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ERGONOMIC INTERVENTIONS IN INDUSTRIES IN THE ELECTRO-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 greater absenteeism, sick leave, and higher 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 carried out 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 Competitiveness often leads to the adoption of outdated production methods, harming workers' productivity and health.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's health; electronics industry.

Introduction

Faced with the need imposed by the market for greater efficiency in production processes, with increased productivity and the adoption of tight deadlines, there is a deterioration in working conditions in companies and corporations. However, producing a 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 compensation processes (PINTO ; TERESO; ABRAHÃO, 2018).

Several studies have demonstrated the effectiveness of ergonomic interventions in preventing and recovering 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 diverse evidence 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 increased productivity resulting from the redesign of equipment and the layout of the work environment to the savings obtained through the reduction of absenteeism, absences 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: force exertion, demanding posture, repetitive movement, hand-arm vibration, kneeling or squatting, lifting 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 carried out with 591 workers in the electronic assembly sector showed a high frequency of musculoskeletal disorders in the extremities of the upper limbs, mainly radial styloid tenosynovitis, trigger finger, carpal tunnel syndrome, lateral epicondylitis and medial epicondylitis. High wrist strength, inadequate wrist posture, contact stress on the wrists, inadequate finger posture, contact stress on the finger and inadequate posture when using the elbows were associated with the outcomes. The findings highlight the importance of evaluating and managing ergonomic risk 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 electronics 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 carried out and their effectiveness in industries in the electronics sector.

Method

A systematic review study, of the scoping review type, was carried out. The study was designed according to the recommendations of the Joanna Briggs Institute (JBI) for the synthesis of evidence for scoping reviews (PETERS et al., 2020) and reported in accordance with the guidelines of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) for scope reviews (TRICCO et al., 2018). The review question was: “What are the ergonomic interventions 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 steps were carried out independently by two 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 selected studies. The electronic databases Cochrane, Medline, Embase, Scopus, Lilacs and Web of Science were searched. The general search strategy used was (ergonomic AND intervention AND electronic AND (factory* OR manufactur* OR industry)). The search strategy was adapted for each database, respecting the languages and their syntax rules. The search deadline was May 31, 2022. Eligibility criteria

Intervention studies were included, regardless of their design, whose participants or work environments were subjected to interventions to reduce ergonomic risk. 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 evidence sources

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 studies evaluated in full 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: location and year of the study, type of study, sample size and characteristics, intervention protocol, method of evaluating outcomes, and criteria for evaluating the quality of the study.

Quality assessment and data synthesis

The instruments recommended by JBI for critical evaluation of intervention studies (https://jbi.global/critical-appraisal-tools) were used to evaluate 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.

Development, Results and Discussion

Figure 1 presents the flowchart of studies included in each stage of the review. Data from the selected studies are presented in Table 1.

Figure 1. Flowchart of the article identification and selection steps.

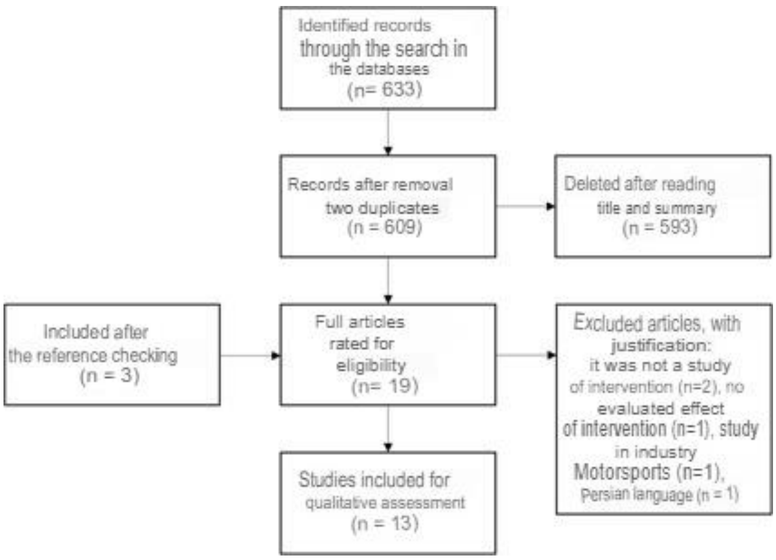

Table 1. Studies included in the qualitative assessment stage

Author and year	Country	n	gender	Middle ages	time average experience
Chung & Wang, 2002	Taiwan	16	feminine	22,0	5,2
Neumann et al., 2002	Suécia	n/a	n/a	n/a	n/a
Yeow & Sen, 2003	Malásia	31	feminine	19,4	3,9
Sen & Yeow, 2003	Malásia	31	n/a	n/a	n/a
Yeow & Sen, 2004	Malásia	20	feminine	18,7	3,6
Yeow & Sen, 2006	Malásia	31	feminine	19,4	3,9
Motamedzade et al., 2011	Irã	80	91,2% feminine	32,2	4,8
Aghilinejad et al., 2016	Irã	105	masculine	34,4	9,7
Daneshmandi et al., 2018	Irã	53	83,0% feminine	38,8	16
Morag & Luria, 2018	Israel	791	both	n/a	n/a
Vega et al., 2019	México	66	both	n/a	n/a
Fadaei et al., 2020	Irã	40	feminine	33,7	4,0
Yeganeh et al., 2020	Irã	54	n/a	n/a	n/a

There were several interventions carried out in the studies, including modifications in the type of handle and transport distance (CHUNG; WANG, 2002), automation of stages of the production line (NEUMANN et al., 2002), adjustment of the inclination and support base for visual inspection of 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 bandages 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 replacing chairs and flooring, changes in arrangement of instruments, replacement of shoes and PPE, reduction of workload, adjustment of production line time, breaks and worker rotation, 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 assessment of 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 studies used 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 questionnaire – DASH (FADAEI et al., 2020).

Although one study defined a control group, with 13 participants (FADAEI et al., 2020), none of the intervention studies included were randomized controlled trials. Some studies were also unable to replicate all measurements carried out at baseline at a time after the intervention (SEN; YEOW, 2003; YEOW; SEN, 2004; YEOW; SEN, 2006; MORAG; LURIA, 2018; VEGA et al., 2019). The way participants were selected, 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 using a test that did not apply to the type of variable evaluated (YEGANEH et al., 2020). The others did not sufficiently describe the analysis methods or did not use them.

Taking into account the low methodological quality of the selected studies, the results of the ergonomic interventions evaluated were generally positive. Furthermore, some studies 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 can also induce some risks that must be considered. The proposed modification in the handle induced postural improvement and allowed a greater maximum acceptable lifting weight, however it resulted in 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 in non-automated positions was identified, increasing the risk of musculoskeletal disorders for these workers (NEUMANN et al., 2002). The change in trunk inclination for visual inspection of circuit boards was associated with overall postural improvement, including neck and 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, encourages the adoption of already depreciated production methods to the detriment of investment in capital goods to adopt more modern methods of work organization (FERREIRA; BOTELHO, 2014). Work organization marked by overload, pressure and other elements that disregard appropriate ergonomic practices contribute to reduced productivity and the worsening of work-related pathological conditions (IIDA, 2002). These conditions are often also ignored by the worker himself, as a defensive strategy to maintain his job, causing 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 improving 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).

Conclusions

Studies with robust and better designed samples are necessary to adequately measure the magnitude of the impacts of ergonomic interventions in companies in the electronics sector. However, despite the different methodologies and methodological flaws highlighted in the selected studies, there was consistency between the positive results of the different interventions tested, both for occupational health and corporate management, highlighting the importance of ergonomic assessment and risk management existing in the work environment.

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