

# A Cross-Sectional Study on the Combined Effects of Heat Exposure and Postural Stress on Job Strain Among Workers in the Tire Manufacturing Industry in Tehran

Shahram Vosoughi<sup>1</sup>, Mohammad Samadi Gol Gholab<sup>2</sup>, Jamileh Abolghasemi<sup>3</sup>,  
Ardalan Vosoughi<sup>4</sup>, Zahrasadat Mousavifard<sup>1\*</sup>

<sup>1</sup>Occupational Health Research Center, Department of Occupational Health Engineering, School of Public Health, Iran University of Medical Sciences, Tehran, Iran

<sup>2</sup>Department of Occupational Health Engineering, School of Public Health, Iran University of Medical Sciences, Tehran, Iran

<sup>3</sup>Department of Biostatistics, School of Public Health, Iran University of Medical Sciences, Tehran, Iran

<sup>4</sup>Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

Received 2025-05-19; Revised 2025-08-03; Accepted 2025-08-26

## ABSTRACT

**Background:** Work related musculoskeletal disorders and exposure to thermal stress are considered as some of the most significant challenges for workers in the tire manufacturing industry, which can lead to decreased human performance and work capacity, as well as increased physical and psychological burden during the execution of tasks. Therefore, the aim of this study is to determine the simultaneous effects of thermal stress and postural stress on the occupational strain index of workers employed in a tire manufacturing company.

**Methods:** In this descriptive-analytical (cross-sectional) study, 147 individuals with at least one year of work experience were selected as the sample based on the inclusion criteria. Participants in the study were divided into three groups: the postural stress exposure group (n = 49), the group exposed simultaneously to thermal and postural stress (n = 49), and the control group (n = 49). For data collection, the Nordic questionnaire and a demographic questionnaire were used. Additionally, the REBA (Rapid Entire Body Assessment) observational method was utilized to determine the postural stress score, while the WBGT (Wet Bulb Globe Temperature) index was employed to assess the thermal stress of the workers. The occupational strain index was determined using JSI 2001 software, and statistical analyses were conducted using SPSS version 16.

**Results:** More than 60% of the production line workers at the tire company reported suffering from one or more musculoskeletal disorders in the past nine months. The average strain index in the first exposure group (postural stress exposure) was  $32.80 \pm 4.212$ , while in the second exposure group (simultaneous exposure to postural and thermal stress), it was  $33.50 \pm 2.801$ . According to the strain index standard, all individuals in the second exposure group and 90% of those in the first exposure group were classified as being at a dangerous level of risk. Additionally, a significant positive correlation was found between the strain index score and the REBA (Rapid Entire Body Assessment) score ( $r = 0.646$ ), whereas no significant correlation was observed between the strain index and the WBGT (Wet Bulb Globe Temperature) index ( $p > 0.05$ ).

**Conclusion:** In the tire manufacturing workers studied, the strain index level ranged from “moderate” to “high-risk strain levels”, with most reporting musculoskeletal disorders in the lower back and spine. There was a significant relationship between the strain index and the final REBA score, while no significant relationship was found between the strain index and the WBGT index.

**KEYWORDS:** Musculoskeletal Disorders, Strain Index, Tire Manufacturing, Wet Bulb Globe Temperature (WBGT), Rapid Entire Body Assessment (REBA)

**How to cite this article:** Vosoughi S, Samadi Gol Gholab M, Abolghasemi J, Vosoughi A, Mousavifard Z. A Cross-Sectional Study on the Combined Effects of Heat Exposure and Postural Stress on Job Strain Among Workers in the Tire Manufacturing Industry in Tehran. *Int J Occup Hyg.* 2025;17(3):162-169.

Corresponding author: Zahra Sadat Mousavi Fard

E-mail: [mousavifardzahrasadat@gmail.com](mailto:mousavifardzahrasadat@gmail.com)

## INTRODUCTION

Musculoskeletal disorders (MSDs) represent a major occupational health challenge worldwide, affecting workers in both developed and developing countries. These disorders lead to increased compensation claims, elevated healthcare costs, reduced productivity, and a decline in quality of life [1, 2]. Occupational exposure to physical and mental stressors—particularly in jobs involving prolonged static postures or high thermal loads—can substantially impact workers' health and job performance.

Several studies have emphasized the influence of personal and psychosocial factors in the development of work-related MSDs. For example, a recent study among Chinese dentists identified individual characteristics, job satisfaction, and mental workload as significant contributors to the prevalence of these disorders.[3] Similarly, in administrative and banking sectors, poor posture and extended computer use were found to play a key role in MSD development, underscoring the need for ergonomic corrections and reduced computer working hours to alleviate strain and improve worker health [4]. Among gas station workers, poor posture was linked to increased fatigue, stress, and a high prevalence of work-related musculoskeletal disorders (WMSDs), highlighting the importance of ergonomic interventions in such settings [5]. Food packing workers also demonstrated a notable prevalence of WMSDs, particularly pain in the back, neck, and upper limbs [6]. Additionally, a study among physical therapists showed a high prevalence of MSDs, with key risk factors including younger age, manual treatment techniques, patient handling, awkward postures, workplace environment, and stress levels, indicating the critical need to address both occupational and environmental factors to improve musculoskeletal health in this group [7]. Data from the United States reveal that between 1992 and 2010, approximately 29 to 35 percent of all recorded work-related injuries and illnesses were attributed to MSDs [8].

In France, MSDs are recognized as the leading cause of occupational disease compensation claims, with an expected increase of 18 percent over the next decade [9]. The prevalence of MSDs also varies across industries; for instance, in Iran's tire manufacturing industry, rates have been reported between 72 and 77 percent [10, 11]. Due to their high prevalence and significant impact, prevention of MSDs remains a national priority and a critical concern in many countries [12].

Effective treatments for these disorders are

not fully recognized, and therefore, prevention is regarded as the best strategy to mitigate their health, economic, and social consequences [13]. The first and most crucial step in preventing musculoskeletal disorders is identifying the factors that cause them [14]. Increased exposure to existing risk factors in work environments significantly raises the prevalence of musculoskeletal disorders [15]. These disorders are associated with various risk factors, so the risk factors for shoulder disorders are not necessarily the same as those affecting the hand or elbow [16]. Ergonomic interventions are among the recognized methods for preventing these disorders [12]. Thus, the initial action to reduce the risk of MSDs symptoms in employees is conducting assessments and analyses of their postures at workstations, which is achieved by evaluating individuals' positions in these stations [17]. Influential risk factors include physical factors (such as improper and fatiguing postures), hand movements, vibrations, as well as organizational and psychological factors like stress, environmental conditions (such as temperature), and individual factors that independently influence musculoskeletal disorders, with the combination of these factors potentially increasing the risk of MSDs [18, 19]. While ergonomic factors play a significant role in the development of MSDs, environmental conditions such as high temperatures can also exacerbate this risk [18, 19]. Thermal stress can lead to fatigue, reduced concentration, and changes in body movement, all of which can increase the risk of MSDs[20]. Additionally, thermal stress is a significant physical hazard in many industries. Exposure to high temperatures among workers engaged in processes with elevated heat, such as smelting and foundry factories, glass industries, and tire manufacturing is common and can lead to adverse effects such as heat exhaustion and neuro-physiological disorders [20, 21].

Exposure to high heat can cause changes in blood flow, inflammation of joints and muscles, and a decreased pain threshold. These factors can exacerbate MSD symptoms in individuals who are already at risk [22, 23]. Particularly in the tire manufacturing process, substantial heat is generated during mixing, milling, and vulcanization stages, which can affect the health of employees. A study conducted by Lee in the tire industry emphasized that temperature should be considered a serious risk factor [22]. It has also been shown that individuals facing high thermal stress have a 2.4 times greater likelihood of musculoskeletal issues compared to those not exposed to such conditions [23].

Various indices have been proposed to assess exposure to thermal stresses in work environments. The Wet Bulb Globe Temperature (WBGT: Wet Bulb Globe Temperature) index is one of the most important of these indicators, aligning with ISO 7243 standards and widely used for controlling thermal stress in military, industrial, and even sports settings[24].

While many studies have examined the separate effects of ergonomic factors and thermal stress on worker health, few studies have investigated the combined effects of these two factors on MSDs [24]. In particular, this issue has received less attention in the tire manufacturing industry, where workers are simultaneously exposed to ergonomic and thermal stressors. Therefore, the present study was designed and implemented to examine the combined effects of thermal stress and postural stress on strain indices among employees working in a tire manufacturing company.

## MATERIALS AND METHODS

### *Participants*

This descriptive-analytical (cross-sectional) study was conducted in 2024 on personnel working in a tire manufacturing factory in Tehran, who performed physical tasks such as pushing, carrying, and manually moving loads. The inclusion and exclusion criteria for this study included a minimum work experience of one year, no history of musculoskeletal disorders or cardiovascular diseases, no history of heart attack, no musculoskeletal injuries resulting from accidents, and no use of medications affecting heart rate (such as propranolol) and antihypertensive drugs.

Employees were divided into two groups based on their exposure to postural stress and thermal stress. The first group consisted of workers who faced only postural stress, while the second group included workers who were exposed to both postural stress and thermal stress exceeding the permissible limits recommended by the American Conference of Governmental and Industrial Hygienists (ACGIH), specifically when heavy work constituted 25 to 50 percent of their working time (WBGT = 29). Additionally, office workers who were initially assessed and found not to be exposed to thermal stress beyond the standards recommended by ACGIH for administrative occupations, as well as those not facing postural stress from repetitive tasks and rapid movements, were selected as the control group.

Based on the study objectives, the types of variables, and the statistical methods required for data analysis, a

total of 147 participants were randomly selected, with 49 individuals in each group, considering a confidence level of 95% and a power of 90%. The sampling method used in this study was simple random sampling from among all employees in the factory.

The exclusion (drop-out) criteria during the study included unwillingness to continue participation, being transferred to another job position that altered their exposure category, taking medical leave exceeding two consecutive weeks, or starting medications that affect cardiovascular or musculoskeletal function during the study period.

This study has a code of ethics (IR.IUMS.REC.1397.044) from the Ethics Committee of Iran University of Medical Sciences.

### *Data collection*

Initially, demographic and organizational information was collected using a questionnaire that included questions about age, gender, height and weight (to estimate the Body Mass Index or BMI), work experience, marital status, and employment status. Additionally, heart rate and blood pressure measurements were taken. To assess the postural status of the participants in the study, the Rapid Entire Body Assessment (REBA) method was utilized.

This method is part of observational techniques for assessing workers' exposure to ergonomic risk factors associated with musculoskeletal disorders, introduced by Higante and McAtamney [25]. It features high sensitivity, ease of use, and requires minimal equipment and tools [26]. This method has been widely employed to evaluate postural issues across various occupations, including industrial and healthcare jobs, tire manufacturing, construction, food processing, and packaging industries[27]. In this method, different body parts are categorized into two groups: Group A (including the torso, neck, and legs) and Group B (including the forearms, upper arms, and wrists). The final REBA score is derived from the combination of the scores for exertion, hand load coupling, and activity type with scores from Groups A and B. The risk levels are classified into five categories: negligible (REBA score: 1), low (REBA score: 2-3), medium (REBA score: 4-7), high (REBA score: 8-10), and very high (REBA score: 11-15) [25]. Acceptable validity and reliability of this method have been reported in many studies[25, 28].

Nordic Musculoskeletal Disorders Questionnaire: The Nordic Musculoskeletal Disorders Questionnaire

is a powerful tool for determining the prevalence of musculoskeletal disorders, dividing the human body into nine anatomical regions. The validity and reliability of this questionnaire have been confirmed in various studies, including Persian-language studies [29-31].

**Strain Index (SI):** The Strain Index quantifies exposure to risk factors for musculoskeletal disorders affecting the hands and wrists. This index assesses the intensity of exertion, duration of effort, frequency of exertion per minute, hand and wrist posture, speed of work, and shift length. Research by Moor and Grag in 2017 showed that the higher the SI for an operator, the greater the likelihood of injury [32].

The Strain Index is a semi-quantitative method for measuring musculoskeletal disorders of the upper extremities, particularly suited for single-task jobs, with well-established validity and reliability in various studies [33]. This method involves the observational and quantitative measurement of six variables, with the resulting number categorizing jobs as “safe” or “hazardous,” exposing workers to ergonomic risk factors. The six variables include: intensity of effort, duration of force application, frequency of force, wrist/hand posture, task speed, and duration of task performance throughout a workday.

Intensity of effort is measured using the Borg Rating of Perceived Exertion. To obtain the Borg index value, a percentage of the maximum perceived effort during an activity is calculated. Then, other items are estimated based on the observer’s understanding of the operator’s work, and the Strain Index score is determined. The Strain Index software version 2001 was developed by Thomas, Bernard, and Walton, with an output index value of less than 3 classified as “safe,” between

3 and 5 as “questionable (uncertain),” between 5 and 7 as “relatively hazardous,” and above 7 categorized as “dangerous” [34]. To record heart rate, the Polar exercise test device was used, and a digital sphygmomanometer was utilized for measuring blood pressure.

### Statistical analysis

After data collection, the normality of quantitative data was examined using the Kolmogorov-Smirnov test, confirming that the data was normally distributed. Therefore, parametric tests were employed for data analysis. It is noteworthy that data analysis was conducted using SPSS version 16.

## RESULTS

In this study, the majority of participants were married (56.79%), and their employment status was mostly as contractors (48.82%) (see Table 1). Additionally, all participants were male. More than 55% of the individuals studied had less than 10 years of work experience.

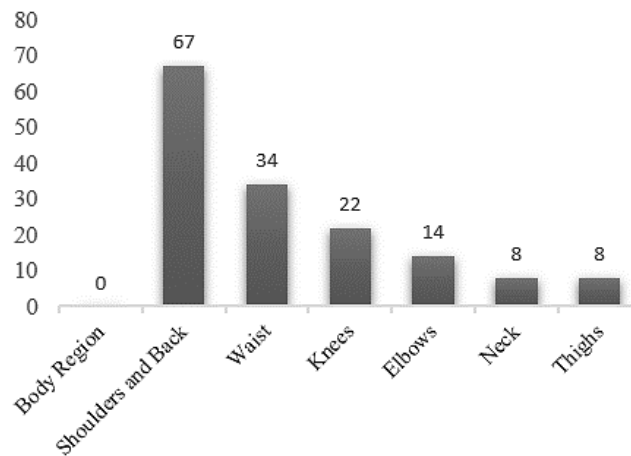
The analysis of variance test showed that there are significant differences between the exposure group and the control group in terms of mean age, work experience, and heart rate (Table 1) with p-values of 0.032, 0.046, and 0.001, respectively. However, the differences in BMI and systolic and diastolic blood pressure were not significant. In examining the marital status of the three selected groups in the study, the Chi-square value obtained from comparing the frequencies of the three groups (“control,” “exposure to postural stress (Group 1),” and “combined exposure (Group 2)”) for the two categories of the marital status variable was 5.717, which is not statistically significant ( $p = 0.57$ ).

**Table 1.** Demographic Information of Study Participants

Variables	Classification	Frequency (%)
Age (years)	30 <	41.2%
	31-39	44.3%
	40 >	14.5%
Work Experience (years)	10 <	55.68%
	11-20	40.2%
	21 >	4.12%
Marital Status	Single	18.4%
	Married	79.6%
	Other	2.04%
Employment Status	Official	3.9%
	Contractual	14.3%
	Contractor	82.48%

**Table 2.** Comparison of Heart Rate among the Three Study Groups

Group	Minimum	Maximum	Mean	Standard Deviation of Mean	Test Statistic	P-Value
Exposure to Postural Stress	60.00	106.00	81.77	1.638		
Combined Exposure to Postural Stress and Heat	63.00	128.00	84.46	2.064	8.283	<0.001
Control	59.00	94.00	75.24	1.096		



**Figure 1.** Prevalence of MSDs in different parts of the body

Therefore, the groups studied did not show significant differences regarding marital status. Using the Analysis of Covariance (ANCOVA), it was observed that age does not have a confounding effect on the relationship between the strain score and the type of group being examined (p-value = 0.33). One reason for this may be the limitation on the age range of the participants in the study. Additionally, work experience and systolic blood pressure did not have a confounding effect on the strain index either, with p-values of 0.79 and 0.240, respectively.

More than 60% of production line workers experienced some form of musculoskeletal disorders over the past nine months (60.7%). The highest prevalence of pain was reported in the back and lumbar region (66.6%), while the lowest prevalence was observed in the neck and thigh areas (approximately 8%). In Figure 1, the prevalence of musculoskeletal disorders among the studied employees is illustrated.

The average score of the Strain Index in the control group was  $0.97 \pm 0.10$ , in the “Postural Stress Exposure” group it was  $32.80 \pm 4.212$ , and in the Combined Exposure group, it was  $33.50 \pm 2.801$ . The difference in the Strain Index scores among the three groups was found to be significant using analysis of variance (ANOVA) ( $P < 0.001$ ), indicating a difference in the average Strain Index scores among the groups. The

Tukey post hoc test showed that the postural group and the combined group had a significant difference in Strain Index scores compared to the control group ( $P < 0.001$ ), while no significant differences were observed between the two experimental groups ( $P = 0.985$ ).

A significant direct correlation was observed between the Strain Index and the Wet Bulb Globe Temperature (WBGT) Index using Pearson’s test ( $p < 0.001$  and  $r = 0.336$ ). Additionally, in the Postural Stress Exposure group, this direct and significant relationship was also found ( $P = 0.02$  and  $R = 0.331$ ). However, in the “Combined Exposure” group, no significant correlation was observed between these two variables ( $P = 0.53$  and  $R = -0.092$ ). The results of the Pearson test indicated that as the SI score increases, the REBA score also increases, which signifies a significant direct correlation ( $P < 0.001$  and  $R = 0.646$ ). A significant direct relationship between these two variables was also observed in both study groups. Additionally, using the Chi-square test, a significant direct correlation was found between the score related to the hand group in the REBA posture assessment and the overall SI index score, as well as the score related to the wrist in the Strain Index ( $P < 0.001$  and  $\chi^2 = 18.976$ ).

In the study, examining the total REBA score in the three selected study groups, the following results were obtained using the Chi-square test. The Chi-square

**Table 3.** Comparison of Strain Scores in the Three Study Groups

Group	N	Min	Max	Mean	Mean Standard Deviation	Test Statistic	P-Value
Postural Stress Exposure	49	2.30	117.00	32.80	4.212		
Combined Exposure to Postural Stress and Heat	49	6.80	78.00	33.50	2.801	40.461	> 0.001
Control	49	0.10	3.00	0.97	0.104		

The levels of the Strain Index in the study groups are presented in Table 4.

**Table 4.** Levels of SI (Strain Index)

SI Level	< 7	7-5	5-3	> 3
Dangerous	90%	6%	4%	-
Almost Dangerous	100%	-	-	-
Uncertain	-	-	4%	96%
Safe	-	-	-	-

**Table 5.** Levels of REBA in the Three Study Groups

Final REBA Score	Risk Level	Group			Test Statistic	P-value
		Control	In Postural Stress Exposure	In Combined Postural Stress and Heat		
1	Negligible	20.4				
2-3	Low	75.5	12.2	6.1		
4-7	Moderate	4.1	59.2	57.1	105.331	> 0.001
8-10	High		24.5	26.6		
11-15	Very High		4.1	10.2		

value obtained from the comparison of frequencies among the three groups ("Control," "Postural Stress Exposure (Case 1)," and "Combined Postural Stress and Heat Exposure (Case 2)") in two categories of the total REBA score was 105.331, which is statistically significant ( $p < 0.001$ ). Therefore, the study groups had a significant difference in terms of the total REBA score.

## DISCUSSION

The tire manufacturing industry is one of the industries where a significant number of workers are exposed to postural stresses resulting from tasks such as pushing, pulling, lifting, and moving materials, among others. Based on the findings of this study, the highest prevalence of musculoskeletal disorders (MSDs) was observed in the lumbar and back regions, which aligns with the results of previous studies conducted in the tire manufacturing industry [11, 35, 36]. Furthermore, the prevalence of musculoskeletal disorders among the studied workers is higher than that in the general population of Iran [11], highlighting the necessity of addressing postural stress in tire manufacturing industry workers. While poor working conditions (e.g.,

standing work, manual load handling, and awkward postures) are likely contributors to low back pain, it is important to acknowledge potential confounding factors such as age, BMI, and pre-existing medical conditions among workers, which were not explicitly controlled for in this study. Future research should incorporate these variables to establish causality more robustly.

The high prevalence of low back pain can be attributed to unsuitable working conditions in tire production, such as standing work, poor posture, manual handling and moving of loads, bending and twisting of the back, and working in a squatting position [11, 36, 37]. These conditions are frequently observed in loading, storage, conveyor, calendaring, curing, and service areas. Each of the above factors can increase the risk of developing low back pain. The variation in pain experience among different body parts may be due to differences in job responsibilities, various working conditions, available facilities at the workplace, and organizational factors. However, overall, the high prevalence rates indicate the inappropriateness of postural conditions during work.

In this study, the assessment of workers' posture

using the REBA method showed that most of the subjects were at a moderate risk level (REBA score: 4-7), which aligns with the findings of Samai and colleagues in a tire manufacturing industry [35]. In another study that utilized the QEC assessment method in the tire industry, the analysis indicated that most individuals were at a high-risk level [11]. The discrepancy in risk levels between REBA and QEC may stem not only from methodological differences but also from variations in the specific tasks assessed. For instance, QEC emphasizes upper limb and repetitive movements, whereas REBA evaluates whole-body postures. Differences in task demands (e.g., load weights, repetition frequency, or workstation design) across studies could further explain these findings. Future comparisons should ensure task homogeneity to isolate methodological effects.

A comparison of the strain scores between the study groups revealed a significant relationship between postural stress and the strain index. The Spearman correlation coefficient indicated that as the REBA risk level increased, the strain index also increased. In the study by Zohrevand Nejad and colleagues [38], a significant relationship was reported between the strain index and QEC, and in the study by Roushani [39], a significant relationship was found between the strain index and the RULA method, which corresponds to our findings using the REBA risk assessment method. According to the results obtained, a very high correlation was observed between the upper limb scores from the REBA method and the strain index. This correlation suggests that the strain index can be used as a complementary and reliable test in relation to the assessment of upper limb posture conducted using the REBA method.

#### **Study Limitations and Future Research**

While this study provides valuable insights, several limitations should be noted. First, the sample was limited to workers from a single industry, which may restrict generalizability to other sectors. Second, job variability (e.g., differences in task duration, frequency, or workstation ergonomics) was not fully accounted for, potentially influencing risk assessments. Third, self-reported pain measures are susceptible to recall and response bias; incorporating objective measures (e.g., electromyography or clinical evaluations) could strengthen future findings. Although the impact of thermal stress on the strain index was not significant in this study (WBGT  $\leq$  29.3), examining higher WBGT levels (e.g.,  $>30$ ) in hotter climates or seasons is recommended.

## **CONCLUSION**

The findings of this study indicate concerning levels of strain among the employees of the tire manufacturing plant, generally ranging from “moderate” to “high-risk strain levels.” These conditions can have serious impacts on the health and well-being of the employees. The results obtained confirm a significant relationship between the level of strain and musculoskeletal disorders, particularly in the lower back and spine. It is crucial to note that the occurrence of these disorders can lead to decreased quality of working life among employees and an increase in absenteeism, ultimately resulting in high costs for employers.

Despite the notable correlation observed between the strain index and the final REBA score, the lack of a significant relationship between the strain index and WBGT suggests that other workplace factors may also influence strain levels. To mitigate these risks, targeted interventions such as ergonomic adjustments, enhanced training programs on safe work practices, and workload management should be considered. Moreover, implementing appropriate rest breaks and promoting proper hydration could help reduce thermal and physical stress.

Furthermore, future studies should investigate additional workplace factors, including workload intensity, rest periods, hydration levels, and ergonomic workstation design. Exploring how these factors interact with thermal stress and other environmental conditions can provide a comprehensive understanding of the determinants of musculoskeletal health. Such insights are crucial for developing effective ergonomic modifications and workplace policies to safeguard workers' health and enhance productivity.

#### **Acknowledgements**

This article is based on the results obtained from a master's thesis in Occupational Health at Iran University of Medical Sciences. We would like to express our heartfelt gratitude to the esteemed Vice Chancellor for Research and Technology at Iran University of Medical Sciences, as well as the management, health and safety officials of the tire manufacturing company studied, and all the hardworking workers who collaborated with us in conducting this thesis.

#### **Conflict of Interest**

The authors declare no conflict of interest.

#### **Funding**

This study was not supported by any funding.

#### **Author's Contributions**

Study Conception or Design: S Vosoughi, M Samadi Gol Gholab

Data Acquisition: M Samadi Gol Gholab, A Vosoughi

Data Analysis or Interpretation: J Abolghasemi

Manuscript Drafting: S Vosoughi, Z Mousavifard

All authors have approved the final manuscript and are responsible for all aspects of the work.

#### AI Statement

The authors confirm that no AI tools or services were used during the preparation of this work.

## REFERENCES

- Janwantanakul P, Pensri P, Jiamjarasrangsi W, Sinsongsook T. The relationship between upper extremity musculoskeletal symptoms attributed to work and risk factors in office workers. *Int Arch Occup Environ Health*. 2010;83(3):273-81.
- Saeedi E, Kordi Y, Gholami Fesharaki M, Kazemi SS, Adibi H. Effect of Ergonomic Principles Education on Temporary Musculoskeletal Disorders of Personnel in Hospital Service. *Int J Musculoskelet Pain Prev*. 2018;3(2):51-5.
- Li S, Guo J, Zhang X, Liu Y, Wang H, Chen L. Factors in Work-Related Musculoskeletal Disorders in Dentists: A Structural Equation Model. *Biomed Environ Sci*. 2025;38(5):639-43.
- Demissie B, Bayih ET, Demmelash AA. A systematic review of work-related musculoskeletal disorders and risk factors among computer users. *Heliyon*. 2024;10(3):e25033.
- Ağar A, Yeginoğlu G, Kızıltan B. The effect of ergonomics training given to office workers on musculoskeletal disorders and working postures. *Int J Occup Saf Ergon*. 2025:1-8.
- Rao S, Vandana R. Work-Related Musculoskeletal Disorders in Food Packing Workers: A Review of Prevalence and Workplace Factors. *RGUHS J Physiother*. 2025;5(1):14-21.
- Khadour FA, Khadour YA, Alawdi SA. Prevalence of Work-Related Musculoskeletal Disorders and Associated Factors Among Doctor of Physical Therapy in Syria: A Cross-Sectional Study. *Health Sci Rep*. 2025;8(5):e70767.
- Bhattacharya A. Costs of occupational musculoskeletal disorders (MSDs) in the United States. *Int J Ind Ergon*. 2014;44(3):448-54.
- Esen H, Hatipoğlu T, Fiğlali N. Analysis of working postures in tire production sector by OWAS method. In: *Proceedings of the World Congress on Engineering*; 2015 Jul 1-3; London, UK. p. 102-6.
- Abedini R, Choobineh A, Razeghi M, Ghaem H. Ergonomic risk assessment of lifting activities; a case study in a rubber industry. *Jundishapur J Health Sci*. 2013;5(1):35-44.
- Choobineh A, Tabatabaee SH, Tozihian M, Ghadami F. Musculoskeletal problems among workers of an Iranian rubber factory. *J Occup Health*. 2007;49(5):418-23.
- Denis D, St-Vincent M, Imbeau D, Jetté C, Nastasia I. Intervention practices in musculoskeletal disorder prevention: a critical literature review. *Appl Ergon*. 2008;39(1):1-14.
- Buckle P. Ergonomics and musculoskeletal disorders: overview. *Occup Med*. 2005;55(3):164-7.
- Amell T, Kumar S. Work-related musculoskeletal disorders: design as a prevention strategy. A review. *J Occup Rehabil*. 2001;11(4):255-65.
- Schneider E, Copesey S, Irastorza X. OSH in figures: work-related musculoskeletal disorders in the EU - facts and figures. Luxembourg: Office for Official Publications of the European Communities; 2010.
- d'Errico A, Caputo P, Haas S, Giacchino R, Costa G. Risk factors for upper extremity musculoskeletal symptoms among call center employees. *J Occup Health*. 2010;52(2):115-24.
- Marras WS, Karwowski W. Interventions, controls, and applications in occupational ergonomics. 2nd ed. Boca Raton (FL): CRC Press; 2006.
- Qu Y, Hu B, Chan P, Jia B, Fischer M, Gershon R, et al. The effect of camera location on observation-based posture estimation. *Ergonomics*. 2012;55(8):885-97.
- Widanarko B, Legg S, Devereux J, Stevenson M. The combined effect of physical, psychosocial/organisational and/or environmental risk factors on the presence of work-related musculoskeletal symptoms and its consequences. *Appl Ergon*. 2014;45(6):1610-21.
- Giahi O, Darvishi E, Aliabadi M, Khoubi J. The efficacy of radiant heat controls on workers' heat stress around the blast furnace of a steel industry. *Work*. 2016;53(2):293-8.
- Dehghan H, Mobinyzadeh V, Habibi P. The effects of heat stress on job satisfaction, job performance and occupational stress in casting workers. *Jundishapur J Health Sci*. 2016;8(3):e35614.
- Lee N, Chung JH, Kim H, Lee I, Kim Y, Park D, et al. Work environments and exposure to hazardous substances in Korean tire manufacturing. *Saf Health Work*. 2012;3(2):130-9.
- Bhattacharya A, McGlothlin JD. Occupational ergonomics: theory and applications. New York: CRC Press; 1996.
- Gaspar AR, Quintela DA. Physical modelling of globe and natural wet bulb temperatures to predict WBGT heat stress index in outdoor environments. *Int J Biometeorol*. 2009;53(3):221-30.
- Hignett S, McAtamney L. Rapid entire body assessment (REBA). *Appl Ergon*. 2000;31(2):201-5.
- Li G, Buckle P. Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. *Ergonomics*. 1999;42(5):674-95.
- Al Madani D, Dababneh A. Rapid entire body assessment: A literature review. *Am J Eng Appl Sci*. 2016;9(1):107-18.
- Stanton NA, Hedge A, Brookhuis K, Salas E, Hendrick HW, editors. *Handbook of human factors and ergonomics methods*. Boca Raton (FL): CRC Press; 2004. Chapter 4, Human factors and ergonomics methods; p. 27-38.
- Choobineh A, Lahmi M, Shahnavaz H, Jazani RK, Hosseini M. Musculoskeletal symptoms as related to ergonomic factors in Iranian hand-woven carpet industry and general guidelines for workstation design. *Int J Occup Saf Ergon*. 2004;10(2):157-68.
- Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, Jørgensen K. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon*. 1987;18(3):233-7.
- Ozgili G, Etemadi Z, Bakhtiari M, Bohlooli S. Musculoskeletal symptoms assessment among midwives, Hamedan, 2002. *J Gorgan Univ Med Sci*. 2006;8(1):52-8.
- Garg A, Moore JS, Kapellusch JM. The Revised Strain Index: an improved upper extremity exposure assessment model. *Ergonomics*. 2017;60(7):912-22.
- Stevens EM, Vos GA, Stephens JB, Moore JS. Inter-rater reliability of the strain index. *J Occup Environ Hyg*. 2004;1(11):745-51.
- Moore JS, Garg A. The strain index: a proposed method to analyze jobs for risk of distal upper extremity disorders. *Am Ind Hyg Assoc J*. 1995;56(5):443-58.
- Samaei S, Mostafaei M, Jafarpour H, Hosseini M. Effect of personal risk factors on the prevalence rate of musculoskeletal disorders among workers of an Iranian rubber factory. *Work*. 2017;57(4):547-53.
- Meksawi S, Tangtrakulwanich B, Chongsuvivatwong V. Musculoskeletal problems and ergonomic risk assessment in rubber tappers: A community-based study in southern Thailand. *Int J Ind Ergon*. 2012;42(1):129-35.
- Reid CR, Bush PM, Karwowski W, Durrani SK. Occupational postural activity and lower extremity discomfort: A review. *Int J Ind Ergon*. 2010;40(3):247-56.
- Nejhad NZ, Khavanin A, Vosoughi S. The Effect of Simultaneous Postural Stress and Noise Exposure on Strain Index Number Among the Machinery Women Aged 25-30 Years old in Gas Supply Parts Manufactories. *Health Scope*. 2015;4(2):e23070.
- Rowshani Z, Hosseini M, Mohammadi S, Safari S. Comparing RULA and Strain index methods for the assessment of the potential causes of musculoskeletal disorders in the upper extremity in an electronic company in Tehran. *Fez Med Sci J*. 2013;17(1):61-70.