergonomic risks	Development of job rotation scheduling models that maximize production rates while manage human workload to remain within safe and comfortable limits in work environtments characterized by repetitive manual tasks, such as assembly lines.	Human performance can change dynamically during a work shift. Factors that can influence human performance include learning, forgetting, fatigue, and recovery. In addition, it's worth considering how ergonomic issues can be integrated into classic line balancing procedures, especially in the context of an aging workforce.
[18]	Operator's physical workload in simulated logging and timber bucking by harvester	A research expert carries out measurments and analysis of the physical and mental workload experienced by operators carrying out harvesting activities. Provides valuable insight into the physical and mental demands of this job to reduce	Independent Variables: Individual work operations and operator work experience Dependent Variable: Changes in pulse rate, temperature, and surface muscle tension.	The findings of this study showed that there were statistically significant differences in the mean values of individual work operations in all measured physiological functions. The null hypothesis of no differences between the null hypothesis that individual work	Researchers did not specify further in future studies. However, researchers suggest that the method of applying Biofeedback 2000 x-pert in analyzing the physiological workload of permanent operators can be used in further research to

		risks and promote better health for workers.		operations do not differ significantly from the point of view if the monitored variables can be rejected. Therefore, it can be concluded that individual work operations have significant differences.	evaluate the physical workload of other forestry workers. Researchers also suggest that the results of this research can be used to optimize efforts by forestry workers and their work environment to reduce the risk of work-related musculoskeletal disorder are a focus in work organization.

4.7. Model research workload

The following is a model based on several studies indexed by Scopus*:*

Table 4 Model research workload

Researcher	Biomechanics	Ergonomic Risk Factors (ERF)	SNI 9011: 2021 Muscle and skeletal disorders due to work (Gotrak)	Nordic Questionnaire	Job Content Questionnaire	Visual Analogue Scale (VAS)	Roland Morris Disability Questionnaire	Biofeedback 200x pert	NASA - TLX	Brog C10 Scale	RULA (Rapid Upper Limb Assessment)	Key indicator methods' (KIMs)	Occupational Repetitive Actions (OCRA)	Exposure Variation Analysis	Epidemiological Investigation of Rheumatoid Arthritis (EIRA)	Work environment				Psychosocial
																Voice	Light	Humidity	Temperature	
[12]																				√
[3]																√			√	
[4]																		√	√	
[13]														√						
[14]												√								√
[15]															√					√
[16]				√																√
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[20]									√	√									
[21]									√		√								
[22]					√														√
[23]				√			√												√
[24]	√																		
Next research	√	√	√												√	√	√	√	√

Based on several studies above, there are several differences between studies. The difference between journals can be seen from the use of different methods and the use of tools used, such as Surface electromyography (sEMG), Electromyography (EMG), and Electrocardiogram (EKG). Psychosocial factors from several studies include work tension and significant work demands felt by workers. So, the author's research design can be drawn with several aspects, namely the use of the Biomechanics method, SNI 9011: 2021 Work-related muscle and skeletal disorders (GOTRAK), and the use of tools in the form of a Heart rate monitor and 4in1 Environmental meter.

5. Conclusion

This research aims to identify the characteristics of a complete bibliography of research papers that have been published in Scopus indexed journals by all authors throughout the word. Physical workload research experienced a significant increase after 2003. The research has been widely recognized by the scientific community worldwide based on the institutions, journals, and countries where the research was published.

The differences in institutions, journals, and countries in which physical workload research is published indicate that this field covers a wide range of research topics. Approximately 74 institutions, 33 journals, and 17 countries are involved in physical workload studies. Det Nationale Forskningscenter for Arbejdsmiljø the institution published 4 articles, making it the institution with the largest number of publications. Next are Aalborg University and Vrijie Universiteit Amsterdam, with a total of 3 articles so they occupy second place in the study of physical workload. Authors from Sweden dominate the field by occupying 9 documents from the total number.

Author co-authorship analysis shows that the most significant number of articles are Andersen ll and Blasfoss, with a link strength of 5 each. Then Lotters f. with the most considerable quotation value, namely 140 quotations. The co-occurrence analysis of keywords shows that the top 10 keywords for physical workload from 2003 to 2023 are risk assessment, human, workload, occupational hazard, ergonomics, adult, male, female, risk factor, work environment, musculoskeletal disease, low back pain, biomechanics, physical activity.

Based on several models that have been determined, the author took several journals indexed by Scopus in several aspects taken in the form of the use of different methods and the use of tools used, such as Surface Electromyography (sEMG), Electromyography (EMG), and Electrocardiogram (EKG). Psychosocial factors from several studies include work tension and significant work demands felt by workers. This is a differentiator between existing and future research.

This research only analyzes the number of articles published, dominance of institutions, journals countries, authors and keywords. This research uses the Scopus database. Future research can use more specific keywords and expand the database to achieve more comprehensice results.

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