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AVALIAÇÃO ERGONÔMICA PELO MÉTODO RULA E FATORES ORGANIZACIONAIS EM UMA INDÚSTRIA COUREIRO-CALÇADISTA: UM ESTUDO DE CASO NO SETOR DE PREPARAÇÃO

ERGONOMIC ASSESSMENT USING THE RULA METHOD AND ORGANIZATIONAL FACTORS IN A LEATHER MANUFACTURING INDUSTRY: A CASE STUDY IN THE PREPARATION SECTOR

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Júlio César Ramos[1]

Jonas Henrique Reckziegel[2]

Jacinta Sidegum Renner[3]

Dusan Schreiber[4]

ABSTRACT

The object of investigation in this study is the preparation sector of a leather bag and accessories manufacturing company, the stage in which cut pieces are overlapped and adjusted before sewing. The objective was to assess the physical and organizational ergonomic conditions of this sector, identifying postural risks and dissatisfaction factors in the work routine. The methodological procedures combined quantitative and qualitative approaches, with direct observation, photographic records, semi-structured interviews with the sector's ten workers, and application of the RULA (Rapid Upper Limb Assessment) method to measure exposure to musculoskeletal risk factors. The results indicated a final RULA score of 6, an action level requiring investigation and short-term change, associated with inadequate and improvised furniture. The interviews revealed that 80% of operators reported tiredness at the end of the workday, with complaints concentrated in arm, neck, shoulder, and lower limb pain. It was also found that 60% of workers identified the receipt of incomplete pieces as the main operational bottleneck, and 30% mentioned excessive overtime as a wear factor. It is concluded that the postural problems are intertwined with work organization failures upstream of the sector, reinforcing that effective ergonomic interventions must combine physical workstation adjustments with changes in production flow management.

Keywords: ergonomics; RULA method; leather industry; occupational health; work organization.

RESUMO

O objeto de investigação deste estudo é o setor de preparação de uma indústria coureiro-calçadista de confecção de bolsas e acessórios em couro, etapa em que peças cortadas são sobrepostas e ajustadas antes da costura. O objetivo foi avaliar as condições

ergonômicas físicas e organizacionais desse setor, identificando riscos posturais e fatores de insatisfação na rotina de trabalho. Os procedimentos metodológicos combinaram abordagem quantitativa e qualitativa, com observação direta, registro fotográfico, entrevistas semiestruturadas com os dez trabalhadores do setor e aplicação do método RULA (Rapid Upper Limb Assessment) para mensurar a exposição a fatores de risco musculoesquelético. Os resultados apontaram escore final RULA igual a 6, nível de ação que exige investigação e mudança em curto prazo, associado a mobiliário inadequado e improvisado. As entrevistas revelaram que 80% dos operadores relatam cansaço ao final da jornada, com queixas concentradas em dores no braço, pescoço, ombros e membros inferiores. Identificou-se ainda que 60% dos trabalhadores apontam o recebimento de peças incompletas como principal entrave operacional, e 30% mencionam o excesso de horas extras como fator de desgaste. Conclui-se que os problemas posturais estão entrelaçados a falhas de organização do trabalho a montante do setor, reforçando que intervenções ergonômicas eficazes devem articular ajustes físicos do posto de trabalho a mudanças na gestão do fluxo produtivo.
Palavras-chave: ergonomia; método RULA; indústria de coureiro-calçadista; saúde ocupacional; organização do trabalho.

1. INTRODUCTION

The manufacture of bags and accessories in the leather and footwear industry brings together, within the same production line, highly repetitive manual tasks alongside stages that demand fine motor precision, such as cutting, beveling, and stitching the pieces. This type of production arrangement, common in small and medium-sized enterprises in the leather and footwear sector, tends to concentrate ergonomic risk factors at workstations that were rarely designed according to anthropometric criteria, having instead been adapted over time based on the availability of furniture and space (IIDA; GUIMARÃES, 2016).

Recent international literature shows that this scenario is not exclusive to the Brazilian context. Studies conducted in footwear, bag, and other leather goods manufacturing across different countries report a high prevalence of musculoskeletal discomfort associated with prolonged static postures, repetitive upper limb movements, and non-adjustable furniture (MOHAMED; RASHID, 2022; ISMAIL et al., 2024). At the same time, research focused on organizational ergonomics indicates that factors such as working hours, information flow between sectors, and management practices directly influence the perception of well-being and the incidence of fatigue, even when the apparent cause of the problem is predominantly postural (YPARRAGUIRRE et al., 2023; TUMOVÁ et al., 2022).

This article originated from a case study carried out in the preparation sector of a leather and footwear industry that manufactures bags and accessories, located in Rio Grande do Sul, responsible for producing approximately 14,000 bags per month and employing 92 workers. The preparation stage consists of overlapping the already-cut leather pieces, adjusting them according to the product's technical specifications, prior to sewing; this is a manual, repetitive activity that requires the worker to maintain a bent posture over the workbench for extended periods.

The question guiding this investigation is: to what extent do the physical conditions of the workstation and the organizational factors of the production flow jointly contribute to the ergonomic risk observed in the preparation sector? The study therefore sought to assess the ergonomic conditions of this sector through two complementary lenses: the biomechanical, by means of the RULA method, and the organizational, through semi-structured interviews with the workers directly involved in the activity.

The relevance of the study lies both in the scarcity of national research focused specifically on the preparation sector in leather and footwear manufacturing, a stage often overshadowed by studies centered on sewing or cutting, and in the opportunity to combine a well-established biomechanical assessment tool with a broader reading of the organizational determinants of the discomfort reported by workers. From a practical standpoint, the results may support decisions on furniture redesign, layout, and work schedule organization in similar production arrangements.

Methodologically, the research is characterized as a descriptive observational case study, with qualitative-quantitative data treatment, as detailed in section 3. The article is organized into five sections beyond this introduction: section 2 presents the theoretical framework, structuring the literature around postural assessment methods, ergonomics applied to manufacturing, the relationship between occupational health and work organization, and organizational ergonomics; section 3 details the methodological procedures; section 4 presents and discusses the results in light of the framework; and section 5 offers concluding remarks, the study's limitations, and suggestions for future research.

2. THEORETICAL FRAMEWORK

2.1. Ergonomics: Conceptual Foundations And Fields Of Application

Ergonomics is concerned with the fit between the demands of work and the physical, cognitive, and organizational characteristics of human beings. Moraes and Mont'Alvão (2010) define the field as the body of knowledge applied to the design, evaluation, and adaptation of tasks, workstations, products, and environments to people's needs, abilities, and limitations. In an earlier formulation, Moraes and Soares (1989) had already characterized ergonomics as a design technology for the communication between man, machine, work, and environment, a definition that anticipates the systemic character the discipline would assume in the following decades.

This systemic character became even more evident as the international literature began to treat ergonomics not merely as an injury-prevention tool, but as a strategic variable in organizational performance. Yparraguirre et al. (2023), analyzing the contribution of ergonomics to management systems and corporate governance, argue that well-structured ergonomic practices go beyond the operational level and have repercussions on productivity indicators, workforce retention, and regulatory compliance. Along similar lines, Mukalay, Swanepoel, and Nenzhelele (2025) propose, for small and medium-sized enterprises, a practical framework that links methodological advances in ergonomics to productivity targets, recognizing that the fragmentation between the two domains, the ergonomic and the productive, has historically been an obstacle to the adoption of improvements in smaller industrial settings.

Kroemer and Grandjean (2005) had already warned that adapting work to the worker is not limited to the design of the physical workstation but also involves the temporal organization of the workday, the distribution of breaks, and the pace imposed by production processes. Markova et al. (2022), discussing the prevention of occupational accidents and diseases through the implementation of ergonomic practices, reinforce this argument by pointing out that European occupational health and safety directives already explicitly recognize psychosocial and organizational factors as determinants of musculoskeletal risk, alongside strictly postural variables.

2.2. Postural Assessment Methods: RULA, REBA, And OWAS

Among the ergonomic assessment instruments aimed at identifying exposure to musculoskeletal risk factors, the RULA (Rapid Upper Limb Assessment) method stands out for its direct applicability to manual workstations that demand intensive use of the upper limbs. Originally developed to investigate work-related upper limb disorders, the method uses postural diagrams and a scoring system that combines the position of the arm, forearm, wrist, neck, trunk, and legs with force and muscle repetition factors, producing a final score that indicates the level of urgency for intervention (MCATAMNEY; CORLETT, 1993).

The applicability of RULA in manufacturing contexts has been widely documented. Mohamed and Rashid (2022), assessing automotive chassis assembly workers, compared the OWAS, RULA, and REBA methods and found that the choice of instrument influences the sensitivity of the analysis to different body segments, recommending the combined use of methods when the activity involves both the upper limbs and the trunk and legs. Korkmaz and Ünver (2024), in a study conducted at a gas spring factory, reached a similar conclusion when comparing REBA, RULA, and OWAS, noting that RULA tends to be more sensitive to static postures of the upper limbs, while REBA more accurately captures overload of the trunk and spine.

Specific sector applications reinforce the robustness of the method in small-scale manual activities. Bera et al. (2024) used RULA and REBA to assess goldsmiths in India, identifying crossed and prolonged seated postures as the main risk factors, an exposure pattern that bears a structural resemblance to bench-based activities such as sewing and the preparation of leather pieces. Similarly, Prashanth, Mangalpady, and Kar (2025) applied RULA to investigate the driving posture of underground mining truck operators, demonstrating the instrument's versatility beyond fixed manufacturing workstations. Mustafa et al. (2024) used RULA analysis in the development of a rehabilitation device for children with cerebral palsy, showing that the method can also guide the very process of product and device design, not only the diagnosis of already existing workstations.

Other studies have sought to improve the precision and speed of RULA data collection through assistive technologies. Sehrt et al. (2024) developed the Auto-REBA system, which combines virtual reality and motion capture to generate postural scores in real time, reducing reliance on manual observation subject to rater variability. Garcia Chica et al. (2027), in turn, proposed a hybrid model combining RULA with fuzzy logic to assess agricultural tasks in greenhouse tomato cultivation, illustrating a trend in recent literature toward integrating classic postural assessment methods with computational intelligence tools capable of handling the uncertainty inherent to biomechanical observation. Mahmood et al.

(2025) applied the REBA method, conceptually derived from RULA, to assess the posture of firefighters during hose rolling, proposing assistive devices validated through finite element simulation, illustrating how postural assessment frequently leads to the development of concrete, low-cost physical solutions.

2.3. Ergonomics Applied To Manufacturing Processes And Production Lines

When examining the literature focused specifically on manufacturing environments, a progressive shift becomes apparent, moving from the punctual assessment of individual workstations toward the optimization of entire production flows under ergonomic criteria. Dalle Mura and Dini (2024) present a genetic approach to assembly line balancing that incorporates ergonomics as an optimization objective alongside process efficiency, validating the proposal through sensitivity analysis. Zhao, Sun, and Nakade (2024) advance in this direction by proposing a mathematical model based on the OCRA method for the optimal switching problem between manual and automated production, starting from the premise that upper limb musculoskeletal disorders are among the most prevalent occupational diseases in industrialized countries.

This concern with balancing ergonomic factors and production indicators also appears in human-robot collaboration contexts. Chen et al. (2026) propose a multi-objective model for balancing collaborative assembly lines between humans and cobots, incorporating a fatigue and recovery criterion into the optimization function alongside robot energy consumption, an indication that worker physical ergonomics is increasingly treated, in the most recent literature, as an engineering parameter as relevant as traditional plant efficiency indicators. Mohammed et al. (2024), in a different setting, apply response surface methodology to optimize the ergonomic dimensions of micro electric vehicle seats, showing that postural assessment principles extend beyond the factory floor and reach product design itself.

The shift toward Industry 5.0 paradigms has intensified interest in automated ergonomic risk assessment systems. Ciccarelli, Papetti, and Germani (2025) describe a sensor-based system for continuous ergonomic risk assessment in manufacturing environments, arguing that traditional observational methods, despite being validated, are limited by rater subjectivity and the time required for systematic application. De la Torre et al. (2024), in turn, report the integration of human-centered simulations into educational production lines, using inertial sensors to refine the precision of ergonomic analysis, a direction that connects directly with the need, identified in this study, to complement traditional RULA observation with instruments capable of capturing the temporal dimension of postural exposure throughout the workday.

2.4. Occupational Health, Fatigue, And Musculoskeletal Risks

The occupational health literature converges on the finding that work-related musculoskeletal disorders (WMSDs) are among the leading causes of absenteeism and productivity loss in repetitive manual activities. Da Silva et al. (2023), investigating port crane operators, associated the prevalence of these disorders not only with the posture adopted during the task but also with broader working conditions, showing that purely biomechanical analysis tends to underestimate the complexity of risk determinants in real industrial settings.

This argument is reinforced by studies focused on logistics and internal transport operations. Akuma and Abdullah (2025) propose a conceptual framework for assessing ergonomic risk factors in railway maintenance operations, noting that repetitive and dynamic tasks, a characteristic also present in the manual preparation of leather pieces, require intervention mechanisms that go beyond the punctual adjustment of furniture. Ismail et al. (2024), in a study on warehouse workers in the courier sector in Malaysia, found that pressure from delivery volume and the absence of structured ergonomic interventions significantly increase exposure to injury, a pattern of production pressure that finds a direct parallel in the production volume demand observed in the leather bag preparation sector.

The relationship between the physical environment and fatigue has also been the subject of systematic investigation. Amalia, Ushada, and Pamungkas (2023) developed an artificial neural network model to determine workers' rest periods based on environmental ergonomics, starting from the observation that small and labor-intensive manufacturing enterprises frequently overlook the relationship between temperature, workload, and the need for physiological recovery. Eldaly, Eldin, and Elgizawi (2023) expand this discussion by analyzing the dilemma between reducing thermal stress in industrial spaces and the ergonomic arrangement of the work environment in low- and middle-income countries, finding that climate-control decisions are frequently made without considering their effects on the positioning and arrangement of workstations, a tension between thermal comfort and physical layout that also manifests, on a smaller scale, in artisanal leather manufacturing facilities.

The classic Brazilian literature on ergonomics had already recognized these environmental and organizational factors as constitutive parts of the risk picture. Santos (1997), in his manual on ergonomic work analysis, proposes an investigative methodology that links the analysis of actual work activity to environmental conditions, production organization, and the characteristics of the working population, an approach that moves away from a strictly biomechanical reading and aligns with the systemic perspective adopted in this study.

2.5. Organizational Ergonomics, Management, And Quality Of Working Life

A substantial body of recent literature focuses on the organizational dimension of ergonomics, understanding it not as a peripheral aspect but as a direct determinant of workers' perceived well-being. Tumová et al. (2022) discuss the importance of studying work environment ergonomics for managers and logistics specialists, arguing that managerial decisions, such as setting production targets, shift scheduling, and staff allocation, produce ergonomic effects as relevant as the physical design of the workstation. Matiringe and Płaza (2022), in a case study in the Polish construction logistics sector, highlight the tension between ergonomic and economic costs, noting that downtime resulting from accidents and absences frequently exceeds, in financial terms, the investment required for preventive ergonomic adjustment.

The relationship between organizational ergonomics and performance has also been investigated through efficiency analysis tools. Roy, Cho, and Avdan (2024) apply Data Envelopment Analysis (DEA) to assess the simultaneous improvement of ergonomic conditions and workplace performance, proposing a framework that identifies production units that are more efficient at reconciling both objectives. Nurmutia et al. (2025), researching logistics factors in cargo ports, use the Relative Importance Index to rank ergonomic problems in the work environment, a method that could be adapted to prioritize interventions in smaller manufacturing contexts such as the one investigated in this study.

Organizational culture and emerging digital factors have also begun to be incorporated into physical ergonomics analyses. Nurwildani et al. (2026) investigate the moderating role of digital culture in the relationship between physical ergonomics and organizational culture in small and medium-sized industries, finding that workers' perception of ergonomic conditions is influenced by cultural and managerial variables that extend beyond the immediate physical environment, a finding relevant to interpreting the organizational complaints, such as the receipt of incomplete pieces, identified in this study. Padhil et al. (2025) propose an integrative model for investigating occupational health and safety in micro, small, and medium-sized enterprises, combining a macro-ergonomic approach with the Human Factors Analysis and Classification System, recognizing that accidents and illnesses in smaller enterprises typically result from systemic organizational failures rather than isolated events.

Finally, the relationship between lean manufacturing practices and ergonomics has been the subject of growing attention. Trebuna et al. (2025) examine the connection between lean manufacturing and ergonomics, arguing that the elimination of process waste, including waste from unnecessary motion and waiting, tends to produce, as a beneficial side effect, improvements in the ergonomic conditions of workstations, even though this is not the primary goal of lean production tools. This argument is particularly relevant to the case investigated in this article, in which failures in the flow of information between the cutting and preparation sectors, manifested in the receipt of incomplete pieces reported by workers, simultaneously represent process waste and a source of psychological pressure on the daily work routine.

2.6. Sectoral Applications Of Ergonomics In Manual And Small-Scale Manufacturing Contexts

Studies focused on manual and artisanal production sectors, structurally similar to bag manufacturing in the leather and footwear industry, offer further support for interpreting the results of this study. Afrifa et al. (2025) developed a height-adjustable device built with locally available, low-cost materials to improve ergonomics in automotive services, demonstrating that technically simple and economically accessible ergonomic solutions can produce significant gains in manufacturing environments with limited resources, a finding particularly relevant to small and medium-sized enterprises in the leather and footwear sector, where replacing improvised furniture with low-cost adjustable solutions represents a viable avenue for intervention.

Ahmad et al. (2023) compared the ergonomic, productive, and economic performance of battery-powered and combustion-powered palm oil harvesting tools, showing that the choice of work equipment, not only the design of the fixed workstation, constitutes a relevant ergonomic variable in repetitive manual activities. Along similar lines, Alias, Udin, and Yaakub (2024) evaluated an innovative armrest for motorcyclists aimed at reducing muscle strain, reinforcing that low-cost assistive devices, when adjusted to the user's anthropometric characteristics, can mitigate postural risks identified in assessments such as RULA.

The literature also documents initiatives aimed at adapting workstations in educational and administrative settings, contributing to a broader understanding of ergonomic adjustment principles applicable to different types of furniture. Salima et al. (2023) analyzed, using RULA-based ergonomic criteria, improvised workstations for remote learning during mobility restrictions, finding that furniture not designed for the task, even when technically available, tends to induce harmful compensatory postures, a finding consistent with the improvised furniture identified in the preparation sector investigated in this article. Akinyoola, Kayode, and Monye (2025) discuss this same tension from the perspective of user-centered product design, arguing that durable ergonomic solutions emerge from the interplay between functional performance, aesthetics, and manufacturing cost, a balance that, in the case of improvised industrial furniture, is often sacrificed in favor of the immediate availability of materials, to the detriment of the postural adequacy of the person operating the workstation. Butlewski, Czernecka, and Zembik (2025) discuss the integration of motion capture technologies into the ergonomic design process, with managerial implications for systemic safety management, suggesting technological avenues for continuous monitoring that could complement punctual assessments such as the one carried out in this study. Finally, Xu et al. (2026) propose a maintainability ergonomics assessment model based on combined weighting of subjective and objective criteria, offering a methodological parameter relevant to future research seeking to rank, more systematically, the multiple dimensions of ergonomic risk identified in small-scale industrial environments such as the one investigated in this research.

2.7. Summary Of The Framework And Its Connection To The Research Problem

The literature review reveals three complementary trends in recent scientific output on ergonomics. First, well-established postural assessment methods such as RULA remain central, their validity continually confirmed across diverse manufacturing contexts, from artisanal jewelry-making in India to underground mining and automotive assembly lines, even as they are increasingly supplemented by technological tools that seek to reduce the subjectivity of manual observation. Second, there is a consolidated tendency to treat ergonomics not as a variable isolated to the workstation but as an element integrated into broader production management systems, ranging from lean manufacturing to cobot-assisted line balancing, repositioning the ergonomist as a contributor to strategic, not merely technical, decisions. Third, the literature on organizational ergonomics reinforces that factors such as working hours, information flow between sectors, and management culture produce effects on worker well-being that exceed the explanatory capacity of purely biomechanical instruments.

It is precisely at the intersection of these three trends that this article's research problem is positioned. The preparation sector under investigation simultaneously exhibits a postural exposure pattern characteristic of repetitive manual bench work, measurable through the RULA method, similar to the studies on goldsmiths and seamstresses reviewed earlier, and a set of organizational complaints related to material flow between sectors and the length of the workday, which connect directly with the literature on organizational ergonomics and lean manufacturing. The analysis and discussion section will revisit these theoretical strands to interpret the empirical data collected, showing the extent to which the case investigated confirms, qualifies, or challenges the findings of the reviewed literature.

Chart 1 – Structuring factors of well-being and ill-being at work

Structuring factor	Content
Working Conditions	Architectural equipment (floor, walls, ceiling, doors, windows, decoration, physical layouts); physical environment (workspaces, lighting, temperature, ventilation, acoustics); instrumental resources (tools, machinery, equipment, information devices, documentation, workstations, complementary furniture); raw materials (materials, informational bases); organizational support (information, supplies, technologies, compensation, training, and benefits policies).
Work Organization	Organizational mission, objectives, and goals (quality and quantity, parameter-setting); division of labor (hierarchical, technical, social); work process (cycles, stages, pace, types of pressure); conduct standards (knowledge, attitudes, expected skills, hygiene, attire/uniforms); prescribed work (planning, tasks, nature and content of tasks, formal and informal rules, technical procedures, deadlines); working time (workday [duration, shifts], breaks, vacation, flexibility); work management (controls, supervision, oversight, discipline).

Socio-professional Work Relations	Hierarchical relationships (immediate supervisors, senior management); peer relationships (coworkers, team members); external relationships (citizen-users of public services, clients and suppliers of private products and services, service providers, auditors, inspectors).
Recognition and Professional Growth	Recognition (of work performed, of effort, of dedication, of the hierarchy [immediate and senior supervisors], of the institution, of citizen-users / clients / consumers, of society); professional growth (use of creativity, skill development, training, opportunities, incentives, equity, career advancement).
Link Between Work and Social Life	Meaning of work (enjoyment, well-being, valuing of time spent at the organization, sense of social usefulness, healthy productivity); importance of the employing institution (personal meaning, professional meaning, family meaning, social meaning); social life (work-home relationship, work-family relationship, work-friends relationship, work-leisure relationship, work-society relationship).

Source: adapted from Ferreira (2012).

3. METHODOLOGY

In terms of its objectives, this research is classified as descriptive, and in terms of its procedures, as a single case study, insofar as it sets out to investigate in depth the ergonomic conditions of a specific production sector, with no claim to statistical generalization across the universe of leather and footwear industries (GIL, 2010; YIN, 2015). According to Prodanov and Freitas (2013), the observational method is among the most widely used in research of this nature, as it allows the actual work activity to be recorded within the very context in which it occurs. The approach adopted is mixed in nature, combining quantitative and qualitative data, which is justified by the very nature of the object under investigation: while postural exposure could be measured using a standardized instrument, workers' perceptions of fatigue, satisfaction, and organizational constraints required a qualitative approach capable of capturing meanings not reducible to numerical scales (FLICK, 2012; DEMO, 2022).

The research setting was the preparation sector of a leather and footwear industry that manufactures bags and accessories, located in Rio Grande do Sul, with a monthly output of approximately 14,000 units and a workforce of 92 employees. The study included the ten workers assigned to the preparation sector, corresponding to 10.8% of the company's total workforce and to the entirety of the professionals linked to this specific stage of the production process, thereby constituting a census of the investigated sector rather than a probabilistic sample.

Empirical data collection took place in 2019 and combined four complementary instruments: (i) direct observation of the work activity, with on-site monitoring of the operators' routine; (ii) photographic records of the workstations and the postures adopted during task execution; (iii) semi-structured interviews with the sector's ten workers, conducted using a script of open-ended questions on perceived fatigue, job satisfaction, and factors hindering task performance; and (iv) application of the RULA (Rapid Upper Limb Assessment) method, following the original protocol by McAtamney and Corlett (1993), to objectively measure exposure to musculoskeletal risk factors in the upper limbs, neck, trunk, and legs.

The treatment of interview responses followed the principles of content analysis (BARDIN, 2016), with responses grouped into emerging thematic categories related to physical sensations at the end of the workday, factors perceived as limiting the activity, and overall perceptions of the job, which were subsequently quantified in terms of relative frequency to allow for graphical presentation. This combination of qualitative categorical analysis with simple descriptive statistical treatment is consistent with exploratory research that seeks to capture both the recurrence and the singularity of the discourse of the subjects investigated (MARCONI; LAKATOS, 2017).

The application of the RULA method followed the steps set out in the original protocol: photographic recording of the typical posture adopted during the preparation activity, segmented scoring of the arm, forearm, wrist, and wrist twist (Table A), segmented scoring of the neck, trunk, and legs (Table B), and combination of the partial scores through Table C to obtain the final score, which classifies the urgency level of intervention on a scale from one to seven. The assessment was recorded on the standardized RULA monitoring worksheet (Cornell University, 1996), filled in with the date and identification of the sector evaluated.

It should be noted, as a methodological limitation, that the organizational dimension of the study relied on workers' self-reported perceptions, gathered through interviews, rather than on objective measurements of working hours, material flow, or productivity indicators. This is consistent with the descriptive and exploratory nature of the research but limits the possibility of establishing causal relationships between the organizational factors reported and the ergonomic scores obtained.

4. ANALYSIS AND DISCUSSION OF RESULTS

4.1. Characterization Of The Production Process And The Preparation Sector

The production process of the company investigated comprises eleven sequential stages, ranging from the receipt and inspection of raw materials to the shipment of the finished product: material receiving, storage, cutting, splitting, beveling, doubling, edge painting, preparation, sewing, inspection, and packaging/shipping. The preparation stage, the object of this study, sits between the finishing of the leather edges (beveling and edge painting) and the sewing itself, consisting of overlapping the cut pieces according to the product's technical specifications so as to ensure proper fit before stitching.

Figure 1 – Production process flowchart for the leather bag.

Process Flowchart					
Client	FEEVALE	Supplier	JÚLIO/ JONAS	Doc No.	01
Model code	0005	Supplier code	S50018	Doc Date:	29/11/2019
Product name: Leather bag					

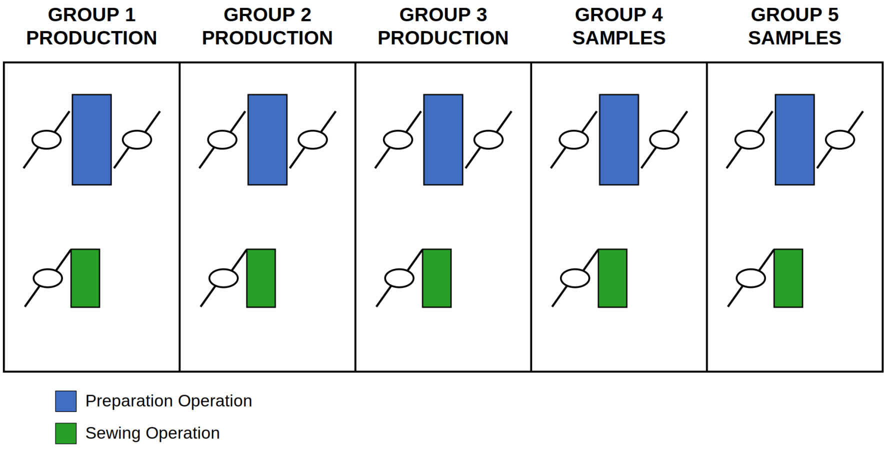
Legend: ⧈ Operation/Inspection ◯ Operation □ Inspection ▽ Storage

Step	Flow	Step description
10. Receive Material	⧈	Receive, inspect, and identify materials.
20. Store	▽	Store and protect according to the specifications of each material.
30. Cut	⧈	Cut leather, fabric, synthetic pieces by hand, and/or band saw, and/or Atom automatic cutting machine.
40. Split	◯	Split the leather to leave the thickness adequate, according to the specifications of the cuts in the product's technical sheet.
50. Bevel	◯	Bevel leather pieces to leave the leather edges with a thickness finished at 0.1mm, for better finishing when overlapping the leather pieces.
60. Double	⧈	Double the leather with different types of fabric, to give structure to the bag, according to the specifications of the cuts in the product's technical sheet.
70. Paint Edge	◯	Paint the leather edge, to give finishing to the borders.
80. Prepare	◯	Prepare leather pieces, overlapping one over another, according to the assembly of the confirmation bag.
90. Sew	◯	Sew leather pieces.
100. Inspect	□	Perform visual inspection, finishing, and place TAG, according to the product's specifications.
110. Pack/Ship	◯	Pack, identify packaging, and ship to client according to requirements.

Source: developed by the authors.

The production flowchart shows that the sector is organized into five work groups, three dedicated to ongoing production and two to sample-making, each comprising one preparation station and one sewing station. This configuration indicates that the preparation activity does not constitute an isolated structural bottleneck but is instead distributed across multiple stations operating in parallel, which, in light of the assembly line balancing literature, suggests that one-off ergonomic interventions at a single station would have limited reach unless replicated in a standardized way across all five groups (DALLE MURA; DINI, 2024; ZHAO; SUN; NAKADE, 2024).

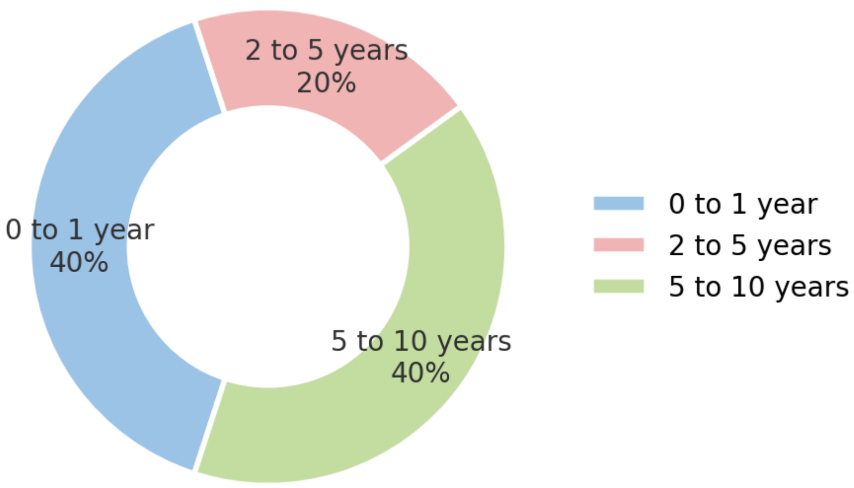
Figure 2 – Distribution of production and sample groups (Preparation and Sewing operations).



Source: developed by the authors.

The sector's workforce shows a bimodal distribution in terms of tenure: 40% of operators have been with the company between zero and one year, another 40% between five and ten years, with only 20% in the intermediate range of two to five years. This configuration is consistent with two non-mutually exclusive scenarios: a relatively recent turnover process that renewed part of the workforce, and the retention of a core of experienced workers who have remained in the role for longer. The coexistence of these two profiles is relevant for interpreting the fatigue and satisfaction data presented below, since newly hired workers and long-tenured workers may develop different strategies for coping with the postural demands of the task, although the data collected do not allow, in this study, for responses to be segmented by tenure.

Figure 3 – Tenure of employees in the preparation sector.



Source: developed by the authors.

4.2. Postural Assessment Using The RULA Method

Applying the RULA method at the preparation workstation produced the following partial scores: in Table A, the arm score was 2, the forearm score was 2, the wrist score was 3, and the wrist twist score was 1, combining for a final arm-and-wrist score of 4. In Table B, the neck score was 4, the trunk score was 3, and the legs score was 1, resulting in a final neck-trunk-legs score of 6. Combining these two results in Table C, together with the muscle use score (1) and the force/load score (0), produced a final score of 6.

Chart 2 – RULA scores obtained at the preparation workstation

Component assessed	**Score**
Arm score	2
Forearm score	2
Wrist score	3
Wrist twist score	1
Final arm and wrist score (Table A)	**4**

Neck score	4
Trunk score	3
Legs score	1
Final neck, trunk, and legs score (Table B)	**6**
Muscle use score	1
Force/load score	0
Final score (Table C)	**6**

Source: developed by the authors, based on the protocol by McAtamney and Corlett (1993).

According to the method's action-level classification (MCATAMNEY; CORLETT, 1993), scores of 5 or 6 indicate a risk level requiring further investigation and short-term change, an intermediate position between level 3-4 ("investigate and change, if possible") and level 7 ("investigate and change immediately"). The result obtained therefore places the preparation activity at an attention threshold that, while not constituting an ergonomic emergency, warrants a planned intervention within a defined timeframe.

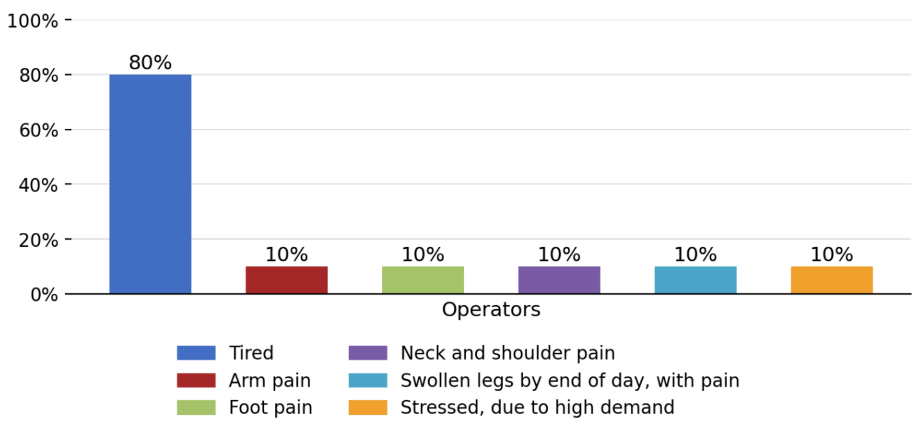
Breaking down the partial scores offers relevant clues for the biomechanical interpretation of the finding. The high neck score (4) is consistent with the nature of the preparation task, which requires the head to remain tilted for extended periods in order to visually follow the precise overlapping of leather pieces on the workbench, a postural pattern widely documented in manual bench-manufacturing activities, as observed by Bera et al. (2024) among Indian goldsmiths who adopt flexed cervical postures for prolonged periods. The trunk score (3), in turn, is consistent with the hypothesis of furniture poorly matched to the height of the task, a finding that converges with Salima et al. (2023), who note that workstations not specifically designed for the activity tend to induce compensatory trunk postures even when furniture is technically available.

It is worth noting that the comparatively low scores for the legs (1) and for force/load (0) indicate that the preparation activity does not involve substantial physical effort or static overload of the lower limbs, distinguishing the risk pattern identified in this study from lifting or load-carrying activities frequently associated with high RULA scores in other manufacturing contexts, such as the one reported by Mohamed and Rashid (2022) in automotive chassis assembly operations. The risk identified here is therefore concentrated in the static neck and trunk posture sustained during the precision manual task, rather than in raw physical effort, a distinction relevant for designing intervention measures, which should prioritize adjusting the height and tilt of the workbench rather than reducing the physical load itself.

4.3. Workers' Perception Of Fatigue And Discomfort

The interview question on how operators felt at the end of the workday revealed that 80% of the ten operators reported feeling "tired", a figure that, on its own, already indicates a high prevalence of self-reported fatigue. The remaining responses, each mentioned by 10% of those interviewed, were distributed among arm pain, foot pain, neck and shoulder pain, swollen legs with pain by the end of the day, and a feeling of stress due to high demand, with the sum of percentages exceeding 100%, indicating that some respondents reported more than one symptom simultaneously.

Figure 4 – Workers' perception at the end of the workday.



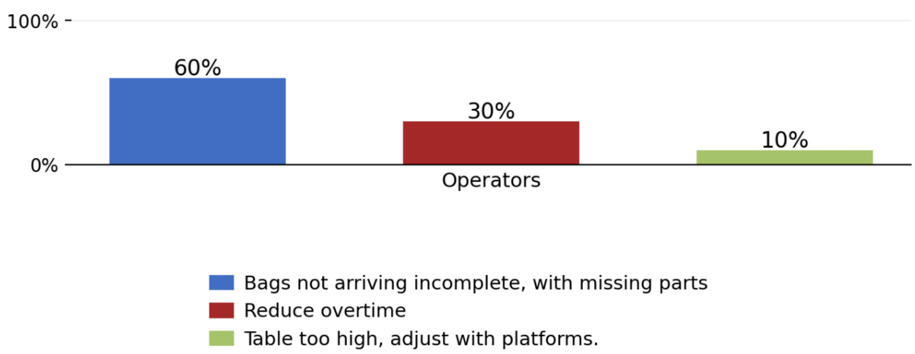
Source: developed by the authors.

The concentration of complaints in the neck, shoulders, and arm directly corroborates the risk pattern identified by the RULA method, whose highest score fell precisely on the cervical segment. This alignment between the standardized biomechanical instrument and workers' subjective perception strengthens the validity of the ergonomic diagnosis performed and is consistent with what Da Silva et al. (2023) describe as a convergence between formal postural assessment and spontaneous reports of discomfort in bench-based and repetitive manual operations. The mention of swollen legs and stress from high demand, in turn, points to dimensions of discomfort that lie beyond what RULA, as an instrument centered on the upper limbs and trunk, is able to capture, signaling the importance of pairing the method with a broader qualitative inquiry, in line with what Amalia, Ushada, and Pamungkas (2023) advocate when incorporating environmental and psychophysiological load variables into the ergonomic analysis of intensive manual activities.

4.4. Organizational Factors Perceived as Limiting The Activity

When asked what could be improved to facilitate the performance of their task, 60% of the workers pointed to receiving incomplete bags, with missing parts, as the main obstacle; 30% mentioned reducing overtime; and, with 10% each, came the need to adjust the height of the table using platforms and the occurrence of discrepancies in the modeling of the bag received for preparation.

Figure 5 – Factors identified by workers as necessary to improve task performance.



Source: developed by the authors.

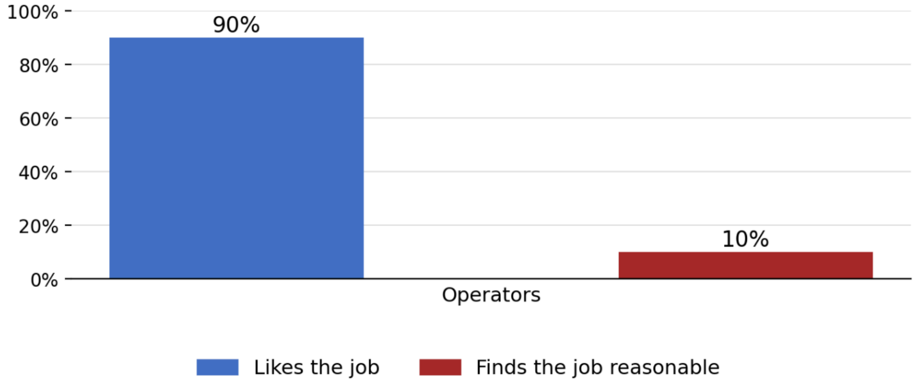
This result is particularly revealing because it shifts the focus of the predominant complaint away from the strictly physical domain of the workstation and toward the organizational domain of the flow between sectors. Receiving incomplete pieces, a problem mentioned by the overwhelming majority of those interviewed, is not a failure of the preparation station itself but rather an upstream dysfunction, likely originating in the cutting and doubling stages that precede it in the production flowchart. This finding connects directly with the literature on lean manufacturing and ergonomics: Trebuna et al. (2025) argue that process flow failures, such as incomplete materials arriving at a workstation, simultaneously constitute productive waste and a source of psychological pressure on the worker, who must interrupt the task, search for the missing piece, or adjust their work pace to compensate for the inconsistency received.

The second most frequent complaint, the extension of the workday through overtime, mentioned by nearly a third of those interviewed, connects directly to excessive working hours as a fatigue factor, and finds theoretical support in Tumová et al. (2022), who discuss the centrality of managerial decisions on scheduling and working hours to the organizational ergonomic picture, and in Kroemer and Grandjean (2005), who had already warned about the cumulative effects of extended working hours on workers' capacity for physiological recovery. The mention, however brief, of the need to adjust table height using platforms confirms, in the workers' own words, the diagnosis of inadequate furniture identified both through direct observation and through the RULA score, showing that the solution to this specific problem is already intuited by the operators themselves, even though it had not yet been implemented.

4.5. Overall Perception Of Work And The Tension Between Satisfaction And Physical Discomfort

A seemingly counterintuitive finding emerges from the third interview question: 90% of workers stated that they enjoy the work they do, and the remaining 10% considered it reasonable; no worker expressed overall dissatisfaction with the activity. Taken in isolation, this result might suggest the absence of any relevant problems in the sector; however, when triangulated with the RULA scores and the high prevalence of reported fatigue, it instead reveals a dissociation between satisfaction with the content and meaning of the work, on one hand, and the physical discomfort arising from the conditions under which that work is performed, on the other.

Figure 6 – Workers' overall perception of their own work.



Source: developed by the authors.

This dissociation is directly supported by the theoretical framework concerning the structuring factors of well-being and ill-being at work, as proposed by Ferreira (2012). According to the categorization adopted in this study (Chart 1), the meaning of work, which includes enjoyment, well-being, and healthy productivity, is just one of five dimensions that make up the work experience, alongside working conditions, work organization, socio-professional relationships, and recognition and professional growth. The data collected suggest that the dimension of the "link between work and social life" and the meaning attributed to the task remain preserved for most of the workers interviewed, whereas the dimension of "working conditions", which encompasses furniture and physical arrangements, and that of "work organization", which encompasses scheduling and process flow, concentrate the problems identified both by the RULA assessment and by the organizational complaints reported.

This pattern is consistent with the literature that treats ergonomics as a multidimensional variable that cannot be reduced to a single indicator of overall satisfaction. Yparraguirre et al. (2023) and Mukalay, Swanepoel, and Nenzhelele (2025) converge in arguing that inadequate ergonomic practices can coexist, over extended periods, with reasonable levels of subjective worker satisfaction, especially when the bond with the activity, with coworkers, or with the employing institution remains positive; this, however, does not eliminate the risk of medium- and long-term musculoskeletal illness, nor does it justify postponing ergonomic interventions identified as necessary by the assessment instruments themselves.

4.6. Integrative Synthesis: Linking Physical Risk And Work Organization

A joint reading of the results shows that the case investigated cannot be adequately understood from a single dimension of analysis alone. The RULA score of 6 identifies a concrete postural risk, concentrated in the neck and trunk, arising from furniture poorly suited to the preparation task, a finding fully aligned with the literature on postural assessment in manual bench-work activities (BERA et al., 2024; KORKMAZ; ÜNVER, 2024; SALIMA et al., 2023). On its own, this physical risk would already justify a physical ergonomic intervention centered on redesigning the workstation.

However, the organizational complaints raised through the interviews, above all the receipt of incomplete pieces and excessive overtime, indicate that a substantial part of the discomfort reported by workers originates in decisions and dysfunctions that extend beyond the preparation station itself, lying instead in the broader production flow and in the management of working hours. The problem of receiving incomplete pieces, in particular, is of the same nature as the coordination challenges between supply chain stages described by Iyer, Seshadri, and Vasher (2010) with reference to the Toyota Production System: internally as well, between sectors of the same plant, the lack of synchronization between whoever supplies the material (cutting and doubling) and whoever receives it (preparation) produces the same effects of waiting, rework, and variability that supply chain management seeks to eliminate at an interorganizational scale. This finding supports the central thesis of the organizational ergonomics literature reviewed in this study: that interventions focused exclusively on the physical adjustment of the workstation, although necessary, as demonstrated by the RULA score obtained, tend to yield only partial gains unless accompanied by changes in the organization of material flow between sectors and in the management of working hours (TUMOVÁ et al., 2022; TREBUNA et al., 2025; MATIRINGE; PŁAZA, 2022).

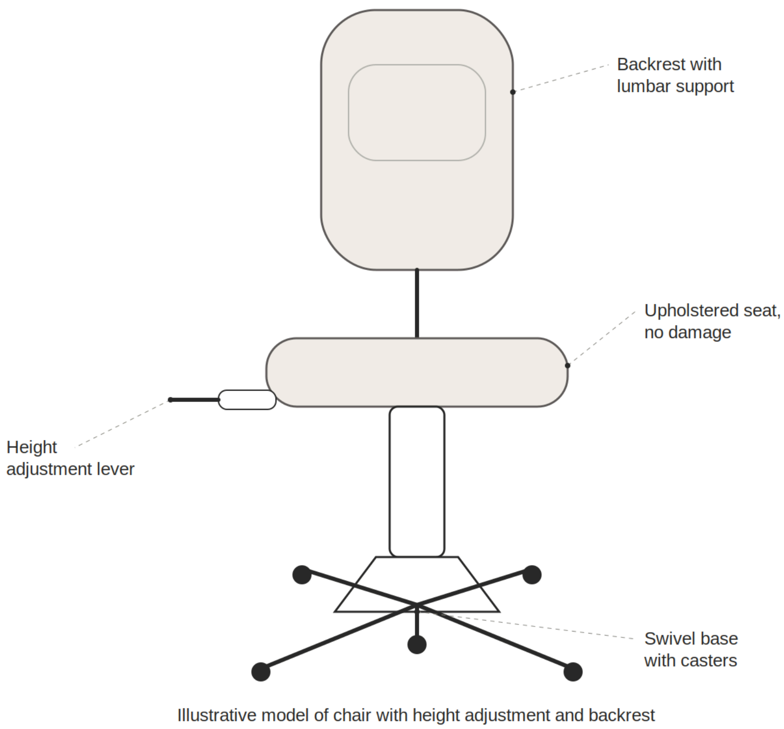
The nature of the solutions suggested by the workers themselves, adjusting table height with platforms, reducing overtime, and ensuring greater consistency in the receipt of pieces, also points to a methodological path for the intervention phase that would follow this diagnosis: the adoption of user-centered design processes, in which the operator themselves is invited to take part in conceiving solutions, in line with the Design Thinking principles systematized by Vianna et al. (2012). The qualitative listening carried out in this research already points, in an embryonic way, toward this type of co-creation, insofar as the workers spontaneously formulated, during the interviews, improvement proposals that are technically feasible and low-cost to implement.

In summary, the case of the leather and footwear bag and accessories manufacturer investigated illustrates, on a smaller scale, the same phenomenon identified by international literature in more complex manufacturing contexts: the ergonomic risk observable at a specific workstation can rarely be fully explained by the biomechanics of the isolated task alone, requiring, for it to be properly understood and effectively mitigated, the simultaneous consideration of the physical and organizational determinants that shape the work experience.

4.7. Practical Outcome: Approval And Implementation Of Improvements

At the time of data collection, in 2019, it was observed that the furniture used by workers in the preparation sector consisted of stools without backrests, some of them with damaged upholstery, which directly corroborates the RULA score obtained and the cervical and dorsal discomfort complaints reported by the operators. Following the presentation of this study's results to the company's industrial director, the latter approved, in 2020, an investment aimed at replacing all the stools in the preparation sector with chairs featuring height adjustment and a backrest, as shown in the illustrative model presented in Figure 7.

Figure 7 – Illustrative model of a chair with height adjustment and backrest, similar to the one acquired by the company to replace the stools in the preparation sector. Illustrative image, with no correspondence to any specific commercial brand or model.



Source: prepared by the authors.

This managerial decision represents a concrete example of translating an ergonomic diagnosis into corrective action, and it aligns directly with the organizational ergonomics literature reviewed: by recognizing inadequate furniture as the central determinant of the RULA score obtained and allocating financial resources to its replacement, the company's management corroborates the argument made by Matiringe and Płaza (2022) that preventive investment in ergonomic conditions tends to be offset by reduced costs associated with absenteeism and productivity loss. The choice of chairs with height adjustment and a backrest also directly addresses one of the solutions intuited by the workers themselves during the interviews, when they mentioned the need to adjust the height of the workstation.

5. CONCLUDING REMARKS

This study aimed to assess the physical and organizational ergonomic conditions of the preparation sector of a leather and footwear industry that manufactures bags and accessories, combining the application of the RULA method with semi-structured interviews with the sector's workers. The proposed objectives were achieved: a RULA score of 6 was identified, indicating the need for investigation and short-term change, predominantly associated with neck and trunk postures resulting from inadequate furniture; and, through the interviews, organizational factors, the receipt of incomplete pieces and excessive overtime, were found to be as relevant to workers' perceived strain as the postural factors themselves. As a practical outcome of the research, presenting the results to industrial management led to the approval, in 2020, of an investment to replace the sector's furniture with chairs featuring height adjustment and a backrest, demonstrating the direct applicability of the ergonomic diagnosis to the management of the company investigated.

The main contribution of this study lies in showing, within a specific context of small-scale manual manufacturing, the need to link physical ergonomic diagnosis with organizational diagnosis, moving beyond the common practice of treating these two dimensions in isolation. The finding that 90% of workers report enjoying their work, alongside a high prevalence of fatigue and a RULA score that calls for intervention, reinforces that subjective satisfaction should not be taken as a sufficient indicator of the ergonomic adequacy of a workstation.

Among the study's limitations are the small sample size, even though it corresponds to the entirety of the workers in the sector investigated, the self-reported nature of the organizational data, gathered through interviews rather than through direct measurement of process indicators, and the impossibility of establishing causal relationships between the organizational factors reported and the ergonomic scores obtained, given the cross-sectional and descriptive design of the research.

For future studies, it is suggested that the RULA assessment be extended to the other production and sample groups identified in the company's flowchart, in order to verify whether the postural risk pattern identified in the group investigated is replicated at the other preparation and sewing stations; that the material flow between the cutting, doubling, and preparation sectors be quantitatively investigated, with a view to identifying the exact origin of the incomplete pieces reported by workers; and that longitudinal studies be carried out capable of tracking the evolution of musculoskeletal complaints over the course of workers' tenure, given the bimodal tenure distribution identified in this research.

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[1] Bacharel em Engenharia de Produção pela Feevale, técnico em Calçado (SENAI) e Contabilidade (IFSUL), Mestrando em Qualidade Ambiental na Universidade Feevale (Bolsista CAPES) e cursando pós-graduação em Docência no IFSUL. ORCID: https://orcid.org/0009-0002-2821-0299 E-mail: acesse o artigo original para visualizar o e-mail

[2] Graduação em Engenharia de Produção pela Universidade Feevale, Técnico em Informática pela IECEG-CNEC. E-mail: acesse o artigo original para visualizar o e-mail

[3] Possui Doutorado e Mestrado em Engenharia de Produção com ênfase em Ergonomia (UFRGS). Fez especialização em Saúde e Trabalho (UFRGS/CEDOP), graduada em Fisioterapia pela Universidade Feevale. Professora de Ensino Superior da Universidade Feevale. E-mail: acesse o artigo original para visualizar o e-mail

[4] Doutor em Administração (UFRGS), Mestre e Bacharel em Administração (Unisinos). Professor e pesquisador da Universidade Feevale nos programas de Pós-Graduação de Administração, Qualidade Ambiental e Indústria Criativa, e docente na IENH. E-mail: acesse o artigo original para visualizar o e-mail