Journal of Ergonomics & Advanced Research
Volume 4 | Issue 1

Research Article Open Access

Ergonomic Risk Hazard Assessment among Denim Washing Workers in the Ahmedabad Region

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Citation: Shreya Gupta, Pragati Jaiswal, Ettishri Rajput (2024) Ergonomic Risk Hazard Assessment among Denim Washing Workers in the Ahmedabad Region, J Ergon Adv Res 4(1): 101

Received Date: May 19, 2024 **Accepted Date:** June 19, 2024 **Published Date:** June 23, 2024

Abstract

Despite the apparel industry's fragmented and globalized nature, it remains a pivotal driver of economic development. The labor-intensive nature of garment work exposes workers to prolonged sitting and repetitive movements, resulting in negative consequences such as musculoskeletal disorders (MSDs), increased absenteeism, reduced productivity, higher costs, and accidents. Work-related diseases and injuries accounted for 1.9 million deaths in 2016, according to joint estimates from the World Health Organization (WHO) and International Labor Organization (ILO).The study aims to identify the ergonomic risk hazards associated with the denim finishing processes. The research draws on multiple sources, including case studies, literature reviews, to identify key factors for work related MSD. The study is exploratory in nature and uses a case study approach with structured data collection using personal interviews, participant's observation, and analysis of videos. Five denim washing units have been used as a representative sample for the industry in the Ahmedabad region. The results highlight the physical hazards associated with the nature of work in the denim washing laundries.

Keywords: Ergonomics; apparel industry; garment workers; musculoskeletal disorders

Introduction

Apparel industry is one of the most fragmented industries, but it is also one of the most globalized industries [1] and it plays important role in the economic development process of countries [22]. Indian Garment industry maintains its distinctiveness with the support of a larger workforce, low-cost materials and low wages in comparison with other industries [2].

The garment industry is a labor-intensive industry [3, 4], forming 8.3% of the total trade in industrial materials in the world [5].The production process is manual work (e.g., design development, assembly, sewing, and finishing).

The garment-sewing operators' work is in delimited rooms and their posture is restrained by both the visual and manual aspects of the task [6]. In addition, the garment- sewing operators' work involves prolonged sitting positions and whole-day repetitive movement, and the rapid pace of the work leads to risk of fatigue and musculoskeletal disorders (MSDs) [7- 11].

Work related MSDs, low back pain and other health problems result in increased absenteeism and lost working time, adverse effects on labor relations, higher insurance and compensation costs, increased probability of accidents and errors, job transfer and higher turnover of workers, more scrap and decreased production, low-quality work and high administrative and personnel costs. [12, 16-18], which ultimately reduces productivity and increases cost to company.

If the MSK symptoms can be decreased by ergonomic measures like correcting body posture or choosing another type of work in the factory, this may improve the quality of work and life of garment workers [19]. With better work circumstances that are fitted to each garment worker, their quality of life would improve as well as their productivity [19]. Ergonomics management is valuable as a cost reduction, quality improvement, performance improvement and productivity-enhancing process.

Literature Review

Almost in all countries, garment industry face serious occupational health and safety challenges [20] and the scenario is also same for the India [21] and it plays important role in the economic development process of countries [22]. The work in garment industry is necessarily categorized as light work, but almost all tasks associated with garment assembly, ironing or finishing, exert static loads on the body [1]. India's garment industry is a one-trillion-rupee industry. In all, around 25% of the amount of its garment production is exported, leaving the remaining 75% for domestic use [23].

The garment industry is a labour-intensive industry [3, 4], forming 8.3% of the total trade in industrial materials in the world [5]. The production process is manual work (e.g., design development, assembly, sewing, and finishing). The garment-sewing operators' work is in delimited rooms and their posture is restrained by both the visual and manual aspects of the task [6]. In addition, the garment-sewing operators' work involves prolonged sitting positions and whole-day repetitive movement, and the rapid pace of the work leads to risk of fatigue and musculoskeletal disorders (MSDs) [7-11].

Ergonomics also play an important role in making the workplace as efficient, safe and comfortable as possible and at the same time enhance human performance. If work tasks and equipment do not include ergonomic principles in their design, workers may have exposure to undue physical stress, strain, and overexertion, including vibration, awkward postures, forceful exertions, repetitive motion, and heavy lifting [13]. In such a scenario it is most essential to design machines and environment with human factors in consideration, given the fact that an average Indian apparel industry worker spends anywhere between 48 and 60 h per week at the workplace [1].

MSDs are very common health problems in all over world and also a major cause of workplace disability [14]. Work-related muscle and nerve injuries, often work- related musculoskeletal diseases (WMSDs), can be extremely painful or completely incapacitating. WMSD's are not inevitable and can be prevented or at least delayed from becoming permanent disabilities if proper measures

are taken in time [1]. Most commonly affected body regions are the low back, neck, shoulder, forearm and hand [11]. Most of the work- related MSDs are cumulative disorders which result from exposures to high or low intensity repeated loads over a long period of time [15].

Work related MSDs, low back pain and other health problems result in increased absenteeism and lost working time, adverse effects on labour relations, higher insurance and compensation costs, increased probability of accidents and errors, job transfer and higher turnover of workers, more scrap and decreased production, low-quality work and high administrative and personnel costs. [12, 16-18] which ultimately reduces productivity and increases cost to company.

Low back pain (LBP), neck pain and other Musculoskeletal Disorders (MSDs) are the leading causes of years lived with disability (YLDs) [24]. LBP ranked highest in terms of disability (YLDs), and sixth in terms of Disability-adjusted life-years (DALYs) in the Global Burden of Disease 2010 Study [25]. Lower back pain (LBP) is the most common musculoskeletal disorder (MSD) affecting the adult population, with a lifetime prevalence of up to 84% [26, 27]. Age, sex, body mass index, work experience, working hours, lack of safety training, awkward working posture, work shift, prolonged standing, lifting heavy objects, sleeping disturbance, history of back trauma, previous medical history of musculoskeletal disorder, and lack of adequate rest interval at work were significantly associated with low back pain. [28] Cigarette smoking was also associated with LBP in some studies. [28] Factors such as job dissatisfaction, low social support from colleagues or supervisors, job stress/high workload, feeling little pleasure, sleeping disturbance, and depression were also implicated to be associated with LBP in different studies [28].

The causes of the disorders include inclined postures, repetitive motions, sustained or excessive force, contact stress, vibration, sustained work postures and other environmental factors. [29] Carpal Tunnel Syndrome, Muscle/ Tendon Strain, Tendonitis, Thoracic outlet Syndrome, Epicondylitis and Back strain are few of the MSDs. [29] The external risk factors include the external loads, the factors that influence the load, and those alter the individual's response to the particular load. [29] Musculoskeletal pain was most common among ironers, packers, and cutters, followed by sewers, quality control assistants, and supervisors and recorders [23]. Workers in the finishing sector had a somewhat higher perception of stress at work than those in other sections [23].

The occurrence of MSDs can affect the productivity, quality, performance, cost and the business of the firm [30]. A study has shown that the occupational hazard can cause human, social and economic losses [12]. Work-related diseases and injuries were responsible for the deaths of 1.9 million people in 2016, according to the first joint estimates from the World Health Organization (WHO) and International Labour Organization (ILO) [31].

It has been observed that with increasing age the prevalence of MSK symptoms is higher [19]. In the study, 72.2% of the workers 18-27 years of age had MSK complaints, but in those>47-year age all had MSK complaints (100%) [19]. Gender had no influence as we found little difference between male (75%) and female (77.6%) garment workers [19]. There was a significant relationship between the major MSK complaints and the types of work performed in the garment factory [19]. It was observed that the machines serger, zig zag and traveti are classified as high risk of developing msds, the postures assumed during the execution of the tasks were classified as poor or very poor, and that the jobs were classified only as reasonable [32].

Evidence showed that use of short breaks can minimize the risk and occurrence of low back pain [33]. The cost of work-related accidents, injuries and illnesses is considerable (3.9% of global GDP) whereas according to WHO and ILO, WRMSDs is an international health concern which is found as the third major reason of disability and early retirement [34]. Similarly, European Foundation for the Improvement of Living and Working Conditions (EUROFOUND) concluded that about 60 million workers reportedly suffer from WRMSDs in Europe [35].

A factory's operator productivity is dependent on various ergonomics factors in addition to the stringent rules governing how the equipment and machinery are organised at the workplace, such as: temperature and relative humidity of the air, speed of air currents, noise level, level vibrations and their directions, CO 2 level, brightness, radiation level, chromatic from the production hall,

ambient music and its volume [36]. The findings revealed an 85.8% prevalence rate and a robust link between WMSDs and depression. [23] Self- esteem, life satisfaction, work related stress and disability are the largest contributors to depressive symptoms among female garment workers. All these important predictors of depression were heavily affected by a worker's experience of IPV and WPV [37]

The various problems of a work place faced by industrial workers in general, are inadequate Illumination, excessive noise, temperature, relative humidity, CO^2 content, electromagnetic field intensity, chromatic, light intensity and ambient music that does not help in the interface between the operators and machinery [36]. Violence against women (VAW) is a well-recognized and serious social, human rights and public health problem [38, 39]. Intimate partner violence (IPV) was ranked 31st among the risk factors for the loss of global disability-adjusted life years in 2016 [40]. This creates a dissatisfaction of the operator in carrying out its function, causing professional problems, triggering with this medical leave [36, 41, 42].

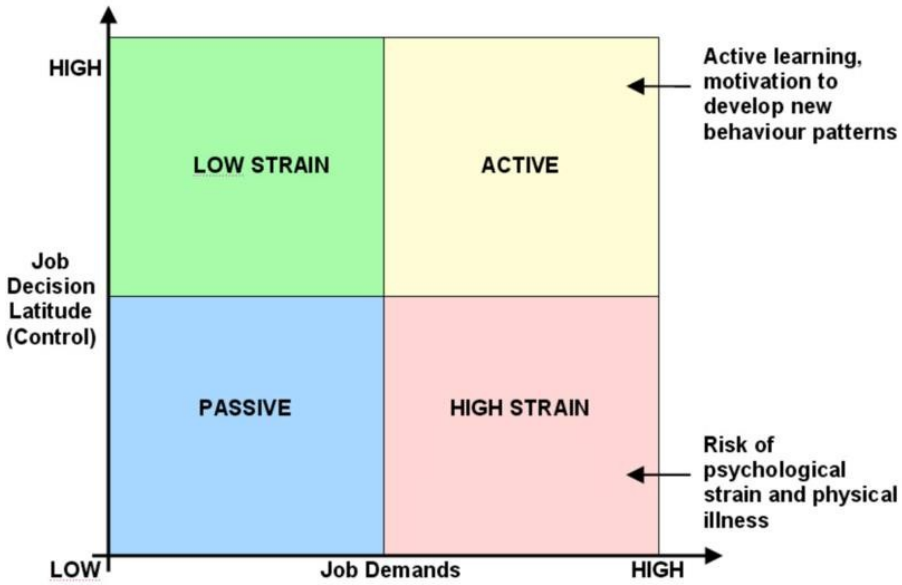


Figure 1: Job decision vs job demand (MSD) (Carr, 2008)

Workers/operators have very low decision-making authority at work, but there is a lot of pressure on them to produce higher-quality products, meet daily goals, and work overtime so that the company will benefit more from their efforts. As a result, there is an increased risk of psychological stress and physical illness, which further lowers productivity and absenteeism. In order to address the source of the low productivity, the organization instead pressures the worker/labor/operators to put more effort.

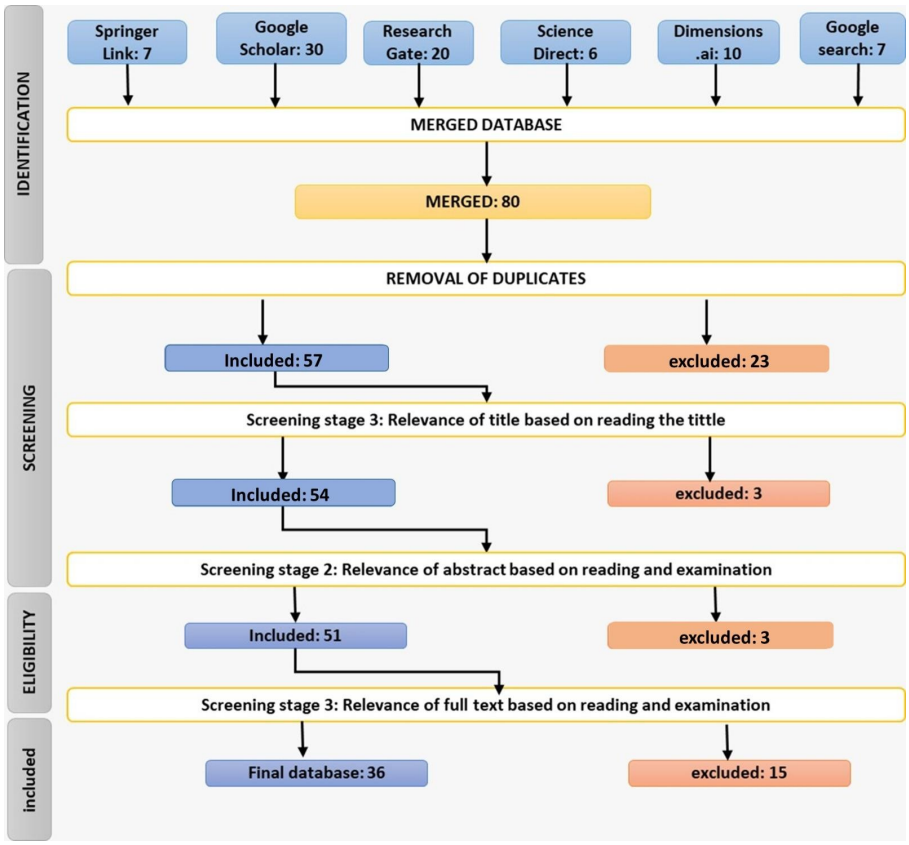
When evaluating the environment conditions in the garment enterprises, another leading factor is the negativity of the thermal comfort conditions. When "Thermal comfort" is mentioned, the factors such as temperature, humidity, and air flow rate come to the mind. These can be dangerous for those working in the establishment. Temperature arising from the employees, working machines, steam/electrical irons, press machines negatively affect the working conditions especially in the summer and reduces the working efficiency. Because of the failure in providing enough ventilation of the environment and air conditioning, thermal comfort is one of the leading factors affecting the work performance and occupational health in the environments where many people work [23].

Thus, it will be possible to increase the effectiveness of the employees and the quality of the work done as is specified in the studies of [43]. As indicated in the study carried out by [44, 45] injuries resulting from poor ergonomic conditions can be prevented with the design of physical working environment around the physical needs of individual employees [44, 45].

The complex job requirements, working conditions being out of physical and psychological limits, operators not fitting in the time available or the rhythm of work, job being insecure, conflicts at workplace can result in destructive and unpleasant stress at work

[46]. The Fatigue, monotony and circadian rhythm can influence the performance of the operator [47]. Another factor that plagues the apparel production industry is the lack of job rotation, thus forcing overuse/underuse of the certain muscles on a daily basis [1]. In such a scenario it is most essential to design machines and environment with human factors in consideration, given the fact that an average Indian apparel industry worker spends anywhere between 48 and 60 h per week at the workplace [1].

If the MSK symptoms can be decreased by ergonomic measures like correcting body posture or choosing another type of work in the factory, this may improve the quality of work and life of garment workers. [19]. With better work circumstances that are fitted to each garment worker, their quality of life would improve as well as their productivity [19]. In general, operators lack from knowledge on the musculoskeletal disorders and bone strength [29]. In such cases, providing them awareness on Musculoskeletal Disorders, training on bone strength improvement, frequent correction in their improper postures and supplementary recovery time for the muscle fatigue recovery would be more beneficial [48]. Ergonomics management is valuable as a cost reduction, quality improvement, performance improvement and productivity-enhancing process.



Summary review flow diagram

Figure 2: Literature Review segregation

Topic

Ergonomic Risk Hazard Assessment among Denim Washing Workers in the Ahmedabad Region.

Research Methodology

As part of our research methodology, structured questions were devised for both labor and supervisors. The qualitative data obtained from their responses was subjected to thematic qualitative analysis, facilitated by the use of MXQDA software. This analytical methodology entails the systematic identification, analysis, and reporting of patterns or themes within the data. Thematic qualitative analysis is a widely employed approach in qualitative research, enabling the revelation and understanding of inherent mean-

ings, experiences, or perspectives within the information collected from participants. The utilization of MXQDA software enhances our capacity for a comprehensive exploration of the qualitative data, aiding in the identification of significant insights and patterns in the responses provided by both labor and supervisors.

Search Strategy

(i) Search for published journal articles using international scientific databases including Dimension.ai, Google Scholar, Science Direct, and Taylor and Francis, ResearchGate

(ii) Search for published MSc/PhD thesis reports using Google, Google Scholar, and Dimensions.ai were retrieved by using search terms like ("prevalence" OR "ergonomics" OR "WMSD" OR "Garment industry") AND ("associated factors" OR "risk factors" OR "factors") AND ("low back pain" OR "environmental factors" OR "musculoskeletal disorder OR low productivity").

In the context of probability sampling, our research paper employs cluster sampling. This entails the classification of the population into subgroups based on variables such as gender, age, experience, education, and location. For our study, we specifically focus on Gujarat as the targeted location. There are about 7,000 denim garment manufacturers in Gujarat, with 70 per cent of them located in Ahmedabad. The rest are split among Surat, Rajkot, and Bhavnagar [49]. The main reason for the success of denim apparel manufacturers in Ahmedabad is the quality of the denim washing segment here, according to Arpan Shah, chairman (arbitration) and treasurer of the Gujarat Garment Manufacturers Association (GGMA) [49].Within Gujarat, we narrow down our study to the Ahmedabad region due to the presence of reputable denim industries and logistical convenience. Geeta Mandir, Narolgram and Naroda are the locations which are preferred for this paper. Subsequently, we conduct walk-in interviews to collect pertinent information for our research. The annexure, containing the questionnaire, is attached at the end of the paper.

Variables

- Work experience
- Working hours and shift
- Rest interval
- Working posture
- Medical history

Proposition

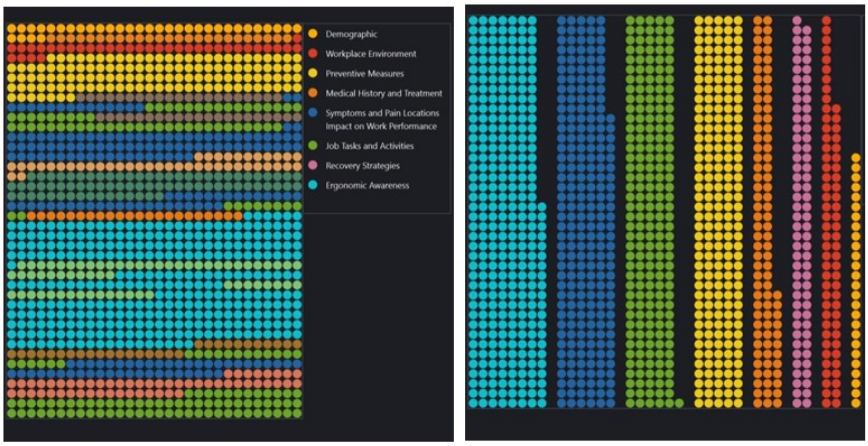
- Long working hours/Lack of adequate rest interval with respect to repetitive work/task is directly link to Work related musculoskeletal disorder.
- Lack of knowledge about correct posture while working repetitive task can be a leading reason for long term WMSD.

Analysis

In our research paper methodology, we employed thematic analysis and conducted the analysis using the MAXQDA software. We conducted our investigation at a 3 medium-scale industry named A, B and C, which employs four, ten and ten workers respectively for the whiskering process, achieving an average daily output of 2000 pieces. During our visit, we conducted systematic interviews with both labors and supervisors.

Figure 3: Color Codes generated

In our analysis, we discerned pivotal keywords consistently surfacing in interviews with both participant groups. Figure 3 reveals the identification of these keywords, forming the basis for code creation. Examining Figure 3 provides a visual representation of code frequencies, facilitating a clearer comprehension of their occurrence and significance. Notably, our investigation accords greater emphasis to ergonomic awareness (25.08%) and symptoms and pain locations (19.17%). This prioritization aligns with the logical connection between possessing ergonomic awareness, experiencing symptoms or pain, and the ability to implement preventive measures accordingly.



Document Portrait

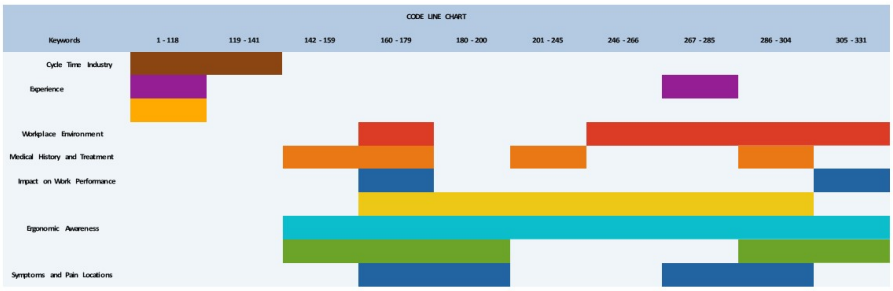
Figure 4: Frequency of codes

As seen in Figure 4, the coding-related MAXQDA document portraits has been created. The interview forms that were collected as a consequence of the interviews were evaluated to create the codes. A document portrait analysis was generated using the fundamental codes that the words, sentences, and paragraphs in the text were associated with during reading after the codes and interview forms were uploaded to the MAXQDA qualitative research. It can be noted that "Ergonomics awareness" and "symptoms" coding are predominate as a consequence of the interviews performed in accordance with the document portrait Displayed in Figure 4.

Word Cloud

Figure 5: word cloud (frequency of word)

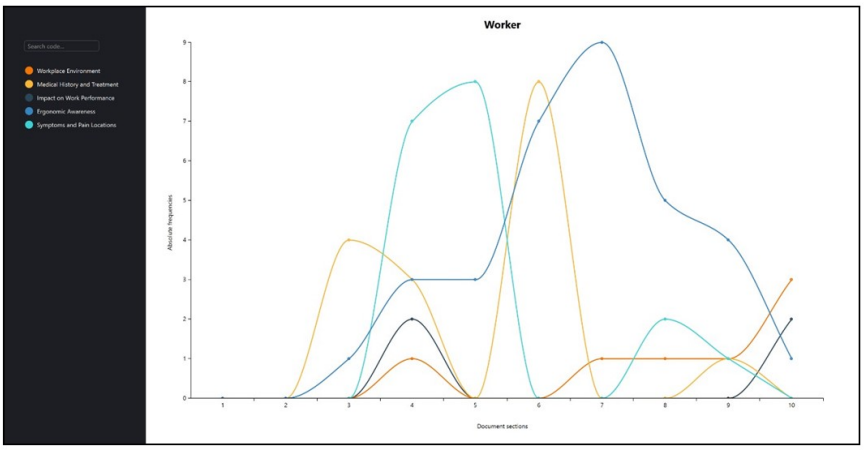
A visual representation of the most frequently occurring words in the data, making it easy to identify common themes and topics. In a word cloud, the size of each word is typically adjusted based on its frequency, so more frequent words appear larger and are more visually prominent. Most occurring word in our document was Operator, ergonomics, whiskering, posture, training, discomfort shown in figure 5.



Code Line

Figure 6: Code portion in document

Through code line analysis in MAXQDA, we discerned that specific types of words are associated with particular lines of text, revealing variations tied to different questions. For instance, in the context of ergonomics awareness, the term 'ergonomics' itself may not be explicitly mentioned, but the recurring theme suggests a general awareness of proper postures. On the topic of preventive measures, respondents frequently refer to taking breaks, especially for their wrists and lower back, indicating a proactive approach to maintaining health during work.



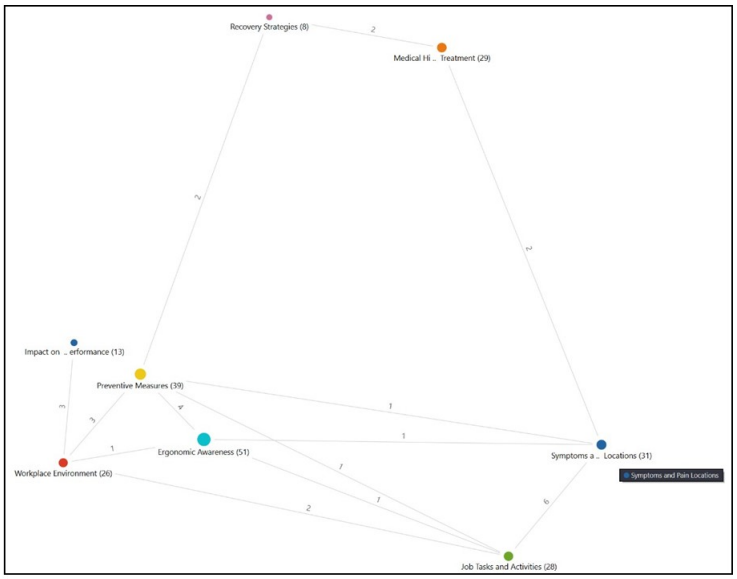
Code Trend

Figure 7: Code Trend Analysis

Code trend analysis has played a pivotal role in unravelling insights and trends within our qualitative research. By employing this method, we have achieved a more nuanced understanding of our research, validating and refining hypotheses through the examination of emerging patterns in response to specific factors or conditions.

The identified codes, including "Ergonomics awareness," "symptoms and pain location," "impact on work performance," "Medical history and treatment," and "workplace environment," consistently emerge throughout the document. This consistent presence underscores the central importance of these themes in our research context.

These recurrent themes signify a comprehensive exploration of ergonomic aspects, workers' experiences, and the broader implications on both health and work efficiency in the context of the denim whiskering process. Through code trend analysis, we have established a robust foundation for understanding the challenges and factors associated with this intricate process.



Coe Map

Figure 8: Code Map Analysis

Through Code Map analysis, we visually represent and explore relationships among codes in qualitative data analysis. Our findings reveal significant connections among specific codes. The primary association is observed between job task activity and pain

symptoms (code 6). Subsequently, another noteworthy link emerges between preventive measures and ergonomics measurements (code 4). Following this, a connection is identified between preventive measures and the work environment (code 3). Moreover, the work environment is found to be associated with the impact on work performance, also coded as 3. This structured analysis provides a comprehensive understanding of the interplay among various aspects of our qualitative data, shedding light on the intricate relationships within the studied phenomena.

REGION	GUJARAT
LOCATION	AHMEDABAD
AREA	NAROLGRAM, GEETA MANDIR, NARODA
SAMPLE SIZE	24 Worker, 2 Supervisor
NUMBER OF INDUSTRY	3
GENDER	MALE
INDUSTRY EXPERIENCE	1-15 Years
CYCLE TIME	20-40 sec
PER DAY	2000pcs
INJURIES	NOT SEVERE
EXTERNAL INJURIES	Skin protrusion between finger, scretched finger tip
PHYSICAL PAIN	Wrist pain, Lower back pain, Neck discomfort
PREVENTIVE MEASURES	Taking breaks in short time

Findings

Figure 9: Overview of research area

The research paper focused on an investigation conducted in three medium-scale industries, involving interviews with 24 workers and 2 supervisors. The study targeted individuals aged between 30 and 50, with all respondents being male, as the nature of the jobs investigated suggested a male-centric allocation. The participants had experience ranging from 1 to 10 years in the field of whiskering.

The duration of the whiskering process varied based on the complexity of the design and worker efficiency. For simpler designs like a top thigh pattern, the process typically took 20-50 seconds, while more intricate designs extended the processing time to 40-70 seconds. Break intervals, on average, ranged from 90 to 120 minutes per shift.

Operators involved in the denim whiskering process may experience mild discomfort in the forearm and wrist regions due to the repetitive nature of tasks, especially during the initial days of engagement. However, this discomfort tends to diminish over time, becoming less of an issue as the task becomes a habit. It's worth noting that although workers may not report immediate pain or discomfort, potential internal injuries may be a future area of study.

Figure 10: Tools for whiskering

Figure 11: Scratched Finger-tip

Industries addressed these ergonomic concerns by promoting practices such as regular breaks and stretching exercises. Notably, finger injuries, including scratched fingertips and skin protrusions, were identified as significant issues, contingent upon the design, time duration, and execution of the process. While these injuries were generally not severe or life-threatening, prolonged standing emerged as a major concern which cause lower back pain issues and neck pain. Low back pain (LBP), neck pain and other Musculoskeletal Disorders (MSDs) are the leading causes of years lived with disability (YLDs) [24]. LBP ranked highest in terms of disability (YLDs), and sixth in terms of Disability-adjusted life-years (DALYs) in the Global Burden of Disease 2010 Study [25]. Lower back pain (LBP) is the most common musculoskeletal disorder (MSD) affecting the adult population, with a lifetime prevalence of up to 84% [26, 27].

Result

In terms of the physical risk factors that contribute to the development of WMSD's, the following have been observed to be especially influential:

(1) Awkward Postures: Among the various aspects of work in the denim apparel industry, the denim finishing process stands out as an operation demanding extensive manual manipulation. This involves raised shoulders and restricted foot movement. In this industry, finishing equipment is often crafted in-house. Whiskering, the initial step in the process, shapes the design and its depth using specially designed equipment made with sandpaper and cardboard. These tools, tailored to specific design requirements, create three distinct shapes, as illustrated in figure 10. Workers select the appropriate equipment and commence the whiskering process, necessitating a standing position. Occasionally, workers may need to bend their knees, contingent on their height and the workspace provided.

The requirement for prolonged standing is unavoidable, with workers spending around three hours to complete at least 90-100 jeans (averaging 1 minute and 30 seconds per jeans), especially when intricate designs are involved. However, standing for such extended periods can lead to discomfort and pain in the legs. Moreover, if a worker consistently sustains full pressure on both legs due to job requirements, it can lead to knee pain, possibly giving rise to enduring problems like arthritis.

Figure 12: Worker posture in whiskering process

Figure 13: Worker posture during in whiskering process

(1) Facilitating Movement Difficulty: Examination of the observed posture reveals a consistent pattern of prolonged standing, elevated shoulders, repetitive right-hand movements, a bent neck and torso, and upper and lower arms engaged in manipulating the product for proper alignment in the designated design. The constrained movement of the feet, stemming from the stationary workstation, prohibits the operator from enjoying the convenience of placing a foot on a stand or periodically shifting weight between

feet throughout the 8–10-hour workday. This limited foot mobility not only diminishes the operator's reach but also introduces additional fatigue due to the non-neutral balance of the body. Consequently, muscles are prone to rapid fatigue even under minimal workloads.

Precision is crucial in the whiskering process, particularly in manual applications, which is prevalent in many medium-scale industries. This method predominantly relies on handwork, where the movement of the hands plays a defining role in shaping the design. Operators utilize their fingers to apply pressure and control the tools for creating designs, with the amount of pressure varying based on the type of design. It is worth noting that increasing force on the fingertips significantly heightens the risk of cuts and protrusions, particularly in the first and middle fingers.

Physical risk factors		
S.no.	Type of MSD	Risk factor
1	Neck MSD	Static awkward neck posture / Stress due to neck bending
2	Elbow MSD	Stress on the elbow due to force and repetition
3	Carpel tunnel syndrome	The combined risk factors involve force and repetition resulting from the stress exerted on the fingers to uphold the intricacy of the design.
4	Hand/wrist (tendinitis)	The combined risk factors / High repetition/ Forceful hand- wrist exertion
5	Finger MSD	Skin protrusion/Scratch at finger tips due to use of sand paper as a tool
6	Low back MSD	Bending and twisting (akward postures) / Static work posture

Figure 14: Physical risk factor

(1) Constricted Mobility: The design of the whiskering workstation has undergone minimal modifications over the years, although efforts to enhance it cannot be disregarded. Research on postural adaptation among standing workers recommends modifications to workbenches for standing tasks, emphasizing a trade-off between neck and trunk flexion in adapting to task distance. Furthermore, standing posture is greatly influenced by foot positioning. The current configuration of whiskering equipment, however, constrains foot movement, diminishing the operator's reach and comfort during extended periods of standing, spanning 8 to 10 hours.

Conclusion

A literature review shows that garment workers, particularly those involved in sewing, cutting, and finishing operations, suffer from significant musculoskeletal (MSK) symptoms. MSK complaints are prevalent in this population, causing considerable suffering and disability. The presence of MSK complaints is closely related to the nature of the work performed.

Garment workers C garment industry. Therefore, it is essential for garment authorities to develop preventive ergonomic strategies to address these issues effectively. The general quality of life of garment workers can be improved, which will increase the quality and productivity of their job.

Additionally, these measures will have a positive impact on the economy of India. In conclusion, this research delved into the intricacies of denim whiskering processes within medium-scale industries, shedding light on the experiences of operators and supervisors. The findings underscored the nuanced nature of the whiskering task, revealing variations in processing times based on design

complexity and worker efficiency. The ergonomic implications were evident, with operators encountering mild discomfort in the forearm and wrist regions, ultimately subsiding as the task became routine. The hypothesis is substantiated, as insufficient awareness of proper posture during repetitive tasks, prolonged standing in a fixed position, and bending the body during the process, coupled with pressure at the fingertip, emerge as primary contributors to long-term Work-Related Musculoskeletal Disorders (WMSD). These disorders include conditions such as lower back pain, neck discomfort, wrist issues, and mild skin protrusions between the fingers, albeit not of a severe nature.

However, the study brought attention to potential internal injuries that may go unnoticed, despite the absence of immediate pain or discomfort reported by workers. This revelation suggests a critical area for future research, emphasizing the importance of delving deeper into the long-term health implications of engaging in repetitive tasks like denim whiskering.

The paper also highlighted industry responses to ergonomic concerns, emphasizing practices such as regular breaks and stretching exercises. Finger injuries, particularly scratched fingertips and skin protrusions, were identified as significant issues, highlighting the need for continued attention to occupational safety measures.

A notable concern that emerged was the impact of prolonged standing on operators, leading to lower back pain and neck discomfort. The inflexibility of workstation height was identified as a potential obstacle, emphasizing the necessity of addressing ergonomic issues, especially in the context of varying individual worker heights.

In essence, this research not only contributes valuable insights into the denim whiskering process but also sets the stage for future investigations into the broader implications for worker health. The ergonomic challenges identified underscore the importance of industry adaptations and further research to ensure the well-being of workers engaged in such tasks.

Future scope

The proposition is substantiated, as insufficient awareness of proper posture during repetitive tasks, prolonged standing in a fixed position, and bending the body during the process, coupled with pressure at the fingertip, emerge as primary contributors to long-term Work-Related Musculoskeletal Disorders (WMSD). These disorders include conditions such as lower back pain, neck discomfort, wrist issues, and mild skin protrusions between the fingers, albeit not of a severe nature.

A potential avenue for future research lies in the observation that operators engaged in the denim whiskering process may initially encounter mild discomfort in the forearm and wrist regions due to the repetitive nature of their tasks. Despite this discomfort diminishing over time as the task becomes routine, it is important to highlight that workers might not immediately report pain or discomfort, raising the prospect of investigating potential internal injuries in subsequent studies.

Furthermore, the prolonged standing associated with the whiskering process has emerged as a significant concern. The inflexibility of workstation height, which cannot be adjusted, poses a potential hindrance to performance, especially considering the variations in individual worker heights. Consequently, the necessity of addressing these issues, particularly in relation to workstation height, has been identified as essential for effectively mitigating potential ergonomic challenges within the whiskering process—an area warranting further exploration in future studies.

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