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Original Article

Redesign of Workspace Through an Ergo-Lean Model to Reduce Musculoskeletal Disorders in SMEs In the Clothing Accessories Sector

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Abstract - *Currently, the textile and clothing industry contributes 2% to the global annual GDP and generates more than 57 million jobs worldwide. In South America, a country with a high market share in the textile sector in Peru, whose industry is the objective of this research due to its lack of studies in the accessory sector of clothing. Musculoskeletal disorders are the most common and leading cause of injury and disability in workers and in the clothing industry; it is due to the handling of materials that involve machinery with a high rate of repetition of work by operators. This article aims to reduce the percentage of Musculoskeletal Disorders (MSDs) by redesigning workstations and using combined ergonomic tools together with Lean tools so that, in addition to giving focus to workers, a different way can be found to add value to the process and improve productivity. A 71.85% decrease in MSDs was achieved in the sewing and cutting area, as well as a decrease in absenteeism by 20.73%, along with savings of S /. 505.72 per year.*

Keywords — *Clothing, Ergonomics, Lean, Musculoskeletal Disorders, Workspace.*

I. INTRODUCTION

The textile and clothing industry is a very important sector for global markets, contributing 2% of the world's annual gross domestic product (GDP) and made up of more than 57 million jobs worldwide, of which 24 million are from the confection sector only [1]. It is estimated that spending on clothing and footwear in Latin America will register a growth of 7.2%, remaining constant in the next 5 years, reaching the figure of 220 billion by 2021[2].

Peru is the largest exporter of clothing in South America, thanks to well-differentiated raw materials such as the fibers of its camelids, alpacas, llamas, and vicuñas, and its Pima and Tanguis kinds of cotton [3]. In this research, the high impact that this sector can have on a country's economy and its growth, in this case, located specifically in Peru, is taken into account. Precisely for Peru, this sector is also of great contribution, being the manufacturing sector 12.5% of the national GDP and the textile sector comprising 7.9% of the participation of the manufacturing sector based on the year 2020 and conforming around 398 thousand positions work nationwide [4]. Taking into account the year 2020, we can say that the previous figures are still low compared to previous years due to pandemic issues; since 2019, there has been a significant drop of 11.1% in the percentage variation of Peru's GDP [5].

Even so, prior to these events, exports of textile clothing, except leather and leather garments, had an increase of 7.9% that contributed to the increase in national exports in 2019, indicating a good previous path in the national participation of this sector [6]. The Minister of Production, José Salardi, had expressed his expectations for 2020 prior to the pandemic, indicating that it was expected to reach an increase of 5% in exports from the sector and reach US $ 2 billion in national exports by doing so [7]. These results demonstrate the great importance and participation of the clothing sector in Peru, making its study the most important due to its high value in order to reactivate the economy.

In a common labor force of an industrialized business, musculoskeletal symptoms (MSSs) are the number one reason for occupational disabilities and injuries[8]. From repetitiveness leading to repetitive strain injuries (RSI) to more long time developed work-related musculoskeletal disorders (WMSDs) [9]. The garment industry is one of high risk on occupational accidents as material handling and use of machinery is generally part of all processes, these being with a high volume of repetition and tension for muscles. It is only natural to see factors that cause WMSDs which are injuries or disabilities that affect the muscles, nerves, or tendons[10]. Today, it is one of the biggest work-related health problems having 2.2 million deaths a year on related diseases and accidents[1].

Another research carried out in the United States identified a problem of productive times in relation to mild pain that would be the main signs of musculoskeletal disorders, taking into account KPIs of absenteeism, performance after symptoms, and costs due to loss of productive time [11].

As mentioned before, it is important within the textile sector to ensure the health of workers and to find a way to keep them comfortable in their work while maintaining productivity[12]. To solve the previous problem, the application of combined ergonomics tools is sought together with lean tools so that, in addition to giving focus to the workers, a different way can be found to add value to the process and improve productivity.

The ergonomics tools analyze anthropometry and the work environment, making part of the research the RULA, REBA, and NIOSH tools. The lean tools to be used are based on the Kaizen method, of which the use of the 5S stands out to determine the added value that can be generated by doing an analysis. In the reviewed literature, applied cases can be found in which the ergo-lean model is incorporated, demonstrating its effectiveness. [13]. Even so, there is a need for more information regarding this model in the textile sector, specifically in Latin America, raising a need to continue the investigation.

The research article is divided into eight parts: Introduction, Literature Review, Innovative Proposal, Validation, Discussion, Conclusions, and References.

II. LITERATURE REVIEW

A. Musculoskeletal disorders in the textile sector

In the manufacturing sector, a very common problem is the presence of musculoskeletal disorders, causing workers to have low productivity or increasing the percentage of absenteeism in companies. The articles reviewed in this work show the high prevalence and impact on health and the economy of the manufacturing industry, specifically the textile industry. In these articles, a very high index of permanence was found in third world countries where similar percentages of permanence are seen by continent, and in none of these cases, an implementation of ergonomic tools was carried out, indicating a priority to costs to the health of the workers.

The results of the articles show that the highest percentages of the presence of symptoms of musculoskeletal disorders are found in Africa and Asia, where there are maximum percentages of 80% and an average 55% presence of these symptoms in workers in the sector [14]. As such, it was found that the workers who have the greatest impact in the manufacturing industry are female when they are given jobs with high muscular impact, which is why the number of women in the area is small [15]. In one case, the economic impact of the presence of an ergonomic model of a plant for production lines in the textile sector was seen using a simulator, which resulted in a considerable reduction in material handling costs and time lost due to unproductivity and 22.92% and 34.01% improvement respectively [16]. Finally, an important factor that demonstrates the impact worldwide is the high influence of the absence and overtime pay factor found in the Bangladesh study, which shows the monthly average of the equivalent of $ 190 a month average per garment company whose sum is equivalent to 3% of the country's national sales [15].

This way, we can see how important it is to consider the symptoms of musculoskeletal disorders in the textile sector so that productivity can be exploited at a higher level and preserve the health of the millions of workers that make up the sector worldwide.

B. Ergonomics

The term ergonomics refers to the science that analyses the environment of a worker regarding the effect on its abilities [17]. Anthropometry is a subtopic of ergonomics, which contributes to it identifying inappropriate body dimensions and postures, leading to the prevention of MSSs. Another related subtopic, biomechanics, studies the biological system and its functions based on the bodies dimension and structure[18].

The application of ergonomics has been relevant in situations of low efficiency by workers due to the discomfort generated by bad postures in the work area. In a first study, low productivity and a delay in the manufacture of the products are observed due to the prevalence of musculoskeletal problems. An application of collaborative industrial robots was proposed as an alternative solution to ergonomic problems that can improve both LM and ergonomic conditions. With the advent of Industry 4.0, the level of automation for manufacturing workstations has increased. New technologies allow production to be more efficient and time flexible on customization, avoiding any up cost or competitive loss[19]. In a second study, a low level of efficiency and well-being of workers was observed due to a poor condition of a work area. As an alternative solution, the ErgoSMED and 5S Audits tool was implemented, improving productivity as well as setup time by reducing a 50% and getting a score increase of 51% through the implementation of the areas of Continuous Improvement, Physical Ergonomics and Operations and Processes[20]. In another research, high downtime and low productivity were identified in manufacturing companies. As a solution, a time study was carried out with a stopwatch, the application of the RULA and REBA tools, finally, the DOP was used to identify the operations and times in seconds that companies require. Downtime reduced by 41%, only required 50% of available labor and increased productivity by 40%[21].

The analysis of the previously explained studies is related to the problems encountered since they originate in an inadequate posture due to the bad habits that are generated at the time of carrying out their task. In addition, the tools that are used as a model of solution also keep a synergy since all these problems that originated have relevance with ergonomics.

C. Lean Manufacturing

In order to reduce exposure to physical risk factors, it is suggested to implement job rotations which helps as a tool to cross-train workers, as well as less boredom and monotony. This is due to the monotony of repetitive tasks carried by some workers. However, the main advantage is the reduction of physical risks that are associated with musculoskeletal disorders. However, studies carried out have suggested that work rotation schedules can also generate risks of injury to workers, for which it is recommended to implement this tool in a moderate way and make use of different complementary tools [22]. Postural stress arises from the heavy activities of workers, and this could be generated even with job rotation if it is implemented intensively[23].

Even so, some studies suggested that in job rotations with high-risk tasks and low-risk tasks, the exposure would be increased in general as instead of some, now all workers would be exposed to high-risk tasks at any point. This result shows the importance of having a focus on overall risk instead of singular areas to avoid exposure[24]. However, in different investigations, the downtime of the manufacturing cell composed of lathe and grinding was reduced with the aim of increasing labor productivity and optimizing the cell by applying job redesign[25]. Many jobs that require high-risk jobs do not consider ergonomic regulations, which end up affecting productivity and work-life [26]. If there is a redesign of jobs, it is found that there is a decrease in complaints of postural stress and work fatigue. Also, in studies, a drastic decrease in the effectiveness of rotation can be observed to reduce the general risk of workers in high-risk jobs.

What can be seen from the research results is that there is a suggestion that job rotation is going to depend largely on how the workgroup itself is composed. This, in addition to including higher-risk jobs, results in a significant decrease in turnover effectiveness, and this is in part to reduce the overall risk that workers may have. In case there are high-risk jobs, the essential thing would be to redesign the work of those tasks that high-risk work requires; that should be the main focus to be able to intervene before thinking about job rotation. This will help the creation of workflow, which with this tool will promote new optimization techniques within the manufacturing sectors.

D. Ergo-Leanin the textile sector

The term ergo-lean derives from the terms ergonomics and lean, which, unlike their unique approaches, together mean the improvement of a process or its productivity through ergonomics tools and lean organization tools to obtain a value enhancement. Having had that term clear, the articles in reference to it show applications mainly with respect to the redesign of jobs in which the anthropometric tools of ergonomics and the basic tools of Kaizen of the lean method are involved. The symptoms commonly seen and treated with the ergo-lean model are related to the upper body, including also vision problems and lower back, of which the most prominent are the neck and lower back. Likewise, a correlation of the application of lean tools with parts of the ergonomic processes was found, of which the 5S tool stands out and the redefinition of production areas, being able to refer to simple work areas or even the design of the plant [27]. The results of the articles show positive effects after the implementation of the ergo-lean model when seeing productivity and time management after having carried out said implementation[28]. With respect to productivity, an improvement was seen in the postural angle for sewing machines which had correction angles between 48 ° and 67 °, being the worst cases where, ideally, the angles are sought to be between 5 ° and 2nd. After implementation, productivity improvements of 16% were recorded for regular operators and 58.5% for heavier workers [29]. Likewise, another article shows a reduction of non-productive times of 87% and a reduction of defective products of 66% thanks to the implementation of the ergo-lean model [30].

As evidenced above, a positive impact is seen in the implementation of the ergo-lean model at the product level and the worker's health level. The precautionary and symptom management effects of musculoskeletal disorders make workers perform better, and absentee costs are directly reduced.

III. INNOVATIVE PROPOSAL

A. Fundamentals

Currently, absenteeism is considered one of the problems that negatively influence organizations, specifically in production, and has an impact on the worker since it can be caused by various causes such as mental, labor, physical and social nature. The generation of value of our proposal is focused on the application of outstanding tools in state of the art, since its main solution is to reduce the rate of absenteeism of the case study, avoiding annual costs for overtime payments to compensate periods of low productivity or compensation for damage to the worker's health. This would be carried out by correcting the bad postures adopted by the workers, reducing physical efforts, a complete reorganization, and an environmental analysis of the work areas to be treated. In this sense, the systematic review of the literature found possible solutions based on a combination of Ergonomics and Lean Manufacturing as one of the most required work philosophies for the identified problem, despite hosting numerous work tools as an alternative to solution.

B. Proposed Model

The proposed model focuses on 5s techniques, Economy of movements, job redesign, and FLD through an Ergo-Lean model. These techniques aim to reduce the main cause that leads to a high rate of absenteeism, musculoskeletal disorders, and in turn, improve worker efficiency by improving the area in which each worker works. Like any process, it is necessary to identify the steps to follow for a good organization and not generate delays when applying the techniques; therefore, this model will be developed in 3 stages, as shown in Figure 1.

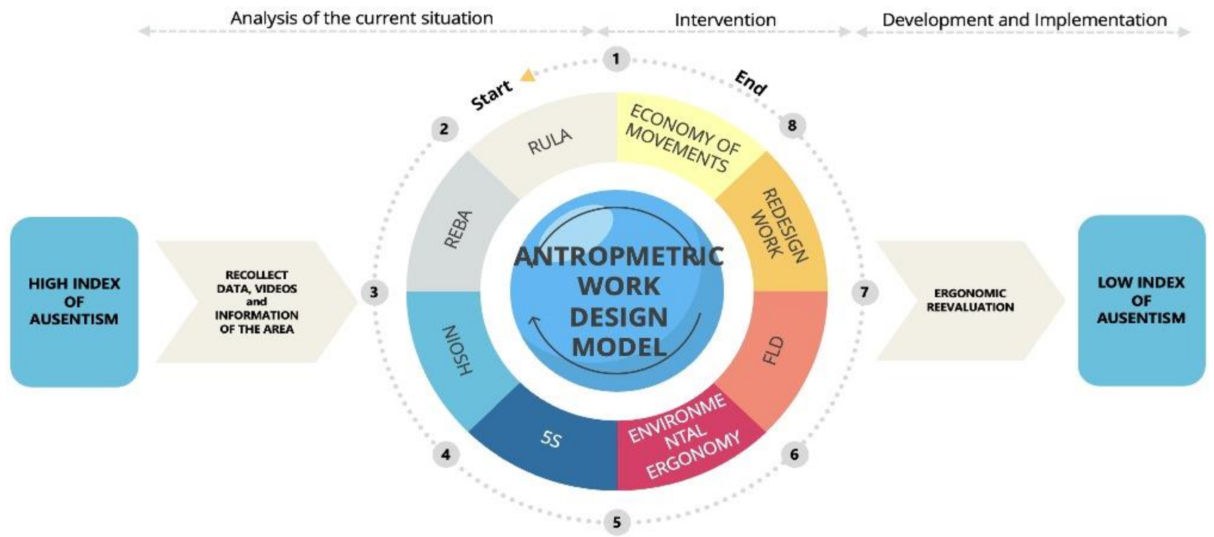

Figure 1 Proposed model

The data of the company in the case study will be collected in order to determine the current situation using tools such as RULA, REBA, and NIOSH. The RULA tool allows evaluating the exposure of workers to risks due to inadequate postures that can cause disorders in the upper limbs of the body[28]. The REBA tool is a method based on the RULA tool, differing in the inclusion of the evaluation of the lower extremities[31]. NIOSH allows you to identify hazards associated with manual lifting tasks.

The environmental analysis analyzes the factors inherent in the organization's environment that may have an impact on them, such as noise and lighting. The 5S tool will allow the identification of unnecessary activities and tools in the work area in order to provide order, cleanliness and have a correct performance of the operator's functions[32]. The economy of movements allows the study of the movements of the human body to reduce or eliminate those that are unnecessary[33]. The purpose of the job redesign is to reorganize the work area that involves the worker having bad work postures when carrying out their work. The Facility Layout Design (FLD) will allow us to verify the correct distribution of the design of the facilities of the company in the case of study to carry out proper planning of distribution[34].

C. Components of the Model

a) Datalog

The first component seeks to collect information prior to activities through physical records and diagnostic tools. This component applies knowledge of ergonomics and lean management to perform a current condition analysis and subsequently apply measurements. Ergonomic diagnostic tools are managed from the following measurement ranges shown in Table 1.

Table 1. Ergonomic Tool Range Chart

Method	Range		
	Optimum	Toimprove	Unacceptable
RULA	[1 - 2]	[3 - 4]	[5 - 7]
REBA	[1 - 3]	[4 - 7]	[8 - 15]
NIOSH	<= 1	]1 -3[	>= 3

b) Ergonomic application

The second component observes the application of the action measures to be able to solve the previously diagnosed aspects.

Among these measures are the economy of movements, the redesign of jobs, and the Facility Layout Design. After having applied these improvements, it is expected to have an effective redesign of workstations supported by ergonomic principles.

c) Ergo-Lean analysis

Finally, the last component seeks to ensure the efficiency of the new proposed model by comparing it with the initial results so that a notable improvement can be evidenced through these.

The KPIs will be an important part of this stage, taking as data the previously performed diagnoses and compliance tests of the workers.

D. Proposed process

The proposed process model to use the ergo-lean improvement method is presented in the form of a flow chart as follows in Figure 2

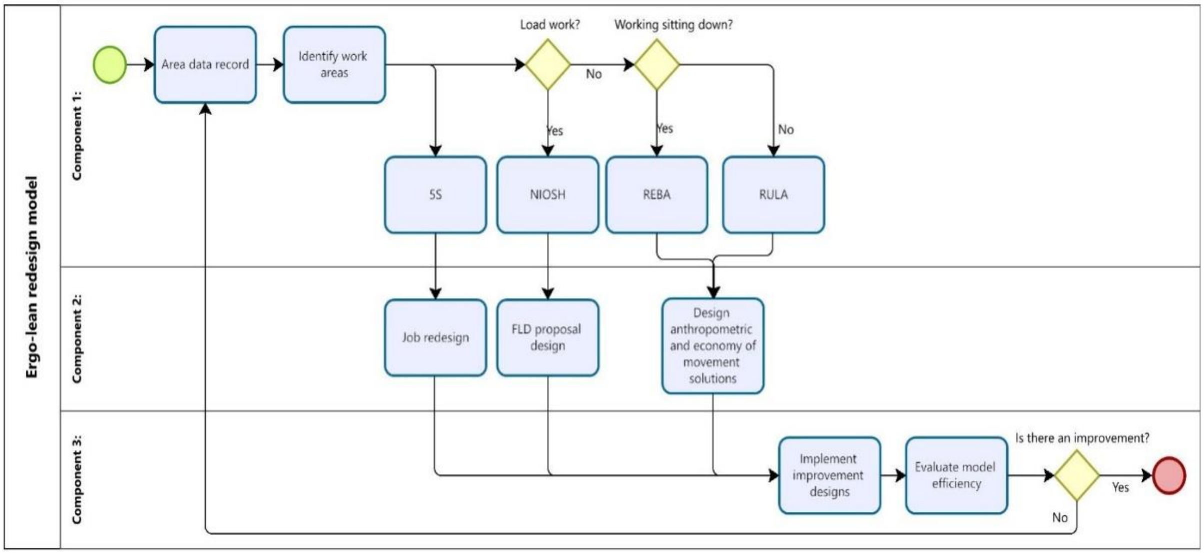

Figure 2 Proposed model process flow chart

E. Indicators of the proposed model

1. Reduction of Level of Exposure to Musculoskeletal Disorders (RLEMDs):

This indicator will determine the ergonomic effect of the model when analyzing the results of the RULA, NIOSH, and REBA tools.

Objective: Reduce the level of Exposure to MSDs by 60%.

RLEMDs (%) = ∑ ((∑ (Initial evaluation scorei – Final evaluation scorei) /Initial evaluation scorei) / # Evaluations) * Current exposure) *100

- Interpretation: Reduction in exposure levels is measured from ergonomic assessment scores.

2. Total Absenteeism Reduction (TAR):

This indicator is the main index to determine the efficiency and development of the ergo-lean model in this research case. This indicator varies from the conditions of complaints and exposure to musculoskeletal Disorders calculated by work season.

Objective: Reduce the level of absenteeism by 25%.

TAR (%) = ((Current annual absenteeism – (External absenteeism + MSDs absenteeism *(1 – RLEMDs))) /Current annual absenteeism) *100

- Interpretation: Total absenteeism is measured by applying the MSD reduction model.

3. Reduction of Ergonomic Indicators in Workstations (REI):

This indicator compares the values before and after the implementation of the proposed model of the RULA, REBA, and NIOSH ergonomic evaluations.

Objective: Reduce the level of Ergonomic Indicators by 50%.

REI (%) = (∑((Initial scorei – Final scorei) /Initial scorei) / # Evaluations)*100

- Interpretation: The reduction of the levels of the ergonomic evaluations carried out is measured.

IV. VALIDATION

A. Basis

This chapter will address the development of the Ergo-Lean model proposed for the redesign of the jobs in the company of the case study, achieving the reduction of muscle fatigue in the operators and, consequently, reducing the rate of absenteeism. First, data and anthropometric measurements will be collected; then, they will be simulated in the Delmia program, and finally, with the results obtained, the current situation will be compared with the objective situation.

B. Proposed validation model

In the following Figure 3, the Validation Model method is shown, presenting the four processes of investigation of the article.

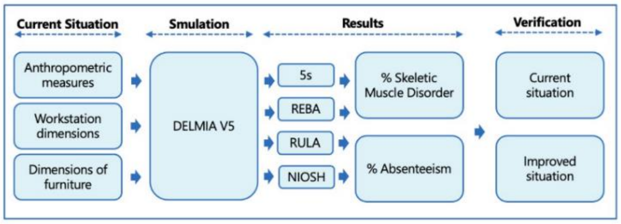

Figure 3 Proposed Validation Model

C. Simulation of digital design –3D Model

The Delmia V5 software used is an analytical program that allows evaluating human behavior in the face of changes in posture and the elaboration of tasks, taking into account the ergonomic aspect at all times. The use of this software allows determining factors of impact to the comfort, safety, and performance of the personnel in a three-dimensional environment. The tools used in the articulated test mannequins allow checking the design of the proposed model, reducing time and costs, as well as allowing to work with different anthropometric variables and environmental factors.

D. Model details

Next, the development of evaluations of the current situation of the jobs and their tasks will be presented, as well as the performance of the simulations of job redesigns in the same evaluations.

- Current situation:

In the following Figures from 4 and 7, the workers are shown doing the tasks as a demonstration of the exposure of MSDs.

a) Mass loads from ground level

Figure 4 Worker Loading Roll of Cloth

Ergonomic tool	Score	Risk level
NIOSH	2.75	The task can cause problems for some workers. It is convenient to study the job and modify it.

Ergonomic tool	Score	Risk level
REBA	12	Action level 4: Very High Risk. Action is needed immediately.

b) Cut fabric

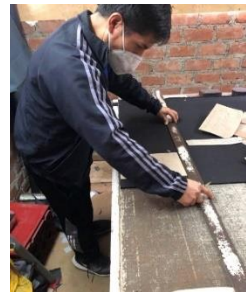

Figure 5 Worker Cutting Pieces of Fabric

Ergonomic tool	Score	Risk level
RULA	7	Action level 4: Very High Risk. Action is needed immediately.

c) Sew pieces

Figure 6 Worker Sewing Pieces

Ergonomic tool	Score	Risk level
RULA	5	Action level 3: High Risk. A redesign of the task is suggested.

d) Check finishes

Figure 7 Worker Conducting Inspection of Finishes

Ergonomic tool	Score	Risk level
RULA	4	Action level 2: Moderate Risk. Observation and study of the task are suggested.

For the ergonomic evaluations, the anthropometric measurements of the production supervisor were used to be used as the average percentile of the plant workers. Following that, the most relevant measures used for the evaluations and the development of the simulations based on these data are noted.

For the ergonomic evaluations, the anthropometric measurements of the production supervisor were used to be used as the average percentile of the plant workers. Afterward, the most relevant measures used for the evaluations and the development of the simulations based on these data are noted in Table 2.

Table 2 Plant Supervisor Anthropometric Measurement Table

Description	Value (cm)
Stature	168.2
Height to eye	158.3
Height to elbow	105.0
Maximum body width	47.8
Front arm reach	72.8
Sidearm reach	73.1

Likewise, the current area of the company in the case study does not present adequate use of the spaces since there is not enough space between the areas for the adequate route. In the same way, it is important to note that the sewing area is not on the same floor as the other areas, and they are only connected by a very narrow staircase, so the principle of economy of movements is not adequately executed as shown in Figure 8.

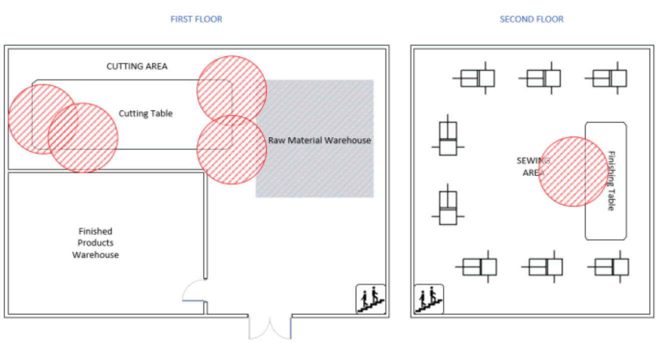

Figure 8 Economy of Movements Plan of the Current Situation

- Proposed workspace redesign model:

In the following Figures from 9 and 12, the 3D models are shown representing the previous tasks as a demonstration of the improvement on exposure of MSDs.

a) Mass load from ground level

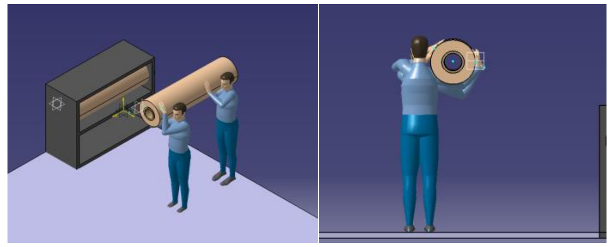

Figure 9 Simulation Workers Loading Roll of Cloth

Ergonomic tool	Score	Risk level
NIOSH	1	The set of tasks can be performed normally by most workers.

Ergonomic tool	Score	Risk level
REBA	3	Level of action 1: Low risk. Little need to intervene.

b) Cut fabric

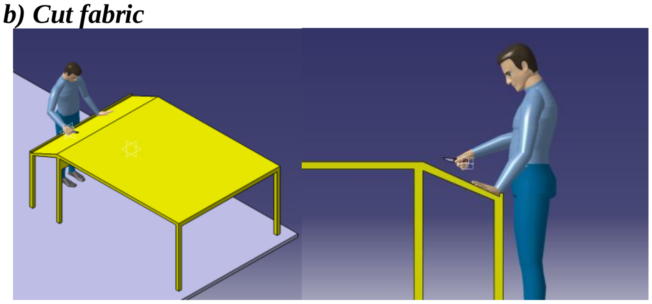

Figure 10 Worker Simulation Cutting Pieces of Cloth

Ergonomic tool	Score	Risk level
RULA	2	Level of action 1: Low risk. Acceptable risk.

c) Sew pieces

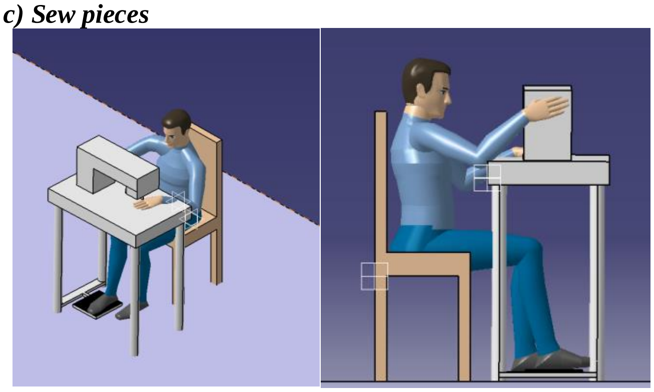

Figure 11 Worker Simulation Sewing Pieces

Ergonomic tool	Score	Risk level
RULA	2	Level of action 1: Low risk. Acceptable risk.

d) Check finishes

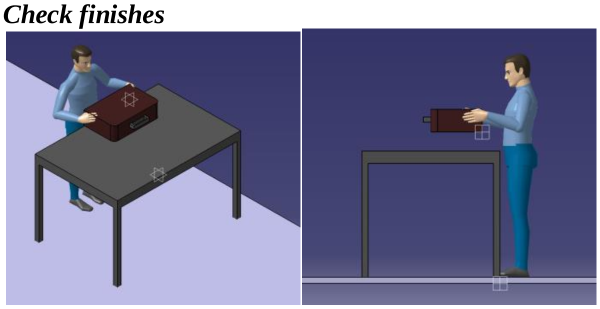

Figure 12 Worker Simulation Performing Inspection of Finishes

Ergonomic tool	Score	Risk level
RULA	2	Level of action 1: Low risk. Acceptable risk.

The redesign of the work areas provides workspaces under the concept of economy of movement since it contributes to greater organization and generates less time wastage. In addition, it is important to note that all areas are on the same floor to facilitate the work of the operators and not have bad postures when moving from one area to another, as shown in Figure 13.

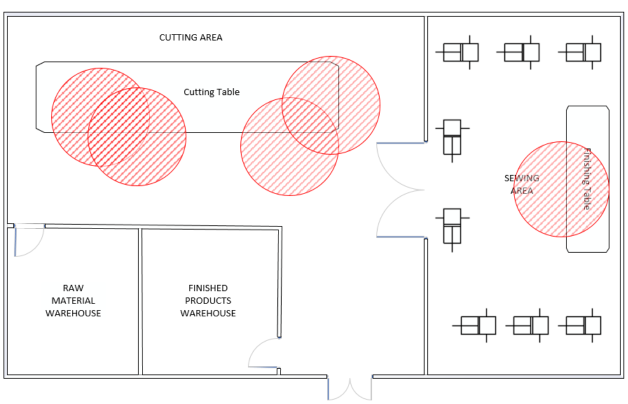

Figure 13 Economy of Movements Plan of the Proposed Model

Following next, by means of a relational table and its diagramming, a new plant design was developed, readjusting the location of its basic areas and even adding an area of finished products that had not previously been appropriately assigned. The location of the raw material warehouse was adjusted, allowing less exposure to MSDs when working with weights of 35kg among more people, at a much more accessible distance, and with better transit space. Figures 14 to 16 show the process of improvement by using a relational table

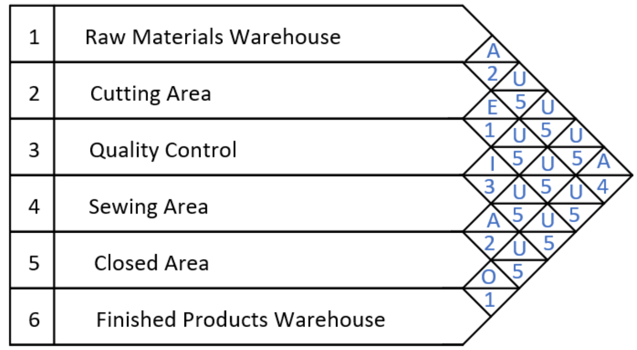

Figure 14 Relational Table of Activities of the Proposed Model

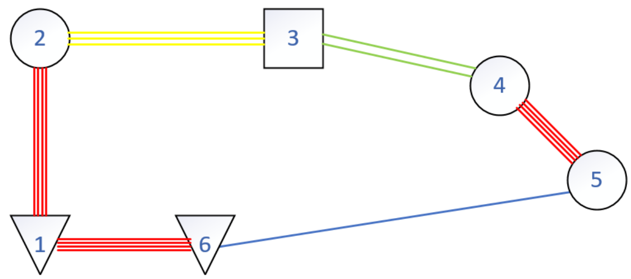

Figure 15 Relational Diagram of Activities of the Proposed Model

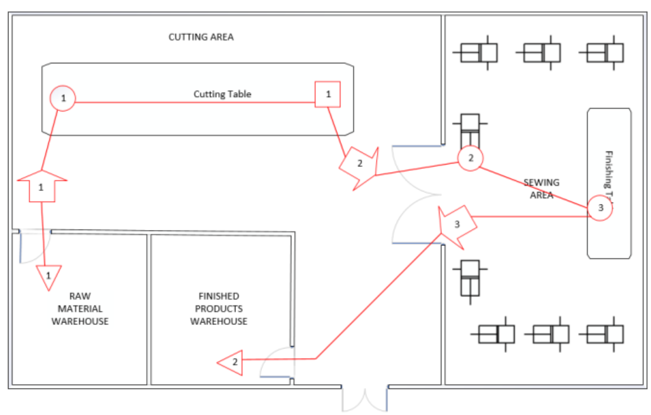

Figure 16 Route Diagram of the Proposed Model

Mainly, it is worth mentioning that the change of plant distribution to a single level was allowed by having a space of the same size available and without productive use, allowing the ease of the process and using the 80 m2 available initially. Next, the finished products warehouse space was readjusted to accommodate a raw material warehouse since this space was not used correctly from the beginning. The transit through the warehouse area and the cutting area allowed a better transport of the raw material and facilitated access to more than one collaborator to support with loads of 35 kgs. By utilizing the full space of the cutting area, space was freed up to have a designated area for quality control of the cut pieces and better traffic to the sewing area, which is now located on the first floor. Finally, the sewing area was positioned close to the finished products warehouse since it involves the final part of the process, avoiding wasted time and greater transport distances.

E. Comparison of indicators

Finally, we see the comparison of the results of the ergonomic evaluations of the simulations and the current cases in such a way that the performance of the proposed ergonomic model is evidenced.

As shown in Figures 17 to 19, the comparisons of the results from the current state and the proposed model represent the improvement on each evaluation.

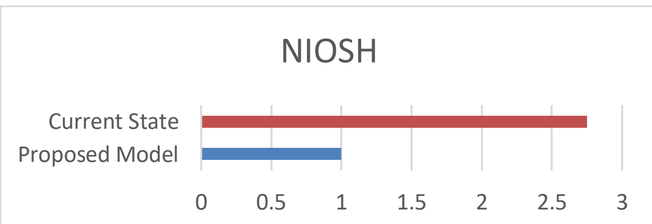

Figure 17 Comparison of the Current State NIOSH Assessment vs. Proposed Model

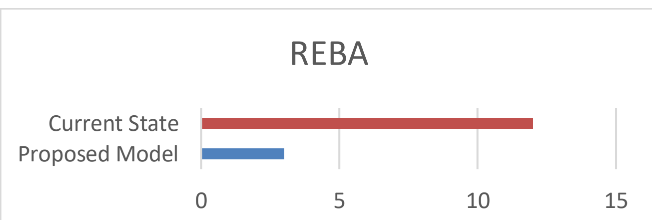

Figure 18 Comparison of the Current State REBA Assessment vs. Proposed Model

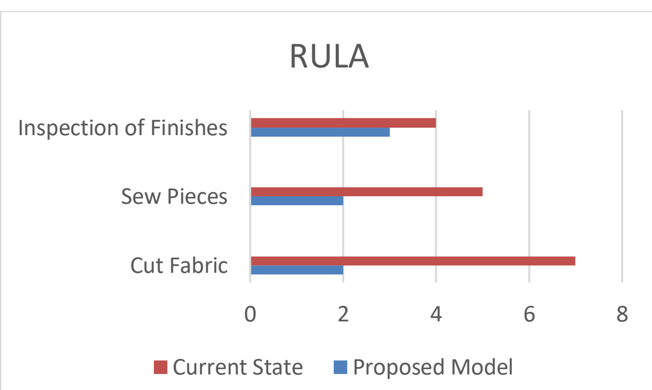

Figure 19 Comparison of the Current State RULA Assessment vs. Proposed Model

The results of the ergonomic evaluations of the proposed model were successful in the RULA, NIOSH, and REBA scores, these being significantly reduced to acceptable levels compared to the current results, being an indicator that proves a good performance of the proposed design as presented in Table 3.

Table 3 MSDs exposure indicator table

Task	Evaluation	% of Improvement	% Root cause	% Exposure to MSDs
Mass load	NIOSH	63.64%	45.28%	28.81%
Transport	REBA	75.00%	24.53%	18.40%
Cutting parts	RULA	71.43%	7.55%	5.39%
Sewing pieces	RULA	60.00%	22.64%	13.59%
Finish control	RULA	25.00%		5.66%
			TOTAL	**71.85%**

As can be seen in the table above, a considerable reduction in the ergonomic indicators RULA, NIOSH, and REBA is noted from the implementation of the proposed model. Using the root cause percentages of the tasks that are part of the work in the positions to be redesigned, a reduction of exposure to MSDs of 71.85% was calculated.

V. DISCUSSION

A. Scenario VS Results

In the initial situation, the RULA 7, 5, and 4 scores in the most critical tasks of the cutting, sewing, and finishing control jobs were reduced to the value of 3 and 2, showing percentage reductions of 71.43%, 60%, and 25% respectively giving an average reduction of 52.14% in said evaluation. Following the example of Erliana et al.[35]whose work with the RULA tool had improvements of 72.92%, taking values from 6 to 2. Likewise, García et. al.[36]shows improvements of 53.71%, having values in the RULA evaluation from 7 to 2. In this way, the result of improvement of the proposed model can be evidenced as coherent since it exceeds the expected average of 60%.

The job redesign model caused a decrease in the REBA index of 75%; that is, the initial value of 12 was reduced to 3, which is a value considered optimal according to the constant repetitiveness of movements in the raw material transport task. In the same way, Cremasco et al. [37] show similar improvements with improvement values of 91.98% with values that improve from 11 to 0.29, demonstrating the relevance of the result improving the repetitive aspect and the active state of work.

On the other hand, the modifications proposed based on the redesign of the layout of the plant, making a complete redesign of the plant as it was found more feasible that all the workstations were on the same floor and also dividing the materials warehouse area into 2 for the MP and PT area, saving long distances for transferring materials from one area to another. The NIOSH index was reduced from 2.15 to 1, the latter value being acceptable according to the ergonomic evaluation since it prevents injuries to workers. In percentage terms, a wide NIOSH reduction of 63.34% could be noted, considering it acceptable, since Cancha et. al.[38]shows an improvement of 59.15% from values from 1.64 to 0.67, thus managing acceptable values in said ergonomic evaluation.

B. Analysis of results

From the reduction of the MSDs obtained from the redesign of jobs, the current absenteeism rate in the production area will be significantly reduced. The current percentage of absenteeism is 5.21%, passing the permissible limit of 3.5% established by the International Organization. [39].The new index obtained from the proposed model is 4.13%, indicating that it still exceeds the permissible limit even with a reduction of the most relevant factor of absenteeism by 71.85%. According to the estimated values, the reduction of this index is 20.73%, being part of the estimated interval of the indicator, still testing the efficiency of the model. The low participation in total absenteeism of 29% of cases due to musculoskeletal problems is justified not reaching the permissible limits, even though it is the largest and most remarkable value of all. The participation of MSDs in absenteeism is represented in Figure 18 as part of a comparison of the current state and the improvement of the proposed model.

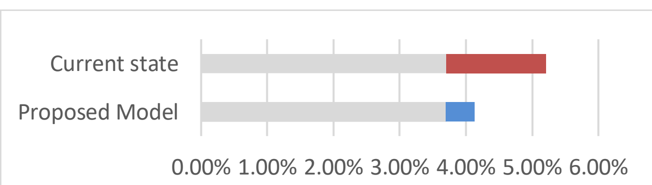

Figure 18 Comparison of the Current State Absenteeism vs. Proposed Model

In addition, it is important to note that a more detailed organization was made using the 5s methodology since the work area where the operations are carried out there is a disorder that prevents a good performance of the operators, and there is an increase in time in looking for the tools necessary for the jobs.

C. Future work

The ergonomic approach to this research could include a more detailed analysis of an environmental ergonomic study allowing a greater perspective of all the factors included in the work system, such as noise, the temperature of the work area, and vibration. If a greater investment is found, they would include the replacement of the floors of the work area with a concrete floor, sophisticated machines and establishing a maintenance policy towards them in order to further improve the work environment and the good performance of the workers. . In addition, it is suggested to carry out an internal study of the other reasons for absenteeism to manage the permissible limit of this.

VI. CONCLUSIONS

The study shown in this article presents as a case study the ergonomic evaluation of a textile accessories manufacturing workshop, analyzing the risk levels present in each of the jobs involved in the production of backpacks, resulting in discomforting and dangerous values. For the health of the employees' work, evidencing the absenteeism due to Musculoskeletal problems of 5.21% per year. In such a way that this problem can be attacked and reduced, the Model of the Ergo-Lean proposal was applied in order to reduce both the percentage of annual absenteeism and the ergonomic exposure levels. Said model required an ergonomic intervention that would seek to improve the economy of movements, redesign workstations, reinvent a Facility Layout Design and deal with environmental ergonomics, resulting in a simulated workstation residence model in DELMIA- software. V5 with data collected from the work areas and anthropometric data from the average established by the production supervisor. The simulation results gave acceptable levels for the RULA, NIOSH, and REBA indices giving improvements of 52.14%, 75%, and 63.64%, respectively and resulting in a reduction of exposure to MSDs of 71.85%. The effect of this improvement in the KPIs allowed determining a result of the new annual absentee rate that would be 4.13%, still having an unacceptable value according to the International Labor Organization. Even so, it can be concluded on the acceptability of the proposed method and its optimal implementation in tailoring workshops such as the case study due to the high impact it had on exposure levels and justifying not reaching acceptable levels with the percentage of contribution to the 20% absenteeism. Improvements for future work involve the implementation of a more defined ergonomic environmental analysis so that more detailed factors such as lighting or the temperature of the work area can be studied. Improvements dependent on greater investments include the replacement of wooden floors by concrete floors, machinery improvement as well as establishing better-regulated maintenance policies, and the inclusion of a raw material elevator to apply use to the upper part of the building in If it is required to upload materials of greater weight. Finally, it is concluded on the viability of the proposed model and the modifications that they entail to solve the problem of the case.

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