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Implementation of Macro Ergonomic Participatory in Physical Work Environment: A Literature Review

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Abstract. All types of work must have potential hazards in the work, namely work-related illnesses or work accidents. The level of potential occupational hazard is influenced by the type of production activity, the technology used, the materials used, the design and construction environment, and the quality of management and workers. Musculoskeletal disorders, caused not only by aging but also by unergonomic settings of the equipment used, are one of the frequent occupational diseases caused by worker-job mismatch. This study aims to review the participatory macro ergonomics literature based on the collected references on the development and application of creating ergonomic physical work environments. Participatory methods are methods that aim to find solutions agreed upon by managers, workers and ergonomics experts, and the result of this research is the ergonomic design of work environments.

Keyword: Participatory Macroergonomy, Musculoskeletal, Physical Work Environment

Abstrak. *Semua jenis pekerjaan pasti ada potensi bahaya dalam pekerjaan tersebut yakni penyakit akibat kerja atau terjadinya kecelakaan kerja. Besarnya potensi bahaya kerja dipengaruhi oleh jenis kegiatan produksi, teknologi yang digunakan, material yang dipakai, desain dan lingkungan bangunan serta kualitas manajemen dan para pekerja. Salah satu penyakit akibat kerja yang sering terjadi dari ketidakselarasan tenaga kerja dengan pekerjaan adalah keluhan muskuloskeletal yang bisa terjadi bukan hanya disebabkan faktor usia namun juga akibat dari sikap akibat fasilitas yang digunakan tidak ergonomis. Penelitian ini bertujuan untuk meninjau literatur macro-ergonomic partisipatory berdasarkan referensi yang telah dikumpulkan mengenai perkembangan dan penerapannya untuk mewujudkan Lingkungan Kerja Fisik Ergonomis. Metode Partisipatori yang merupakan suatu metode yang bertujuan untuk mencari solusi disepakati oleh pihak manajemen, pekerja dan ahli ergonomi adapun hasil dari penelitian ini berupa rancangan lingkungan kerja yang ergonomis.*

Kata Kunci: Makroergonomi Partisipatori, Muskuloskeletal, Lingkungan Kerja Fisik

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1. Introduction

One of the strong determinants of hospital service quality is a safe, good and healthy working environment. There is a continued and aggressive interaction between people and our environment, which creates physical and cognitive tensions in humans [1]. In hospital supply areas, laundry convocation abides answerable for preparing clothing, sheets, and surgical linens, restoring them to their complete and preserved condition, and distributing appropriate quantities to individual hospital areas. In hospital laundries, workers are exposed to environmental, alchemical, and organic hazards from waste and generally work in areas that lack ergonomic structures [2].

Musculoskeletal disorders are one of the occupational diseases that often result from mismatches between workers and jobs. Musculoskeletal disorders are musculoskeletal disorders experienced by humans that range from very mild to severe. When muscles are subjected to repeated static loads over an extended period of time, problems can occur in the form of damage to joints, ligaments, and tendons. Persistent failures can be divided into two groups [3].

Work ergonomic factors include high loads and prolonged monotonous, and uncomfortable working postures. Back pain is a work-related illness. This pain is felt in the lower back and originates from the area's spine, nerves, muscles, and other structures. Back pain can also be caused by diseases or disorders other than the spine. For example, diseases and abnormalities of the testicles and ovaries can be caused by improper posture at work [4].

According to WHO in [5], it shows that 33% of the population in developing countries experience persistent pain. In the UK, around 17.3 million people have suffered from back pain and of that number, about 1.1 million people become paralyzed as a result of the back pain. 26% of American adults reported experiencing low back pain for at least 1 day for 3 months.

Based on the outcome from Basic Health Research (2018), the pervasiveness of MSDs in Indonesia analyzed by health professionals based on diagnosis or symptoms is 11.9% and 24.7%. The number of people suffering from back pain in Indonesia is unknown with certainty, but it is estimated to be between 7.6% and 37%.

Based on data from the Central Bureau of Statistics in 2018, 26.74% of workers over the age of 15 suffer from a medical condition or health problem (RI, 2019). This is caused by increasing age and decreases muscle strength [6]. There is a link between age and health problems. We find that with age, a person in adulthood damages body tissues, leading to a decrease in physical performance, that is, the strength of the back muscles, which impedes activity. The decline in activity capacity or work capacity is caused by a decrease in physiological, neurological, and physical capacity, and occurs in different rhythms for each individual from age 30 to her 40s and beyond [7].

The survey conducted on laundry section workers in five hospitals in Indonesia in 2021, using the Body Map & Symptom Survey instrument, obtained data on five body parts that experienced

many complaints from mild – the pain was shoulder (35.51%), calves (33.64%), waist (28.97%), lower back (20.56%), and neck (19.63%). The part of the body that experiences many complaints is in accordance with the ergonomic risk factors experienced by the officer, namely awkward posture in the shoulder area due to a lot of upper extremity movements above the shoulder height, static muscle work due to long-standing, awkward posture in the lumbar and lower back areas due to bending and twisting, and awkward downhill posture [8]. Health problems experienced by workers, according to research conducted on 482 workers in 12 regencies/cities in Indonesia, 16% of which are in the form of musculoskeletal disorders. Research by the Center for Health and Ergonomics Studies ITB in 2006 – 2007 obtained data on around 40–80% of workers reported musculoskeletal complaints [2].

One way to improve the work system to be safe and secure can be using the method which is a method that aims to find solutions agreed upon by management, workers, and ergonomists [9]. The main role of an ergonomics is to create an ergonomic and sustainable design to save resources significantly [9]. The principle of Participatory involving workers in decision-making can produce a design that best suits the needs of workers [9]. This is because the involvement of workers as end users will increase the likelihood of successful implementation of a participatory program even though management seeks to resist system changes that occur [9]. Management is also an important component in implementing the P participatory program because the funding and decision-making assistance for any system changes that occur come from management so that collaboration with effective management can increase awareness of the importance of ergonomics in the workplace [9]. This study aims to review macro ergonomic-participatory literature based on the references that have been collected regarding its development and application to realize the Ergonomic Physical Work Environment.

2. Musculoskeletal

Work-related musculoskeletal disorders abide a prevalent health dilemma in the industrial earth. Musculoskeletal disorders are disorders of the fretfulness, tendons, habit, and aiding the design of the musculoskeletal arrangement a certain bottle causes lethargy, ache, ache, localized swelling, numbness, and tingling. MSDs usually arise from cumulative damage caused by long-term physical and psychosocial stress at work [10].

Risk aspects leading to his MSD at work include; (1) Handling heavy objects (2) Repetitive behaviors performed with more energy. (3) Vibration/vibration; (4) Static and awkward posture resulting from the improper workplace, tools, and work methods; (5) The working system needs to be fixed. Exposure to these factors affects the worker's body, including decreased blood flow and localized muscle fatigue. If these are not fully restored, MSE escalations will occur faster.

3. Macro Ergonomic

H.W. Hendrick introduced macro ergonomics in 1984. Rapid technological advances have led to the emergence of macro ergonomics and the need for organizations to adapt to these changes.

Micro ergonomic measures are no longer considered effective in reducing the number of accidents and increasing productivity. Therefore, the broader context of ergonomics, namely macro ergonomics, requires integration with organizational design and management factors. Macro ergonomics is a prospect, an approach, accepted as a subfield of ergonomics or human factors. This macro ergonomics is concerned with human-organizational interface technology. Conceptually, macro ergonomics uses a top-down socio-technical approach to designing work systems. Macro ergonomics aims to optimize the design of the work system concerning the characteristics of the sociotechnical system and subordinate it to the work system as a whole [11].

4. Participatory Ergonomic

Participatory ergonomics is a macro ergonomics method that emphasizes worker involvement in ergonomic design and analysis [12]. On the other hand, Wilson describes "participatory ergonomics as the planning and control of most of one's work activities, with sufficient knowledge and power to influence both processes and outcomes to achieve desired ends. "Participation in"[13]. This means that participatory ergonomics means that people (workers) are involved in the planning and managing of work activities and are well-informed and empowered in the process, resulting in desired goal achievement. This method allows employees to participate in work planning, monitoring, and decision-making to promote confidence and work motivation. These participatory ergonomics were developed because traditional control methods were considered ineffective because they put workers under pressure and stress, thereby reducing productivity.

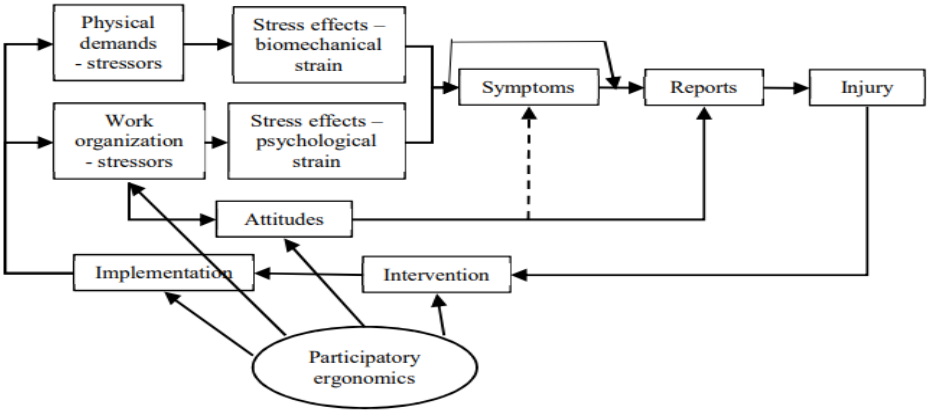

Figure 1 Illustration of the Role Model of Participatory Ergonomics in Reducing Occupational Injury and Illness (Source: Haines & Wilson, 1998) [13]

In the participatory ergonomics approach, Hignett, et al. [14] created a framework called the Participatory Ergonomics Framework. This framework highlights the ranking dimensions of the importance of worker engagement. The most important dimensions are decision-making consultation and the involvement of workers at all levels of the organization. The order of the dimensions of the framework by order of importance is described in Table 1.

Table 1 Participatory Ergonomics Framework by Order of Interest (Hignett, Wilson, & Morris, 2005) [14]

Level	Dimensional	Dimension Order
1	Accomplishing	Group Delegation - Group Counselling - Individual Counselling
2	Shareholders	Operators - Supervisors - Middle management - Unions - Technical staff - Senior management
3	Order (Task)	Process Development - Identifying Problems - Finding Solutions - Solution assessment - Solution application - Process maintenance
4	Human factors	Process initiation and management - Role as a team member - Training participants - Consulting
5	Participation	Fullidirect - Partialidirect - Representative
6	Concentration	Tool or task design - Workplace and team or work organization design - Policy or strategy development
7	Impact	Whole Organization - Department / Cooperation
8	Demands	Required - Optional
9	Sustainability (permanency)	Ongoing - Temporary

A key feature of participatory ergonomics is the formation of an ergonomics team to guide the intervention process. This team typically consists of workers or representatives, managers, ergonomics specialists, occupational health and safety officers, and research specialists. This formation is a way of sharing organizational experiences to develop the best possible interventions. This newly formed team is typically trained by specialists (ergonomics) and familiar with ergonomics principles. Given the basic concepts and methods of ergonomics, the team uses that knowledge to develop and improve the workplace [15].

5. Research Methodology

The research method with bibliometric analysis is one of the oldest branches of library science. As a scientific study, this branch developed because a handful of scientists in the early 20th century were interested in the dynamics of science as reflected in the production of scientific literature through the approach of studying ergonomics scientific articles in national journals. The study of scientific articles in international journals was carried out on Scopus-indexed ergonomics articles (www.scopus.com) with the keyword "participatory ergonomics." In accordance with the research objectives, ergonomics articles must be written by at least one researcher affiliated with an industrial engineering institution from Indonesia.

6. Results

6.1. General Results

Based on a review of journals, it was found that macro ergonomics has been applied in various industries, both service industries, manufacturing, and office environments. From review journals, 8 of them are applied to service industries such as hospitals and education; 12 articles on manufacturing industries such as the palm oil industry, the automotive industry, brick factories, and others; and there are two articles in the office.

Table 2 Frequency of Application of Macro Ergonomics in Industry

Application of Macro Ergonomics	Publication
Service Industry	[2] [5] [6] [7] [19]
Manufacture	[1] [8] [17] [18] [20]
Office Environment	[4] [9] [10] [13] [14] [15][16] [21] [22]

From scientific review articles, all analysis and design of research articles are carried out using a work system approach. This means that the macro ergonomics approach in all review articles is top-down, where the analysis and design stages are carried out within the scope of the work system. The macro-ergonomics factors that are most often considered consecutively are people, organization, and technology, environment, and task.

Table 3 Frequency of Application of Macro Ergonomics in Industry

Article	Publication
Person	[1][2][5][6][7][8][9][10][15][17][16][19][21]
Organization	[1][4][5][7][9][10][12][13][14][17][18][20][21] [22]
Technology and Equipment	[1][2][5][6][8][9][10][14][15][17][18][19]
Task	[1][5][6][7][8][10][14][17][18][20]
Environment	[4][6][7][8][9][12][13][14][15][18][20][22]

6.2. Thematic Analysis

A study by Tappin, Vitalis & Bentley [16]. This study applies a participatory ergonomics approach to the meat industry to reduce workers' risk of MSDs and develop intervention plans that include work systems and broader industrial practices. Increase these interventions have been endorsed by key stakeholders across the industry and have survived the investigation period. While this approach will help achieve the study's goals, the presence of key industry-supported stakeholder groups and the mandate of this initiative are important prerequisites for its success.

A study by Aldo Lintang Pratama, Muhammad Yusuf and Cyrilla Indri Parwati [17]. It is improving work systems with a participatory ergonomic approach to analyze factors and obtain data to reduce the risk of worker injury. Based on this research, the results of an analysis based on the Ovako work analysis system "OWAS" indicate that there are work postures that pose a risk of muscle injury for workers. Indicates that the working posture during liquid injection is Category 3. This means that it should be improved as soon as possible. Hyperflexion can be minimized by providing workers with knowledge of better working postures, following guidelines drawn from existing literature and theory. Come from. Awareness of workers' use of personal protective equipment (PPE) needs to be improved, documented in the form of work-in-progress photographs, and directed by. Of course, this also requires the company's commitment to creating a culture around the importance of using personal protective equipment in the workplace for the safety and health of its employees.

A study from Paulus Skaput et al. [9] implementing NOSACQ-50, JSA, and participatory ergonomics implementations to create comfortable, safe and humane working environments to measure occupational health and safety environments in the rubber, stock fit, and chemical

warehouse sectors. Create the studies conducted using the Job Safety Analysis (JSA) method to measure potential hazards (determine the extent of work activity). The highest level of risk is then measured based on risk assessment methodologies. Work systems are then improved through participatory ergonomics (PE). According to the survey results, the JSA carried out ten work activities with the highest risk ratings, i.e., rubber cutting, priming, and sanding. Improvements using participatory ergonomics (PE) methods have created the activity of cutting the rubber by shifting the alignment of the rubber in the bearing to a vertical position. Priming activity by replacing the glue container and brush with special tools. Polishing work by installing an exhaust fan.

Based above analysis findings, the design of ergonomic working environments in hospitals can be done with technical and administrative control involving all levels of the organization. The problem of the incompatibility of ergonomic aspects between work facilities and humans and its effect on health has yet to receive serious attention in Indonesia. This is evidenced by the fact that many workplaces still need to be guided by ergonomics rules to provide a work environment for workers.

Health Law No. 36 of 2009 Article 165:

"Workplace managers should implement all forms of health initiatives through worker prevention, remediation, treatment, and recovery. Based on this article, hospital workplace managers are obliged to provide meals to their employees. In addition to occupational safety, one way is occupational safety".

Robertson [23] argues that effective macro ergonomic design can facilitate several aspects of work system micro ergonomic design that ensure ergonomic compatibility of system components with the overall structure of the work system. Macro ergonomics can also be seen as a social engineering system that approaches the design of work systems and their general application to the human workplace, human-machine, and human-software interfaces, he said of Hendrick. Consistent with the statement. The macro ergonomics discussed relate to aspects of organizational structure, interactions with workers within the organization, and worker motivation. Andersen explained that an ergonomic work system supports human well-being (physical, cognitive, etc.) and overall performance (quality, efficiency, etc.).

Occupational health is an element of health related to the work environment and work, which can directly or indirectly affect work efficiency and productivity. Meanwhile, work safety is the main means to prevent work accidents that can cause harm in the form of injury or injury, disability or death, property loss, damage to equipment or machinery, and environmental damage widely. Ergonomics risks that often occur are awkward postures caused by work facilities. The impact is musculoskeletal disorders (MSDS), such as muscle pain and low back pain (LBP). The work attitudes often carried out by hospital laundry unit operators in doing work include standing, sitting, bending, squatting, and walking. The working attitude is carried out in accordance with the conditions in the existing work environment. Unhealthy working system conditions will cause

work accidents because workers do unsafe work. A wrong work attitude, awkwardness, and out of habit will increase the risk of injury to the musculoskeletal area. Many ergonomic risks occur in hospital laundry units. One of the dangers of ergonomics is bending when loading and removing dirty linen from the trolley (awkward posture), which results in muscle pain or low back pain. The primary data from the observation is that the work activities of the laundry unit operator are at risk of ergonomics in the hospital. Work-related to transportation picks up dirty linen and delivers clean linen from each post to the laundry unit. The study found that the linen trolley was the most dominant work tool that also contributed to the increased risk of ergonomics.

7. Conclusion and Future Research

From the results and discussion of the research conducted, it can be concluded that preventing the occurrence of health problems due to work in the hospital laundry unit, it can be done by making improvements to the design of work facilities which consist of designing work facilities, namely linen trolleys and lighting improvements, noise levels, humidity levels and temperatures—laundry area space. An ergonomic work environment must be supported by organizational policies towards workers, such as providing poor work facilities, namely the physical work environment in the Hospital laundry unit. This is supported by the government issuing a law on applying OHS in hospitals and government regulations PMK/No.7/2019/Hospital Environmental Health.

Ergonomics risk for laundry unit operators can be reduced, in accordance with the improvement of the physical work environment, thus technical control is prioritized in controlling risks due to bending work and working environmental conditions, namely lighting, noise levels, humidity levels, and room temperature in the laundry area, followed by administrative control and only last time to use personal protective equipment if there is still an unacceptable risk. It is recommended to use a trolley whose height can be adjusted to the operator's height; thus, the operator can adjust the height of the trolley to his height so as to reduce the angle of the back arch.

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