Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/SA6.20250122
Published: May 12, 2025

Improvement in a Garment SME Using 5s and Ergonomics to Increase Productivity and Reduce the Risk of Developing Occupational Musculoskeletal Disorder

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Abstract

The study focuses on reducing the development of occupational Musculoskeletal Disorders (MSD) and increasing productivity in textile and apparel Small and medium-sized enterprises (SMEs). Most previous research in the sector proposes techniques and methodologies to improve the performance or ergonomics of the companies, without considering the joint use of tools to mitigate both problems. Therefore, we propose the application of the lean 5S methodology to eliminate waste and maintain a continuous flow through classification, order, cleanliness, standardization and continuous improvement, in complement with the anthropometric design of the workstations and ergonomic evaluations of the operators. The model was validated through a pilot test, RULA, REBA and simulation software (3DSPP and Arena). The results show that the integrated approach effectively addresses the challenges of the sector by reducing cycle time, increasing the number of clean, tidy and ergonomic stations, reducing lower back compression, the level of risk and the percentage of maximum voluntary effort adopted by workers.

Keywords
5s, Ergonomics, MSD, productivity, cycle time.

1. Introduction
The global textile industry has experienced significant changes due to factors such as the Coronavirus (SARS-CoV-2) pandemic, which affected the global supply chain and demand for textile products as a result of the shutdown of operations. This impact was reflected in Peru, since, according to statistics, during 2011-2020 the sector's Gross Domestic Product (GDP) showed a contraction of 5.2% on average per year, worsening in 2020, falling by 31.8% with respect to 2019 (Ministerio de Producción 2022). Small companies, which represent 95% of the Peruvian textile sector, are the most affected (Ministerio de la Producción 2022). In addition, there is a gap of 45.1 thousand metric tons between the country's production and imports. Consequently, it is imperative that textile and apparel companies adopt measures to minimize this adverse impact. Therefore, tools and methodologies that allow them to be more

competitive must be implemented.

On the other hand, the industry evidence ergonomic problems; due to the labor intensity of the industry (Aftab et al. 2021), poor workplace design and the adoption of repetitive and unstable postures or movements by workers (Choobineh et al. 2007). This causes workers to experience muscular injuries resulting in work-related disorders (Alves et al. 2018). The most frequent in textile workers is the musculoskeletal disorder (MSD) that affects the quality of life and performance of people in organizations, being this a relevant occupational health and safety problem (Nunes and McCauley 2012).

Despite these problems, the textile sector is crucial to many economies, including Peru. Its worldwide economic value is estimated at US$439.1 million dollars (Aftab et al. 2021) and generates about 57 million jobs (Fadillah and Muslim 2019). According to Ministerio de la Producción (2022), e in 2020 it represented approximately 6.3% of the national manufacturing GDP. Being the fourth activity with the highest contribution to the country's manufacturing GDP (Instituto Nacional de Estadística e Informática 2019).

In this article, we will study the case of a small company in Lima-Peru, specialized in the design and manufacture of garments. The company under study presents problems such as: high cycle times due to the presence of non-value-added times, high percentage of workers with pain or discomfort in some part of the body, and disorganized, dirty and ergonomically inadequate workstations, which result in low productivity. It is important to point out that a direct relationship was found between the size of the organization and its productivity. To be precise, the productivity of a large company is 4.5 times that of a micro-company, 4.4 times that of a small company and 2.7 times that of a medium-sized company, figures close to the average for Latin America (Ministerio de la Producción 2022). Based on this, the company, being a small company, shows a considerable gap in its productivity. Considering the root causes of low productivity, a causal linkage diagram with solution tools was made as shown in Figure 1.

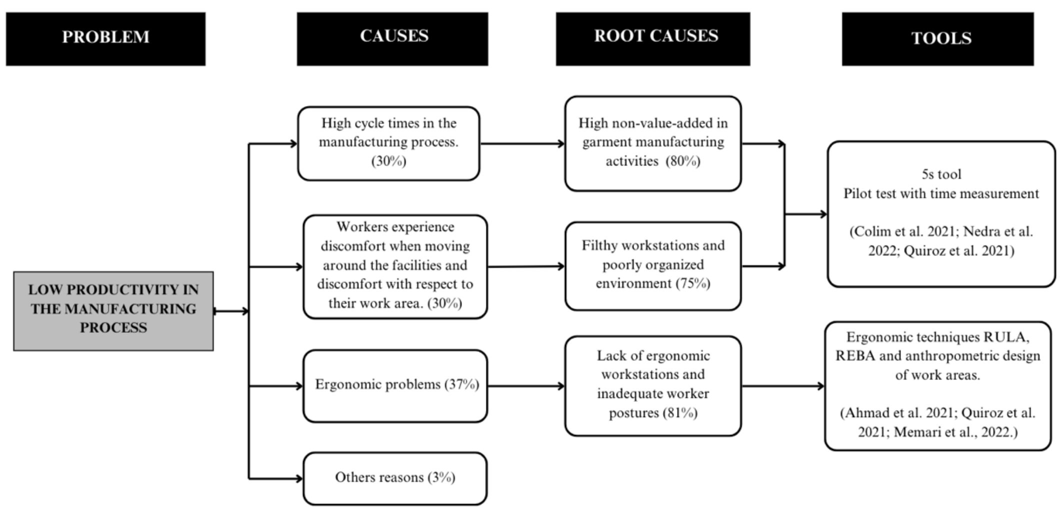

Figure 1. Diagram linking causes to tools.

This research is important because it aims to find solutions through the implementation of engineering tools such as 5S and ergonomic methodologies. The results of this study can help companies in the sector to improve their processes without compromising the well-being of their workforce.

1.1 Objectives

The objective of this research aims to optimize the process performance of the cutting and sewing areas and reduce the risk of contracting developing musculoskeletal disorders in a garment manufacturing MSE company. These improvements will be obtained through the implementation of 5S tools and anthropometric design, which will be validated through the evaluation of indicators, simulation of the processes under study and a biomechanical simulation.

2. Literature Review

The literature review conducted was aligned in the search for articles in 2 approaches: Lean and Ergonomics. Regarding the use of Lean Manufacturing tools, it was found that their use is successful in small companies and leads to improvement, in some cases not requiring large capital investments (Memari et al. 2024). Such as the use of 5S, which in previous studies proved to be the first step to reduce waste and increase productivity, obtaining efficient and effective results (Kawalec et al. 2018). A In addition, it allows identifying unnecessary activities and instruments in the work area in purpose of providing order, cleanliness and a correct performance of the operator's functions (Baca et al. 2021, Kose et al. 2022). Its success is evidenced in several investigations, as in the case of the use of 5S in a clothing company to reduce the variability of the production process and to achieve a line balance; after the implementation, an increase in efficiency of 25% was obtained, the lack of balance in the line was reduced by 35% and the number of waiting workstations was reduced by 28% (Kumar et al. 2022). However, most Lean research has focused on Western countries and has largely ignored developing countries (Alkhoraif et al. 2019). Previous research has also proposed techniques to improve productivity, without considering worker well-being. It should be noted that some studies show that the intensive application of lean manufacturing may be associated with an increase in musculoskeletal disorders, as well as work-related stress (Domínguez et al. 2021).

Regarding the ergonomic approach, it was found that the main causes of risk are related to postural movements in the wrist, forearm and neck. A study in a sewing station of a textile company evidenced the finding of MSDs in the lower part of the body in 78%, 76% in the hands and wrists, 52% in the neck and 48% in the shoulders of the population studied. (Lakhal et al. 2019). Similarly, in the study of Aftab et al. (2021) it was concluded that MSD symptoms in workers in the garment industry are common and require the attention of researchers who can design and implement appropriate proposals. Due to the fact that this sector requires workers to perform monotonous, repetitive activities for long periods of time. This generates significant economic impacts for the organizations due to lost work days, medical expenses and loss of productivity (Yelin et al. 2016). In addition, the cost of covering occupational accidents, injuries and illnesses, which represents 3.9% of the world's GDP (Elsler et al. 2017). Regarding ergonomic methodologies, several studies have used different tools, among the most common and effective to evaluate working conditions are RULA, REBA and NIOSH. The RULA method analyzes the risks of contracting MSDs in the upper part of the body due to improper postures. (Silvano and Oliveira 2019). Furthermore, REBA is a method based on RULA, which, in addition to the upper diagnosis, also takes care of the lower limbs. (Malhar et al. 2016). NIOSH has identified hazards associated with lifting tasks. To address the ergonomic challenges faced by the sector, a study redesigned the work areas considering the lean and ergonomic aspects, due to problems of worker absenteeism and the risk of contracting MSDs. A simulation model was carried out with DELMIA V5 software, achieving an improvement in the ergonomic indicators (RULA, REBA, NIOSH) and a 71.85% reduction in the exposure to generate musculoskeletal disorders (Quiroz et al. 2021).

Figure 2 evidence few studies that conducted research with an ergo-lean approach with the objective of studying the conditions and aspects of the worker to improve their efficiency and well-being (Shahin et al. 2023). One notable element among the aforementioned is the study of Vinoth and Sivakumar (2022) who conducted research with an ergo - lean approach in purpose to study the conditions and aspects of the worker that are not considered. They developed a waste identification diagram that relates physical, psychosocial, work area design and management factors; to observe the risks to which the worker is exposed. After the implementation of the diagram, a reduction in cycle time of 4.63 minutes and in the effort made by the operators was observed. Moreover Shahin et al. (2023) They put forward a new proposal called 5s+1, so that, by implementing safety, the accident rate, defect rates and equipment availability are reduced. Based on this, it is concluded that in the textile industry, the significant problem of the possible development of MSDs in operators should not be left aside, by implementing only lean proposals that reduce costs or improve productivity.

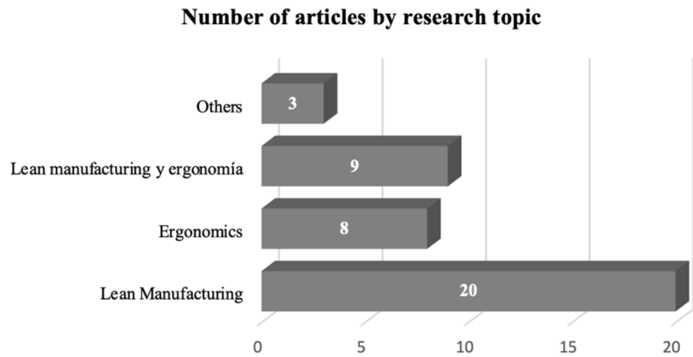

Figure 2. Number of Articles by Research Focus

3. Methods

One of the most widely used tools for initial problem analysis and mapping is Value Stream Mapping (VSM). This tool was used in this study to identify the problems. Figure 3 presents the sequence of activities in the manufacturing process with their respective percentages of non-value-added time. The development of a large-scale VSM of the processes and their interactions benefits the analysis of problems and their subsequent solution, since it makes it possible to identify waste, areas for improvement and bottlenecks. (Bugvi et al. 2021).

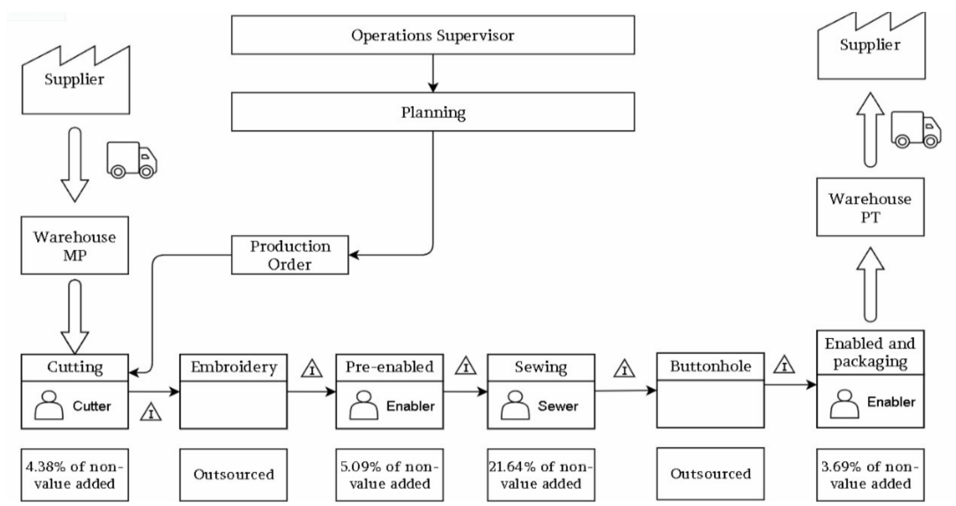

Figure 3. Value Stream Mapping

For the cycle time of the activities, the process was timed in order to determine the times for each area and the non-value-added times. Likewise, to collect ergonomic problems, we used the Nordic questionnaire, a tool that allows us to identify risk factors related to the development of MSDs. Subsequently, to determine the main causes, a tree diagram was drawn up, as shown in the Figure 1.

This research will address two aspects, ergonomics with the use of rula, reba and anthropometric design. Furthermore, Lean where the 5s methodology will be used, so that the joint use will allow us to benefit the well-being of the worker and the efficiency of the process. As mentioned Colim et al (2021), Lean and Ergonomics can reduce lead time by eliminating wasteful manual handling of non-productive materials and awkward postures, as well as increase worker efficiency, safety and health.

In the case of 5S, it has been used in different studies to solve problems such as: high waste, high production times and poor utilization and inadequate handling of inputs. In the research of Kose et. al (2022), with the use of 5S and SMED, a 58% decrease in setup time was obtained. Likewise, as mentioned in Bhattacharya et al. (2019) the implementation of a 5s management system can improve the health and safety conditions of workers. To validate the benefits in cycle time and productivity that can be generated by the implementation of 5s within the area of a selected space, a pilot test was conducted.

The lack of anthropometric adequacy of workstations in garment MYPES is one of the most frequent causes of fatigue, discomfort and MSDs both in daily life and in the work environment. Consequently, carrying out an anthropometric design of workstations is essential to prevent occupational hazards for both workers and companies. Anthropometric design makes it possible to adapt the workspaces and furniture used in the process to the physical characteristics of the workers, in order to reduce the risk of injury and improve productivity. For this study, the anthropometric dimensions of the population under study will be used, so that stations can be designed to fit the dimensions of the employees. With the objective of knowing the improvements generated by the implementation of the anthropometric design, initial and final evaluations of postures, exerted force, repetitiveness of movements and extreme loads were carried out using the rula and reba methods, which allow knowing the level of risk to which the worker is exposed. The indicators to be considered are shown in Table 1, which were derived from articles proposing improvements in the processes through the use of ergonomic and lean tools. The indicators generated by the 3DSSPP software were used.

Table 1. Process indicators

Component	Validation Tool	Indicator	Description
Ergonomics	Rula	Risk level	Ergonomic tool that measures the risk of musculoskeletal injuries in the neck, trunk and upper extremities.
	Reba	Risk level	Ergonomic tool that measures the risk of musculoskeletal injuries throughout the body.
	Software 3DSSPP	Low back compression	Pressure exerted on the operator's lower spine in a posture, during his activities.
		Percentage of people able to maintain posture	Percentage of people who can maintain a posture without risk to their health.
		Body balance	Stability that the worker has in a posture at the moment of performing his activities.
		Percentage of maximum voluntary effort	Percentage of effort that an operator can voluntarily perform in relation to his or her maximum limit.
Lean Manufacturing (5S)	Software Arena – Pilot test	Cycle time.	Number of seconds required to make a t-shirt.
		Productivity	Number of t-shirts manufactured per man hours.

4. Data Collection

The unit of analysis for this research is the production of 1 long-sleeved shirt collar polo shirt, which represents approximately 60% of sales. It should be noted that the buttonhole and embroidery processes are outsourced, so they are not considered for the study. The work areas selected are cutting and sewing, since, as shown in Figure 3, the sewing area has the highest percentage of non-value-added time with 21.64% compared to the other areas, and according to Table 2, 100% of its workers have ailments in at least 5 parts of the body. Regarding the cutting area, it is the third area with the third highest percentage of non-value-added time with 4.38% and it is also the second area in which there are ailments in at least 4 areas of the body. In addition, the areas in question present greater problems of order, cleanliness and ergonomics, as shown in Figure 4.

The evaluation to determine the current situation of the company was carried out through physical observations, tours, video recordings, photographs and surveys to the operators. The Nordic questionnaire was used which allowed identifying the main ailments in the various parts of the body of the workers, taking into account that, Lakhal et al. (2019) in their research conducted in a sewing station of a textile company showing that 78% of the population studied present MSDs in the lower body, 76% in the hands and wrists, 52% in the neck and 48% in the shoulders, the results of the study survey are shown in Table 2.

Figure 4. Initial situation of the fitting out, sewing and cutting stations

Likewise, from the individual interviews, it was found that 100% of the workers evidenced problems of cleanliness, order, lighting, availability of tools and adequate movement to perform their duties.

Table 2. Results of workers' body ailments.

Area	Worker	Ailment					
		Neck	Shoulder	Back	Wrist / Hand / Arm	Ankles/Feet	Other
Cutting	1		x	x	x		x
Sewing	2	x		x	x	x	x
	3	x	x	x	x	x	x
	4	x	x	x	x	x	x
Enabling	5	x		x		x	

For the productivity and cycle time indicators, a time measurement was performed, timing the process in a sample of 30 for each activity. Using the Input Analyzer software, the distribution that best fit the sample of times for each activity was determined, considering that the p-value had to be greater than 0.05 for both the chi-square test and the Kolmogorov-Smirnov test, and the histogram distribution that appeared in the software had to be consistent with the trend of the data. The result is shown in Table 3.

Table 3. Optimal distribution for each activity of the initial process

Area	Activity	Distribution (seconds)
Cutting	Transfer of fabric and molds to cutting area	ERLANG (4.41,3)
	Inspection, laying of fabric, mold squaring and sizing1	TRIANGULAR (29, 39.8, 65)
	Front and back cutting	NORMAL (30.9, 7.93)
	Sorting and fitting of pieces 1	NORMAL (22.7, 5.23)
	Breastplate	2 + GAMMA (4.15, 3.28)
	Inspection, fabric stretching, mold squaring and dyeing 2	NORMAL (42.7, 7.19)
	Sleeve cutting	UNIFORME (10, 32)
	Sorting and fitting out of parts 2	NORMAL (18.6, 6.75)
	Transfer of parts to the warehouse	NORMAL (17.2, 7.44)
Sewing	Breastplate to breastplate connection	UNIFORME (26, 61)
	Front to front breastplate connection	1 + 93 * BETA (3.55, 5.26)
	Breastplate to front	NORMAL (13.6, 3.3)
	Breastplate pre-finishing	20 + ERLANG (16, 2)
	Shoulder attachment	1 + GAMMA (5.26, 3.95)
	Neck to body and ribbon attachment	47 + EXPONENCIAL (31.9)
	Tape closing, label and bib finishing	116 + 301 * BETA (0.958, 1.41)
	Sleeve to bodice and seaming part of the breastplate	47 + LOGNORMAL (24.3, 48.1)

	Cuff closing	14 + 7 * BETA (0.669, 0.655)
	Sleeve cuff to sleeve and polo shirt closing	105 + LOGNORMAL (55.4, 122)
	Cuff to sleeve joining	37 + LOGNORMAL (67.3, 223)
	coarse sewing	28 + ERLANG (6.45, 2)

The calculated distributions were used as input data for the simulation run in Arena Software, in order to calculate the cycle time. In line with the calculations, the productivity of labor in poles per man-hour of the cutting and sewing stations was determined as shown in Table 4.

Table 4. Labor productivity per workstation

Process	**Productivity**
Cutting	35.95 (t-shirt/man-hour)
Sewing	15.77 (t-shirt/man-hour)

5. Results and Discussion

5.1 Numerical results

After the implementation of the tools, the defined indicators were measured. The results per indicator are shown in Table 5 and Table 6. In which the values obtained pre and post validation of the proposed improvement model are analyzed and compared, so that the benefits and improvement obtained can be verified.

With the implementation of the 5S pilot test in the cutting and sewing area, an improvement in order and cleanliness was evidenced. Likewise, a continuous workflow was achieved by reducing obstacles in the movement of the operators, as well as the reduction of non-value-added time due to the search for tools. Table 5 shows that cycle times in the cutting and sewing areas were reduced, with a more significant improvement in the sewing area. This progress achieved is a direct variable in the improvement of productivity, since it manages to produce a greater quantity of garments using the same number of initial resources.

Table 5. Process performance indicators

Indicator		**Initial value**	**Final value**	**Achievement**
Cutting cycle time (seconds/t-shirt)		200.28	195.28	2.50% reduction
Sewing cycle time (seconds/t-shirt)		913.04	811.11	11.16% reduction
Productivity (t-shirt/man-hour)	Cutting productivity	35.95	36.87	2.56% reduction
	Sewing productivity	15.77	17.75	12.56% increase

In the ergonomic analysis, 2 postures per area were evaluated, in order to analyze the behavior in the situations.

Table 6 Ergonomic indicators of the process

Posture	Indicator	Initial Value	Final Value	Achievement
Posture 1- cutting	RULA-risk level	4	2	50% reduction
	REBA-risk level	4	1	75% reduction
	Compression in the lower back (kg)	104.93	157.95	50.53% increase
	% People who can maintain posture	86%	100%	14% increase
	Body balance	Unacceptable	Acceptable	Positive improvement
	% Maximum voluntary contraction	84%	70%	14 % reduction
Posture 2 - cutting	RULA-risk level	4	2	50% reduction
	REBA-risk level	4	1	75% reduction
	Compression in the lower back (kg)	213	142.45	33.12% reduction
	% People who can maintain posture	16%	54%	38% increase
	Body balance	Unacceptable	Acceptable	Positive improvement
	% Maximum voluntary contraction	54%	49%	5% reduction
Posture 1- sewing	RULA-risk level	3	1	66.67% reduction
	REBA-risk level	2	1	50% reduction
	Compression in the lower back (kg)	66.48	31.3	52.92% reduction
	% People who can maintain posture	19%	100%	81% increase
	Body balance	Unacceptable	Acceptable	Positive improvement
	% Maximum voluntary contraction	19%	11%	8% reduction
Posture 2 - sewing	RULA-risk level	3	1	66.67% reduction
	REBA-risk level	3	1	66.67% reduction
	Compression in the lower back (kg)	134.7	31.3	76.76% reduction
	% People who can maintain posture	99.98%	100%	0.20% increase
	Body balance	Unacceptable	Acceptable	Positive improvement
	% Maximum voluntary contraction	33%	11%	22% reduction

Anthropometric design increases the percentage of ergonomic workstations. Likewise, with the implementation of 5s in these areas, the worker's discomfort with respect to the order and cleanliness of their physical environment is reduced, directly influencing their productivity. In the case of the rula and reba methods in the cutting area, an average improvement of 62.5% was obtained in both cutting and sewing, achieving risk levels between 1 and 2, which indicate that no changes are necessary and the postures are acceptable. Similar results were shown in the study by Quiroz et al. (2021), where ergonomic indexes were reduced by an average of 65.59% and 71.85% of exposure to muscular disorders.

Regarding the indicators of the simulation in the 3DSSPP software, a representative percentage reduction in back compression was found, indicating that the new posture adopted generates less load on the lower back and greater comfort. However, in the case of cutting posture 1, an increase was generated, but this is within the acceptable limit, due to the fact that in the initial position the worker had a point of support, so that less pressure was exerted on the back, however, the feet were left without support, showing an unstable posture. Likewise, with respect to the percentage of people able to maintain this posture, there was an increase of 33.3% on average, showing that more people can adopt the new posture without this having an impact on their health. Regarding the percentage of maximum voluntary compression, there was a decrease of 12.25% on average, showing that the worker does not need to exert excessive force that affects his health. Finally, the body balance was compared, considering as unacceptable if the center of gravity is outside the zone estimated by the simulator or between the maximum limits; all the base situations had a rating of unacceptable, showing that the worker does not have adequate stability and in case of a sudden movement may lose balance; in the improved situation it was found that the posture has an acceptable balance, generating greater comfort for the worker. Similar positive results were presented in the study of Gualtieri et al. (2020) that reduced mechanical overload by 42.33% on average and in the case of Kose et al. (2022) an optimization of 19% was achieved in ergonomic indicators.

5.2 Grafical Results

In the study by Kumar et al (2022) on 5S implementation in a garment company, the efficiency was improved by 25%. In line with the above, in the present study it was found that, in the performance indicators, improvements of 9.60%

in cycle time and 5.61% in productivity were generated as shown in Figure 5.

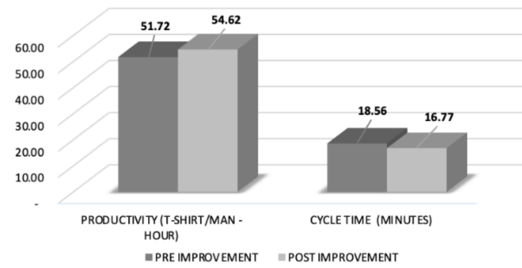

Figure 5: Cycle time and productivity variation

It is important to point out that the ergonomic improvements presented in Figure 6 show a reduction in the risk of contracting MSDs, because the furniture adapts to the anthropometry of the worker, allowing him to adopt correct postures and perform his activities continuously without suffering discomfort or muscular pain. This generates improvements in cycle time, since it minimizes the time spent in comfortable postures and unplanned breaks generated by accumulated fatigue.

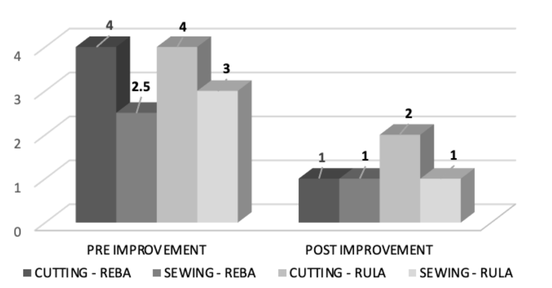

Figure 6. Ergonomic indicators (Rula and Reba)

5.3 Proposed improvement

The proposed improvement to optimize the low productivity of the company under study consists of three main stages. The first one is the analysis and diagnosis, which consists of conducting a field study to investigate the main problem and the areas of study; by using different tools and conducting a literature review of previous research. The second stage is the development of the proposed solution where the lean approach is used together with the ergonomic approach using anthropometric design of workstations and a pilot test of 5S, the joint use of both allows the workstations to have adequate space and the furniture is optimal for workers. Finally, a validation of the improvement is carried out through a 5S pilot test, measurement of indicators, simulation in Arena and 3DSSPP software (Figure 7).

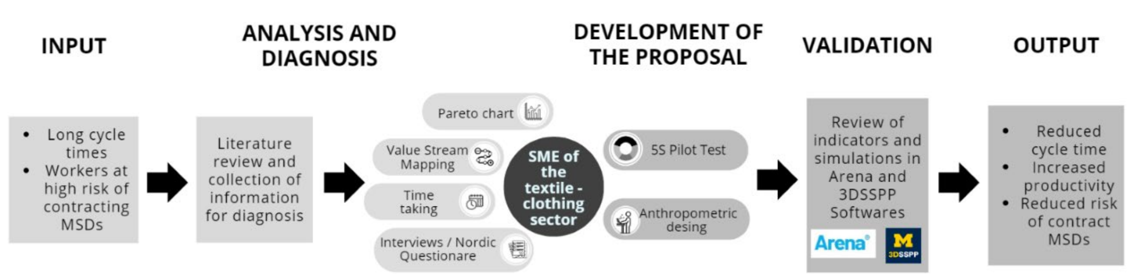

Figure 7. Improvement proposal model

5.4 Validation

A 5S pilot test was carried out in the cutting and sewing area, where 5S was implemented in 5 states during 15 days.

In the first classification stage, color cards, a visual management tool, were used to classify inputs, tools and equipment according to their level of use in order to eliminate unnecessary items. In the second stage, the objects were organized efficiently and assigned a specific place according to the process flow and level of use. For the third stage, a cleaning plan was defined where care and supervision activities were assigned in order to maintain the classification made, where the person in charge, area, product category and frequency were identified. In the fourth stage of standardization, inventory limits were defined for inputs, and colored tape was used to define specific spaces for tools and inputs in the work areas, and labels were placed to detail the type of product, information on inventory limits and regularity of cleaning. Finally, in the fifth stage, follow-up policies and training on the importance of 5S were established for workers, and a person responsible for verifying compliance with the defined standards was assigned. After the implementation of the pilot test, visits were made to evaluate the final situation and to time the cycle time per activity in both work areas. With the use of the Input Analyzer software, the distribution that best fit the sample of times obtained was determined, which was used as input data to simulate the process for each work area and thus obtain the cycle times. It is worth mentioning that simulation is one of the effective methods aimed at examining different solution scenarios (Nedra et al. 2022). In the present investigation, the Arena software was used, and the cycle time was determined as an indicator of the model. Figure 8 represents the simulation of the cutting and sewing process; after running the model, reductions in the cycle time of both processes were evidenced.

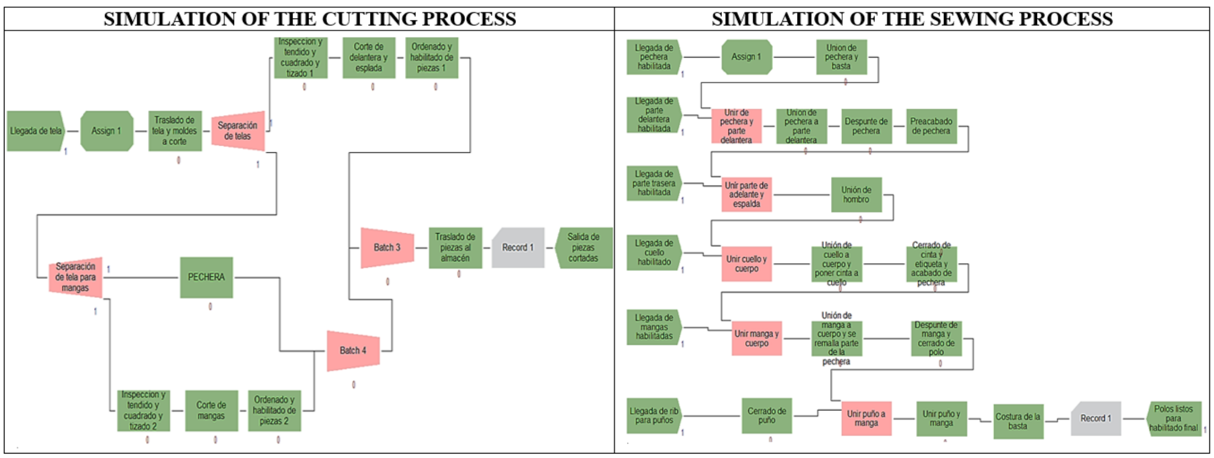

Figure 8. Simulation in Arena Software

In the study by Quiroz et al. (2021), the Delmia V5 software was used as a validation tool, which evaluates the behavior of the worker according to the positions adopted. In the present study, 3DSSPP software was used to simulate the postures of the cutting and sewing workstations pre and post improvement, with the objective of evaluating the improvement in the indicators provided by the program. Postures acquired by the operators were represented considering their anthropometric data, measurements of the station's furniture, force exerted, working hours, angles and positions formed by the body parts, as shown in Figure 9 and Figure 10.

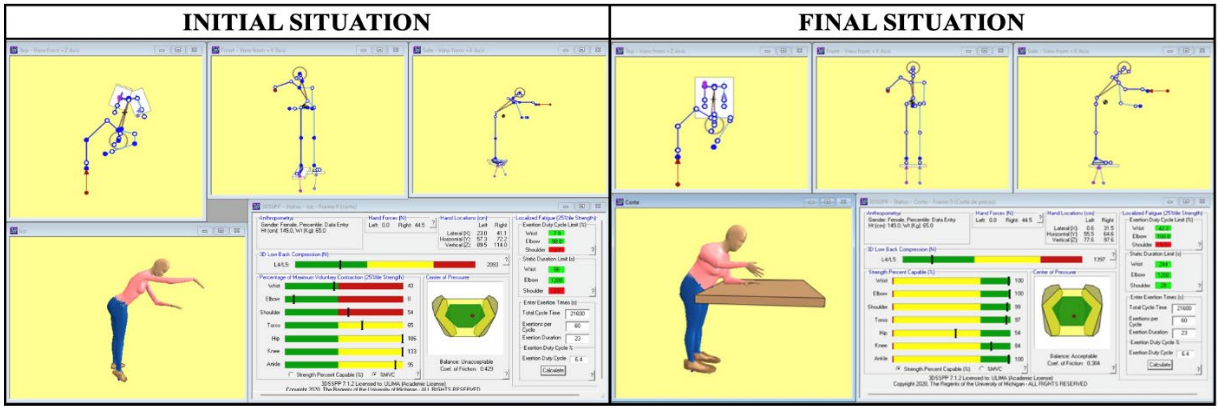

Figure 9. Variation of adopted cutting postures

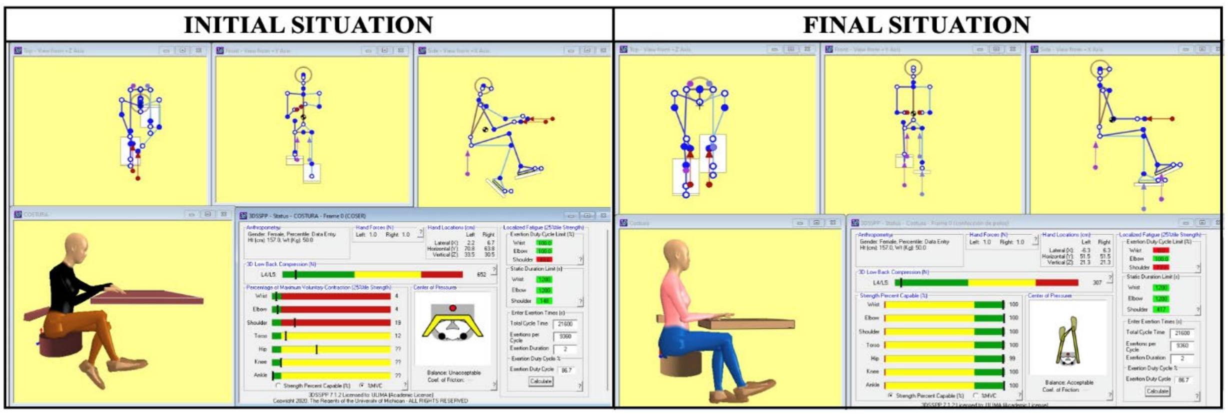

Figure 10. Variation of the adopted sewing postures

6. Conclusion

The contribution of the research is the combined use of the lean 5s tool and the anthropometric design to solve problems in the textile and apparel sector, considering the performance of the operative process, the working conditions and the well-being of the collaborators. After validation, it was evidenced that the methodologies under study generate a reduction in the process cycle time of 11.16% in the sewing area and 2.50% in the cutting process, as well as an improvement of 12.56% in the productivity of the cutting and sewing process. On the other hand, the compression of the lower back, maximum voluntary contraction, body balance and percentage of people who can maintain the postures studied without putting the worker's health at risk have shown a significant improvement. In addition, an average improvement of 62.5% was obtained in the Rula and Reba indicators, achieving risk levels between 1 and 2, which indicate that changes are not necessary and the postures are acceptable. All this reflects a reduction in the workers' risk of contracting musculoskeletal disorders. This improvement translates into higher productivity. It should be noted that it does not require a large initial investment for implementation, therefore, the use of these techniques is recommended for SMEs that need to increase their performance without making large capital investments. Among the limitations of the present research, it was found that the experimentation stage was carried out in a short period of time, due to the limited resources available. Therefore, it is proposed that future research should carry out validation stages in longer periods of time, since the existence of variables such as follow-up and control of the implementation, level of involvement and resistance to change of the workers or leaders of the organizations can directly affect the expected result. In addition, the use of more detailed anthropometric tools is recommended to improve the validity of the data. On the other hand, with respect to the anthropometric design tool, it is proposed that further research should consider ergonomic plans and training in the use of furniture, since the lack of knowledge or competence of the sector's collaborators may result in not achieving the expected benefit. The present study can be taken as a basis for future research to expand the analysis of new tools and/or methodologies that are considered pertinent, considering ergonomic and operational variables. Likewise, it is necessary to deepen the analysis of the different problems that the textile industry presents in aspects related to the planning of operations, thorough environmental evaluations of textile companies and the design of facilities that consider the well-being of the worker.

References

Aftab A., Ashfaq A., Iqra J., Nasif J., Usama A. and Amjad H., Investigation of ergonomic working conditions of sewing and cutting machine operators of clothing industry, *Industria Textila*, vol. 72, no. 3, pp. 309-314, 2021.

Alves D., Oliveira Z. and Cardoso J., Ergonomic Analysis of the Work in a Garment Industry in Laranjal-Minas Gerais, *International Journal of Engineering Trends and Technology*, vol. 64, no. 2, pp. 81-88, 2018.

Alkhoraif A., Rashid H. and McLaughlin P., Lean implementation in small and medium enterprises: Literature review, *Operations Research Perspectives,* vol.6, pp. 1 -19, 2019.

Baca J., Sánchez F., Castro P., Marcelo E. and Alvarez J.C. , Productivity Improvement In Companies of A Wooden Furniture Cluster In Peru, *International Journal of Engineering Trends and Technology*, vol. 69, no.10, pp. 97-107, 2021.

Bhattacharya, A., Nand, A. & Castka, P., Lean-green integration and its impact on sustainability performance: A critical review. *Journal of Cleaner Production,* vol. 236, pp. 1 – 19, 2019.

Bugvi, S., Hameed, K., Fawad, M., Irfan, A., Murtaza, S., Muhammad, Q. and Muhammad, B., Performance Improvement through Value Stream Mapping - A Manufacturing Case Study, *Jurnal Kejuruteraan,* vol. 34, no. 2, pp. 1007 - 1018, 2021.

Choobineh, A., Tabatabaei, S., Mokhtarzadeh, A. and Salehi M., Musculoskeletal problems among workers of Iranian Rubber Factory, *Journal of Occupational Health*, vol. 49, no. 5, pp. 418–423, 2007.

Colim, A., Morgado, R., Carvalho, J. and Sousa, N., An Empirical Study of the Work Conditions and Productive Performance After Collaborative Robotics Implementation in a Manufacturing Assembly Process, *FME Transactions*, vol. 49, no. 4, pp.859-866, 2021.

Dominguez, D., Mendoza, I., Navarro, C., Montoya, I., Cruz, S. and Vargas, O., ErgoVSM: A new tool that integrates ergonomics and productivity, *Journal of Industrial Engineering and Management*, vol. 14, no. 3, 2021.

Elsler, D., Takala, J. and Remes, J., An international comparison of the cost of work-related accidents and illnesses, Available :https://osha.europa.eu/en/tools-and-publications/publications/internationalcomparison-cost-work-related-accidents-and/view. Accessed July 07, 2024.

Fadillah M. and Muslim E., Ergonomic evaluation in a screen-printing division of a garment small-medium enterprise (SME) using the posture evaluation index in a virtual, *AIP Publishing,* vol. 2193, no. 1, pp. 050006-1–050006-8, 2019.

Gualtieri, L., Palomba, I., Merati, F. A., Rauch, E. and Vidoni, R., Design of Human-Centered Collaborative Assembly Workstations for the Improvement of Operators' Physical Ergonomics and Production Efficiency: A Case Study. *Sustainability,* vol. 12, no. 9, 2020.

Instituto Nacional de Estadística e Informática, Available: https://m.inei.gob.pe/estadisticas/indice-tematico/economia/, Accessed on April 01, 2025.

Kawalec, M., Pacana A. and Rewilak, J., Development of the 5S method implementation on the grounds of collected experience, *Zeszyty Naukowe. Organizacja i Zarządzanie/Politechnika Śląska*, vol. 119, no. 8, pp. 127-137, 2018.

Kose, Y., Civan, H., Ayyildiz, E. and Cevikcan, E., An Interval Valued Pythagorean Fuzzy AHP–TOPSIS Integrated Model for Ergonomic Assessment of Setup Process under SMED, *Sustainability,* vol. 14, no. 21, pp. 1-31, 2022.

Kumar, D., Mohan, G. and Mohanasundaram, K., Design & implementation of the production line in garment industry, *Industria Textila*, vol. 73, no. 6, pp. 687-692, 2022.

Lakhal, A., Sejri, N., Jaafar, F., Chaabouni, Y. and Cheikhrouhou, M., Elaboration of a rest index for a sewing post in a clothing industry, *Industria Textila,* vol. 70, no. 5, pp. 430-434, 2019.

Malhar, S., Kulkarni, V. and Kapali, C., Ergonomics Study for Injection Moulding Section using RULA and REBA Techniques, *International Journal of Engineering Trends and Technology,* vol. 36, no. 6, pp. 294-301, 2016.

Memari, A., Panjehfouladgaran, H., Abdul Rahim, A. and Ahmad, R., The impact of lean production on operational performance: a case study, *Asia-Pacific Journal of Business Administration,* vol. 16, no. 3, pp. 530.552, 2024.

Ministerio de la Producción Perú, Available: https://ogeiee.produce.gob.pe/index.php/en/shortcode/oee-documentos-publicaciones/publicaciones-anuales/item/1065-estudio-de-investigacion-sectorial-sector-textil-y-confecciones-2020, Accessed on March 30, 2025.

Nedra, A., Néjib, S., Boubaker, J. and Morched, C., An Integrated Lean Six Sigma Approach to Modeling and Simulation: A Case Study from Clothing SME, *Autex Research Journal,* vol. 22, no. 3, pp. 305-311, 2022.

Nunes, I. and McCauley, P., *Ergonomics – A systems Approach*, 1, Intech Open, 2012.

Quiroz, J., Aquino, D., Rodriguez, E. and Montoya, M., Redesign of Workspace Through an Ergo-Lean Model to Reduce Musculoskeletal Disorders in SMEs In the Clothing Accessories Sector, *International Journal of*

Engineering Trends and Technology, vol. 69, no. 12, pp. 163-174, 2021.

Shahin, M., Chen, F., Hosseinzadeh, A., Koodiani, H., Bouzary, H. and Shahin, A., Enhanced safety implementation in 5S + 1 via object detection algorithms. *International Journal of Advanced Manufacturing Technology,* vol. 125, no. 7, pp. 3701-3721, 2023.

Silvano. H. and Oliveira Z., Ergonomic Analysis of Call Center Work In A Company In City of Cataguases, *International Journal of Engineering Trends and Technology,* vol. 67, no. 11, pp. 16-22, 2019.

Vinoth, H. and Sivakumar, A., Integrating Ergonomic Factors with Waste Identification Diagram to Enhance Operator Performance and Productivity in the Textile Industry. *Transactions of Famena*, vol. 46, no. 1, pp. 1-21, 2022.

Yelin, E., Weinstein, S. and King, T., The Burden of Musculoskeletal Diseases in the United States, *Seminars in arthritis and rheumatism*, vol. 46, no. 3, pp. 259-260, 2016.

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