



ERGONOMIC INTERVENTIONS IN INDUSTRIES OF THE ELECTRICAL AND ELECTRONIC SECTOR: A SYSTEMATIC REVIEW OF THE LITERATURE

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Abstract

The contemporary market demands efficiency in production processes, leading to a deterioration in working conditions. However, this results in increased absenteeism, sick leave and high medical costs. Studies show that ergonomic interventions can prevent and recover lost productivity associated with musculoskeletal disorders. Although ergonomics seeks to improve efficiency and safety, the financial benefits are not always evident. A systematic review highlighted a high prevalence of exposure to occupational ergonomic risk factors. In the electronics assembly sector, musculoskeletal disorders are common due to factors such as poor posture and repetitive movements. A scoping review was conducted to identify ergonomic interventions and their effectiveness in the electronics industry. Although studies vary in methodology and quality, interventions have shown positive results, although some may have side effects. Competitiveness often leads to the adoption of outdated production methods, harming workers' productivity and health. However, simple and low-cost measures can improve working conditions and productivity. It is concluded that more studies are needed, but ergonomic interventions consistently show benefits for both occupational health and corporate management.

Keywords: ergonomics; worker health; electronics industry.

1. INTRODUCTION

In view of the need imposed by the market for greater efficiency of production processes, with increased productivity and the adoption of tight deadlines, there is a deterioration of working conditions in companies and corporations. However, producing a

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result contrary to what was expected, these working conditions prove to be counterproductive, due to the increase in absenteeism, work leaves, the need for functional readaptations, expenses with medical care, as well as the high costs of indemnity lawsuits (PINTO; TERESO; ABRAHÃO, 2018).

Several studies have demonstrated the effectiveness of ergonomic interventions in the prevention and recovery of loss of work productivity associated with musculoskeletal disorders (BATTEVI; VITELLI, 2013; ESMAEILZADEH; OZCAN; CAPAN, 2014; MARTIMO et al., 2020). Although ergonomics is mainly concerned with the performance of activities in a safe and efficient manner, and the literature presents several evidences of the results of its application, these are often not expressed in a way that can be easily converted into financial gains. However, there is a growing body of tangible evidence on the cost-benefit of ergonomic improvements, ranging from the increase in productivity resulting from the redesign of equipment and the layout of the work environment to the savings obtained with the reduction of absenteeism, leaves and work-related accidents (BEEVIS; SLADE, 2003; SILVA; PRUFFER; AMARAL, 2012).

A systematic review of the literature with meta-analysis showed an extremely high prevalence of occupational exposure to ergonomic risk factors (HULSHOF et al., 2021). Risk factors were defined as occupational exposure to one or more of: strength effort, demanding posture, repetitive movement, hand-arm vibration, kneeling or squatting, standing and climbing. Five studies met the eligibility criteria, covering 150,895 individuals, from 36 countries. The pooled prevalence of any occupational exposure to ergonomic risk factors was 76% (95% CI 69%-84%). A study conducted with 591 workers in the electronics assembly sector showed a high frequency of musculoskeletal disorders in the extremities of the upper limbs, especially radial styloid tenosynovitis, trigger finger, carpal tunnel syndrome, lateral epicondylitis and medial epicondylitis. The outcomes were associated with high wrist strength, inadequate wrist posture, wrist contact stress, inadequate finger posture, finger contact stress, and inadequate elbow posture. The findings highlight the importance of ergonomic risk assessment and management involving these workers (PULLOPDISSAKUL et al., 2013).

However, although the literature indicates the high prevalence of disorders related to ergonomic risks in these work environments, a synthesis of the evidence on the effectiveness of forms of intervention in occupational risks in industries in the electrical and electronic sector has not yet been carried out. Systematic reviews provide a high level of evidence, and the results can help decision-making to reduce ergonomic risks efficiently. Thus, this study aimed to



identify which ergonomic interventions were performed and their effectiveness in industries of the electrical and electronic sector.

2. METHOD

A systematic review study was carried out, of the scoping review type. The study was prepared according to the Joanna Briggs Institute (JBI) recommendations for the synthesis of evidence for scoping reviews (PETERS et al., 2020) and reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines for scoping reviews (TRICCO et al., 2018). The review question was: "What ergonomic interventions have been carried out and their effectiveness in industries in the electronics sector?". The primary outcome of the study was the result of the ergonomic interventions performed. All stages were conducted by two independent reviewers (F.J.H. and J.A.E.). Disagreements were resolved by consensus with the group of authors.

Search strategy

The literature search strategy included searching electronic databases, complemented by checking the references of the selected studies. The Cochrane, Medline, Embase, Scopus, Lilacs and Web of Science electronic databases were searched. The general search strategy used was (ergonomic AND intervention AND electronic AND (factory* OR manufactur* OR industry)). The search strategy was adapted to each database, respecting the languages and their syntax rules. The cut-off date for the search was May 31, 2022.

Eligibility criteria

Intervention studies, regardless of their design, whose participants or work environments underwent interventions to reduce ergonomic risk were included. No restrictions were applied on the type of actions implemented.

The following were excluded: (1) observational studies, reviews, conference abstracts, letters, and editorials; (2) studies in languages other than English, Spanish or Portuguese; (3) studies published more than 20 years ago (before 2002).

Selection of sources of evidence

The selection of articles was initially made by title and abstract. The free software Zotero was used as a reference manager to assist in the stages of identifying duplicate studies and selecting articles.



Then, the texts were read in full and selected based on the eligibility criteria, also by two reviewers, independently. Reasons for exclusion of fully assessed studies were recorded separately, explaining the reasons for exclusion. The study selection process was presented in a flowchart.

Data extraction

A standardized form was used for data extraction, namely: place and year of study, type of study, sample size and characteristics, intervention protocol, form of evaluation of outcomes, and criteria for evaluating the quality of the study.

Quality assessment and data synthesis

The instruments recommended by the JBI for critical evaluation of intervention studies (<https://jbi.global/critical-appraisal-tools>) were used to assess the quality of the selected studies. The data extracted from the studies, as well as the synthesis of the qualitative analysis, were presented in the form of tables.

3. DEVELOPMENT, RESULTS AND DISCUSSION

Figure 1 shows the flowchart of the studies included in each stage of the review. The data from the selected studies are presented in Table 1.

Figure 1. Flowchart of the stages of identification and selection of articles.

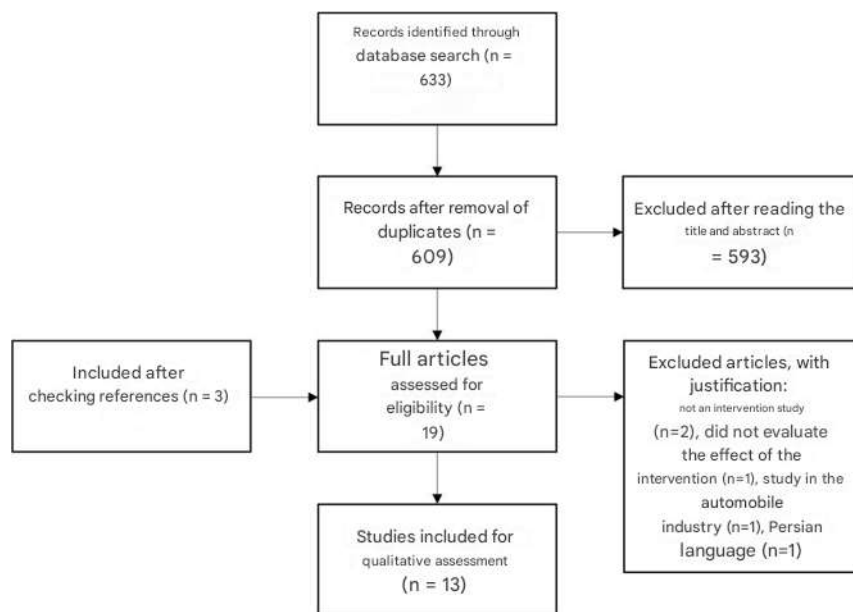




Table 1. Studies included in the qualitative evaluation stage

Author and year	Country	n	Sex	Middle Ages	Average time experience
Chung & Wang, 2002	Taiwan	16	female	22,0	5,2
Neumann et al., 2002	Sweden	n/a	n/a	n/a	n/a
Yeow & Sen, 2003	Malaysia	31	female	19,4	3,9
Sen & Yeow, 2003	Malaysia	31	n/a	n/a	n/a
Yeow & Sen, 2004	Malaysia	20	female	18,7	3,6
Yeow & Sen, 2006	Malaysia	31	female	19,4	3,9
Motamedzade et al., 2011	Iran	80	91.2% female	32,2	4,8
Aghilinejad et al., 2016	Iran	105	male	34,4	9,7
Daneshmandi et al., 2018	Iran	53	83.0% female	38,8	16
Morag & Luria, 2018	Israel	791	both	n/a	n/a
Vega et al., 2019	Mexico	66	both	n/a	n/a
Fadaei et al., 2020	Iran	40	female	33,7	4,0
Yeganeh et al., 2020	Iran	54	n/a	n/a	n/a

Several interventions were carried out in the studies, including changes in the type of handle and transport distance (CHUNG; WANG, 2002), automation of production line steps (NEUMANN et al., 2002), adequacy of the slope and support base for visual inspection of the plates (DANESHMANDI et al., 2018), educational programs and training (MOTAMEDZADE et al., 2011; VEGA et al., 2019; YEGANEH et al., 2020) including participatory ergonomic interventions (MORAG; LURIA, 2018), use of elastic bandage and exercises (FADAEI et al., 2020), as well as multiple interventions at workstations based on ergonomic risk diagnoses carried out at the baseline of the studies, such as the replacement of chairs and floors, changes in the arrangement of instruments, replacement of shoes and PPE, reduction of workload, adjustment in production line time, breaks and turnover of workers, confinement of machines to reduce noise and odors (YEOW; SEN, 2003; SEN; YEOW, 2003; YEOW; SEN, 2004; YEOW; SEN, 2006; AGHILINEJAD et al., 2016; VEGA et al., 2019; YEGANEH et al., 2020).

The instruments used for ergonomic evaluation of the interventions also varied. The application of validated instruments was not clearly identified in five studies, although the evaluation was carried out through direct observation (NEUMANN et al., 2002; YEOW; SEN, 2003; SEN; YEOW, 2003; YEOW; SEN, 2004; VEGA et al., 2019).

The use of the Borg scale (CHUNG; WANG, 2002), *Strain Index* (MOTAMEDZADE et al., 2011), *Nordic Musculoskeletal Questionnaire* (MOTAMEDZADE et al., 2011), *General Nordic Questionnaire* (DANESHMANDI et al., 2018), Corlett and Bishop discomfort scale (AGHILINEJAD et al., 2016), *Rapid Upper Limb Assessment – RULA* (DANESHMANDI et



al., 2018) and the *Disability of the Arm, Shoulder and Hand* – DASH questionnaire (FADAEI et al., 2020).

Although one study defined a control group, with 13 participants (FADAEI et al., 2020), none of the included intervention studies were randomized controlled trials. Some studies have not yet been able to replicate all baseline measurements at a time after the intervention (SEN; YEOW, 2003; YEOW; SEN, 2004; YEOW; SEN, 2006; MORAG; LURIA, 2018; VEGA et al., 2019). The form of selection of participants, as well as aspects related to loss to follow-up, were not clearly explained in all studies. Regarding data analysis, only two used appropriate methods (MOTAMEDZADE et al., 2011; MORAG; LURIA, 2018). Two studies used independent rather than paired tests to evaluate interventions (CHUNG; WANG, 2002; AGHILINEJAD et al., 2016) and one reported having used a test that did not apply to the type of variable evaluated (YEGANEH et al., 2020). The others did not sufficiently describe the methods of analysis or did not use them.

Except for the low methodological quality of the selected studies, the results of the ergonomic interventions evaluated were generally positive. In addition, some studies have evaluated the impact of interventions also focusing on improving the company's productivity and revenue (NEUMANN et al., 2002; YEOW; SEN, 2004; YEOW; SEN, 2006; YEGANEH et al., 2020). Some studies have shown, however, that despite the reported ergonomic improvement, interventions may also induce some risks that should be weighed. The proposed modification in the grip induced postural improvement and allowed a greater maximum acceptable lifting weight, however it led to greater radial deviation (CHUNG; WANG, 2002). The automation of repetitive work on the assembly line reduced the risk of work-related musculoskeletal disorders, but an increase in intensity and monotony was identified in those non-automated workstations, increasing the risk of musculoskeletal disorders for these workers (NEUMANN et al., 2002). The change in trunk tilt for visual inspection of circuit boards was associated with total postural improvement, including neck, trunk, but was also associated with a slight worsening in the position of the forearm (AGHILINEJAD et al., 2016).

In many situations, the competitiveness of labor, in terms of costs, stimulates the adoption of production methods that are already depreciated to the detriment of investment in capital goods for the adoption of more modern methods of work organization (FERREIRA; BOTELHO, 2014). The organization of work marked by overload, pressure and other elements that disregard appropriate ergonomic practices contribute to the reduction of productivity and the aggravation of pathological conditions related to work (IIDA, 2002). These conditions are often also overlooked by the worker himself, as a defensive strategy to maintain his job,



resulting in worse consequences in the medium and long term for both the individual and the employer (CARVALHO; MORAES, 2011). However, sometimes simple and low-cost measures can contribute to the improvement of working conditions and the well-being of workers combined with the establishment of a more productive environment in companies (BEEVIS; SLADE, 2003; SILVA; PRUFFER; AMARAL, 2012; BATTEVI; VITELLI, 2013; ESMAEILZADEH; OZCAN; CAPAN, 2014; MARTIMO et al., 2020).

4. CONCLUSIONS

Studies with robust and better designed samples are necessary for the adequate measurement of the magnitude of the impacts of ergonomic interventions in companies in the electrical and electronic sector. However, despite the different methodologies and methodological flaws pointed out in the selected studies, there was a consistency between the positive results of the various interventions tested, both for occupational health and for corporate management, evidencing the importance of ergonomic assessment and management of existing risks in the work environment.

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