

Análisis ergonómico en el área de empaque de la Empresa Productos Lácteos Escambray

Ergonomic analysis in the packaging area of the company Milk Products Escambray

Juan Antonio Mateo-Rodríguez; Anicel García-Rodríguez; Niurka Carrera-Bravo

Universidad de Cienfuegos, Cienfuegos, Cuba

Correo (s) electrónico (s)

juanantoniomateorodriguez1990@gmail.com

anicelgarcia8412@gmail.com.

niurkacarrerabravo71@gmail.com

ORCID:<http://orcid.org/0009-0005-1464-7061>

<http://orcid.org/0000-0002-4586-3139>

<https://orcid.org/0000-0001-8660-1488>

Recibido: 6 de noviembre de 2023

Aceptado: 16 de enero de 2024

Resumen

La investigación se cometió en la Empresa de Productos Lácteos Escambray de Cienfuegos, con el objetivo de realizar un análisis ergonómico en el área de empaque para contribuir a la eliminación de las no conformidades detectadas en el sistema de gestión de la calidad, el incremento de la productividad y a la adecuada implementación de las disposiciones legales aprobadas en materia laboral. Se utilizan entrevistas, observaciones directas, revisión de documentos, así como técnicas para el análisis desde el punto de vista ergonómico tales como el método Rapid Upper Limb Assessment. Como resultado se determinan el gasto energético, la capacidad de trabajo física de los obreros y se proponen mejoras para las diferentes posturas adoptadas. El estudio conduce al bienestar del trabajador, la reducción de gastos, aumento de la productividad, cumplimiento de la legislación laboral vigente y a eliminar no conformidades asociadas con la certificación de la calidad.

Palabras clave: Análisis ergonómico; No conformidades; Gestión de la calidad; Productividad; Seguridad y salud del trabajo.

Abstract

The research was carried out at the Escambray Milk Products Company in Cienfuegos, with the objective of performing an ergonomic analysis in the packing area to contribute to the elimination of the nonconformities detected in the quality management system, the increase of productivity and the adequate implementation of the legal provisions approved in labor issues. Interviews, direct observations, document review and ergonomic analysis techniques such as the Rapid Upper Limb Assessment method are used. As a result, the energy expenditure and the physical work capacity of the workers are determined and improvements are proposed for the different postures adopted. The study leads to worker welfare, cost reduction, productivity increase, compliance with current labor legislation and elimination of non-conformities associated with quality certification.

Keywords: Ergonomic analysis; Nonconformities; Quality management; Productivity; Occupational health and safety.

Introduction

According to Alonso (2006), "human beings have always tried to adapt what they do and the environments where they live to their own use. This field is precisely the one that studies ergonomics, the adaptation to the capabilities of the worker, of the human being" (p. 10). In line with this, Gomes (2014) refers that.

(...) the evolution of the industrial society in the last centuries has been demanding from ergonomics and Production Engineering a joint and continuous effort towards the provision of solutions in order to meet the needs of modern societies. (p.5)

Its implementation contributes to increase work efficiency by guaranteeing the well-being of man in the performance of his work through an adequate design of the means and of the workstation in general. A deficient adaptation of man to the work place can be the cause of errors, accidents, low production, among other elements that negatively affect the results of the organization.

In Cuba, the term occupational safety and health (OSH) encompasses an integral conception of what can be understood by safety in the workplace and focuses on the prevention of risks that may affect people, facilities and the environment, also including damages that affect the quality of products and services, competitiveness and economic efficiency. The need to increase the culture and promote the sustained development of OSH, as well as the implementation of prevention programs integrated to the general management of the company, are reasons of prioritized attention for the implementation of the business improvement process in Cuban organizations since 2009.

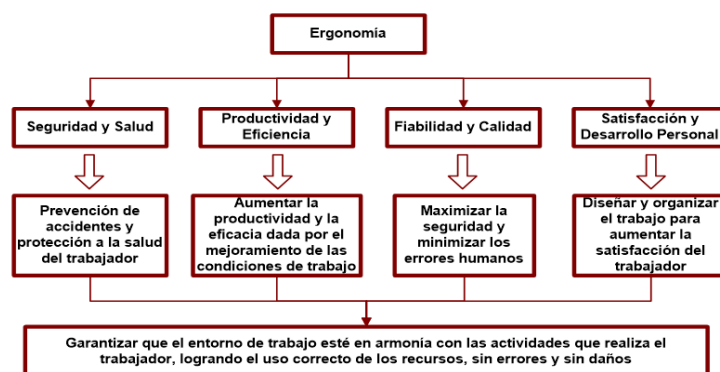
The Labor Code (2013) and its Regulations (2014) consolidate and improve the regulations in this area. These regulations establish the obligation of the organization to comply with OSH legislation.

Therefore, it is necessary to adopt measures to ensure safe working conditions, as well as the prevention of occupational accidents, occupational diseases or other damages that may affect the health of workers and the working environment. In addition, risks at work must be identified and evaluated and preventive actions must be taken to reduce or avoid them.

At present, given the demands of the environment and the need to increase competitiveness, the implementation and certification of the quality management system (QMS) is a strength for Cuban entities. Given the unique nature of the entity's productions and its impact on the local and national economy, it is working to achieve the certification of the quality management system based on the ISO 9001: 2015 NC. This standard, in order to ensure compliance with the requirements of the product or service, establishes several paragraphs related to the need to adequately manage the necessary conditions in terms of environment and infrastructure in all operations and/or processes.

For the sake of compliance with these obligations, the correct management of OSH is vital and within it, Ergonomics acquires a fundamental role. Authors such as Riesco (2019), warn about the field of action and objectives of the same (see image 1), evidencing the positive impact on the efficiency, effectiveness and satisfaction of internal and external customers of the organization.

Image 1 Main objectives of ergonomics



Source: Taken from Riesco, 2019

The company's need to properly manage the infrastructure and work environment required by current legislation, through the improvement of OSH, justifies the development of the study to obtain information in this regard and to know the ergonomic factors that influence work performance, conditions, expenses, productivity and worker's health in the organization. Based on this situation, the general objective of the research was oriented to develop an ergonomic analysis in the packing area for the improvement of OSH management in the Escambray Milk Products Company (EPL), in Cienfuegos province, and in turn contribute to the implementation of the entity's QMS. Development

Sample and methodology

The different methods and techniques assumed for the research are based on the dialectical-materialistic approach; of the theoretical type, the historical-logical one is used to know the evolution and importance of Ergonomics within the labor context, the analysis and synthesis and the inductive and deductive in order to establish the relationship between the analyzed elements. Among the empirical methods used the bibliographic review and analysis, interview, documentary analysis and the application of techniques.

An analytical study was carried out to identify the area with the highest prevalence of injuries. For this purpose, the records of the company's human capital management and the statistical information of the company in the year 2022 and the first three quarters of the year 2023, related to medical certificates, were reviewed. The analysis was performed on workers in the selected production area who agreed to participate in the study and workers who did not attend the day were eliminated.

As a starting point, the tool called Diagnostic Technology is applied. The use of the same has been validated, initially from the NC 3000:2007, related to the Integrated Human Capital Management System (SGICH), in Cuban entities and by authors such as Dousat et al. (2011) and Cuesta (2020). This allows detecting those gaps present in the organization, related to the management of human resources, which limit the achievement of superior results and the increase in productivity.

In the development of the research, NC 116: 2001 is used, which establishes the basic ergonomic requirements to be considered in positions, processes and work activities valid to ensure the safety, health and welfare of the worker, as well as to contribute to the quality and efficiency of their work. It states that the requirements must be considered when designing, constructing, organizing, maintaining or managing.

The determination of energy expenditure during work is of practical importance, while the comparison with the physical work capacity is decisive in order to detect limiting factors in daily performance. In agreement with Mateo and Garcia (2023), metabolic consumption from activity components is the most commonly used method. It estimates the metabolism according to the postures adopted while performing the task, the type of work, as well as the variation of the same with the speed of the movement, allowing calculating this component from the displacement studied, finally, it takes into account the basal metabolism.

In order to preserve health by reducing exposure to risk factors, it is vital to know the worker's capabilities and limitations. Taking into account the elements presented by Real (2011), the bench test is used as a method for estimating physical work capacity. This is practical to develop these studies and takes into account energy consumption, heart rate, sex, height and weight.

Authors such as Alonso (2006), have addressed the importance of anthropometry and its use as a tool of ergonomics in order to adapt the environment to people, and thus establish a compatible and harmonious relationship between the worker and his environment.

The evaluation of the physical postural load and the presence of psychosocial aspects is evaluated in detail by the Rapid Upper Limb Assessment (RULA) method, which, according to Real (2011), is vital because it considers the exposure to risk factors for musculoskeletal disorders.

To facilitate the work, the e-Rula software version 1.1 is used, which is applied to the most frequent postures that describe the work performed by the operator in the different activities that make up the "Packaging" operation.

Results

Organizational context

The Escambray Milk Products Company (EPL) is located in the industrial zone, km 1, Cumanayagua, Cienfuegos province. It is unique in the territory and is subordinate to the Agri-Food Industry Business Group, which belongs to the Ministry of the Food Industry (MINAL). The organizational structure groups the areas of regulation and control of Human Capital, Technical and Development, Production, Accounting and Finance and General Management. The following units are designed for production: Pasteurizer and soy derivatives (PDLS), Ice Cream, Cheese, Collection, Aguada and Logistics. The entity is one of the largest sources of employment in the locality and represents one of the main pillars of exports at the border.

The main raw material is the milk collected and the initial treatment to it is produced through the pasteurization process, which is key in the organization, being the packaging area part of it.

To carry out the study, a team was formed by:

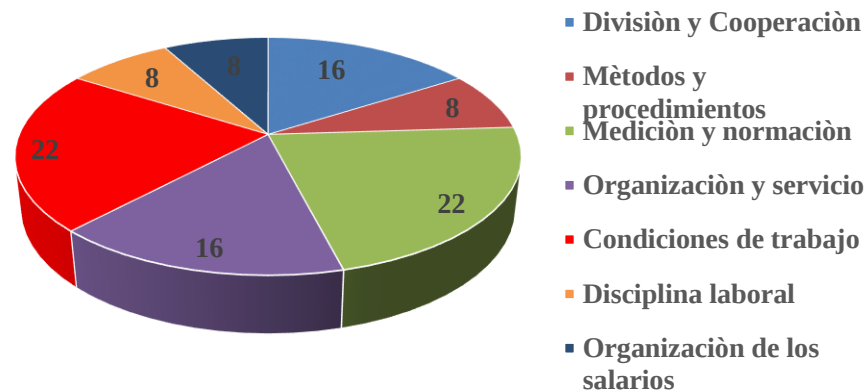
- Human Capital Director.
- Specialists B in Human Resources Management (main specialist and the one in charge of OSH).
- Brigade chief of the process under study.
- Quality specialist.

Diagnosis

In order to contribute to the improvement of business management, based on the improvement of the integrated management of human capital, the tool proposed by the MTSS "Diagnostic Technology" was applied by the management of this activity. The results showed that the Work Organization (WO) module had a low score and, therefore, it represents greater limitations for the correct integration of human capital to business management. To go deeper, the checklist that integrates the 7 elements of the

WO, proposed by Moreno (2017), is applied, highlighting as one of the most negative elements the working conditions. The percentages of non-compliances are shown below:

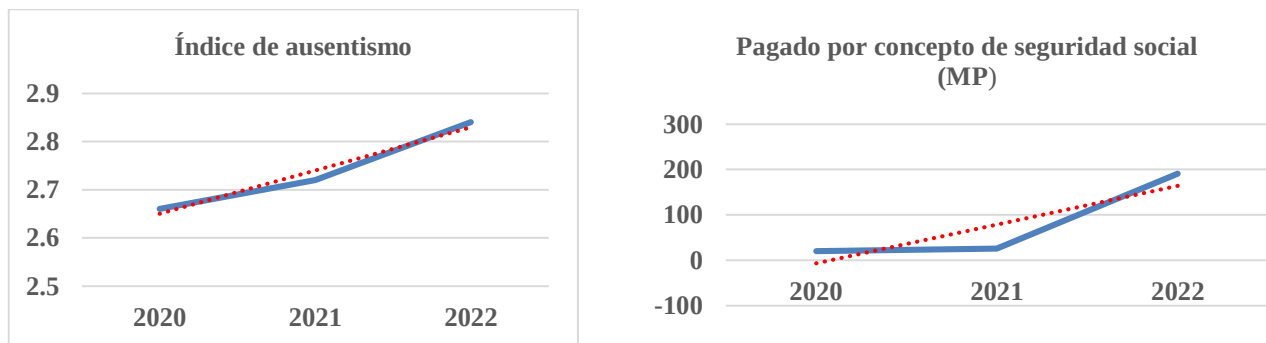
Graph 1 Percentage of deficiencies obtained for each of the WO elements.



Source: Own elaboration

As a complement to the previous results, and based on the analysis of the statistical information provided to the National Statistics and Information Office (ONEI) and the Ministry of Labor and Social Security (MTSS), it can be seen that the number of man-days lost (absenteeism index) and the amount paid for social security (in thousands of pesos), both related to work-related illnesses, are increasing. The actual figures reported are shown in Graph 2.

Graph 2 Behavior of absenteeism rate and social security expenditure.

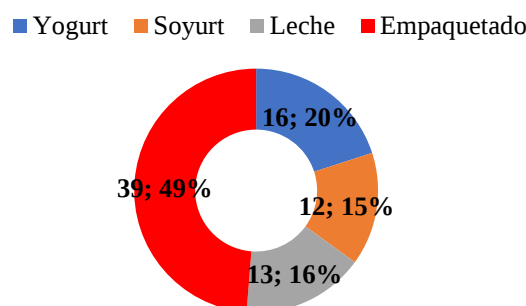


Source: Own elaboration

In the year 2022, a total of 244 medical certificates were presented to workers due to ailments related to their work activity, and distributed throughout the organization's facilities. In the year 2023, the situation did not improve; at the end of the third quarter, 245 medical certificates had been processed for ailments caused by the work activity performed. Among the areas with the highest number of sickness reports were UEB Cheese (40), Central Office (60) and UEB PDLS (80). In both periods, the

latter is among those with the highest number of affected workers. The relationship between the medical certificates and the production lines is shown in graph 3, determining the highest incidence in "packaging" (49% of the cases), and therefore, the need to carry out the study in this area.

Distribution of medical certificates received in 2023 in the PDLS by area.



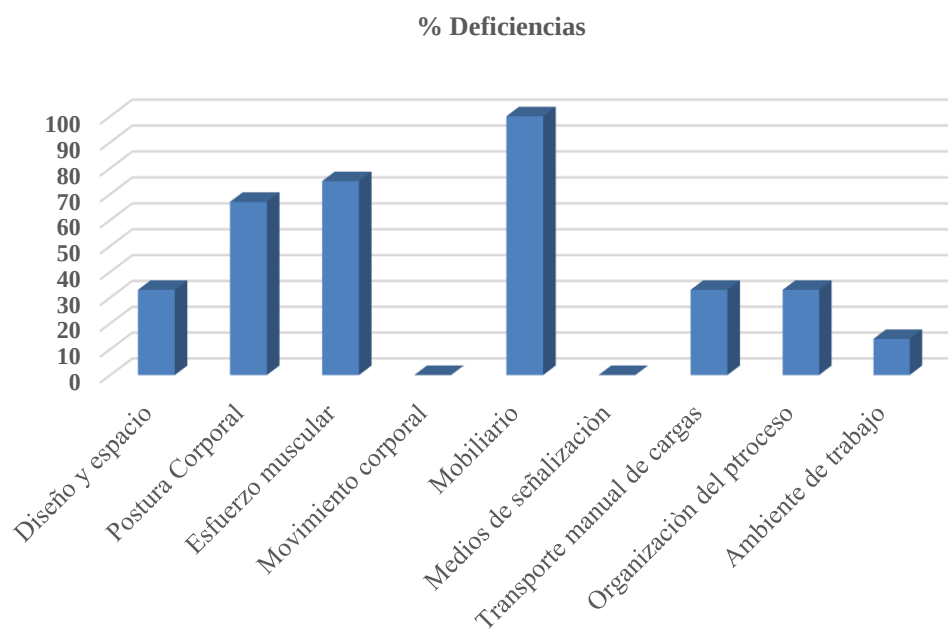
Source: Own elaboration

Occupational safety and health (OSH) and ergonomic analysis

With respect to occupational safety and health, studies have been conducted by the company; it has the identification of hazards and risk assessment as established by Law No.116/2013, and Decree Law 326/2014. For risk assessment, the General Risk Assessment Method is used. The main risks to which workers are associated are identified in the procedure "Hazard Identification, Risk Assessment and Control".

To perform the ergonomic analysis, the guide proposed by Riesco (2019) was adapted to the process under study. This is elaborated from the requirements contemplated in NC 116:2001, it takes into account from the design of the position to the work environment and measures whether or not the established obligation is implemented or not. The amounts of deficiencies detected (%), for each of the elements contemplated in the standard, are as follows:

Graph4.Percentage of non-compliances by elements of NC 116:2001.

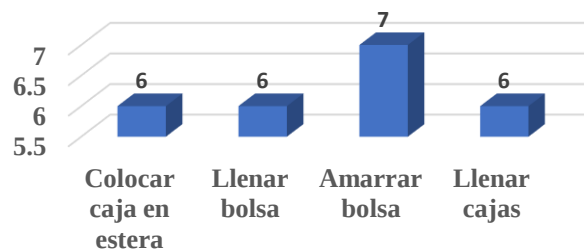


Source: Own elaboration

Postural evaluation

The results of the postural load evaluation (graph 5) are obtained through the e-Rula software version 1.1, applied to the most frequent postures adopted in the work performed by the operator in the different activities that make up the study area. The values are associated with the flexion of the trunk, the extremities and the weight being handled and the permissible range is up to 4.

Graph 5 Score of the postures identified in the process



Source: Own elaboration

Energy expenditure of the activity and of the workers

The energy expenditure of the activities performed by the workers during the activity is calculated taking into account that most of the body posture is stationary, the type of work is with two arms and is performed by women.

Table 1 Calculation of the energy expenditure of the activities performed by the workers during the bagging operation.

Etapas del trabajo	Posturas del cuerpo (W/m ²)	Tipo de trabajo (W/m ²)	Velocidad de trabajo (m/s)	Metabolismo basal (W/m ²)	Gasto energético (W/m ²)	Duración total (min)	Gasto energético (W/m ²)*min
Colocar caja en estera	25	85	-	41	151	167	25217
Llenar bolsas	25	65	-	41	131	375	49125
Amarrar bolsas	25	65	-	41	131	750	98250
Llenar cajas	25	85	-	41	151	417	25217
Total							197809
							W/m ² *min
					Gasto energético ponderado		115.75 W/m²
					Gasto energético ponderado		2.97 Kcal/min

Source: Own elaboration

To calculate the energy expenditure of the workers, the bench test is performed on 4 workers who are selected taking into account their age, weight and the work they perform so that it is a non-statistical sample, but representative of the composition of the workforce. The description of this test and its results are shown below:

Table 2 Bench test results

Trabajador	Edad	Sexo	Peso (kg)	Frecuencia de referencia	Frecuencia cardiaca para cada salto			VO ₂ max (CFT) (lO ₂ /min)	GE _{hombre} (kcal/min)
					1	2	3		
1	44	F	80	114.4	98	113	125	1.47	7.05
2	39	F	85	117.6	101	116	128	1.43	6.86
3	32	F	76	122.2	104	121	128	1.38	6.62
4	51	F	88	109.8	92	110	-	1.26	6.04

Source: Own elaboration

Table 3 Summary of ergonomic problems, levels according to RULA and proposals for improvement in the activities analyzed.

Elemento	Problemas ergonómicos	Nivel según RULA	Propuestas de mejoras	Nivel según RULA luego de mejoras
Colocar cajas en estera	Tronco flexionado a más de 60 grados Cuello flexionado más de 20 grados	6	Elevar la altura de la superficie de trabajo	4
Llenar bolsas	Tronco flexionado a más de 60 grados Cuello flexionado más de 20 grados	6	Elevar la altura de la superficie de trabajo	4

Amarrar bolsas	Tronco flexionado a más de 60 grados y giros de la muñeca	7	Elevar la altura de la superficie de trabajo Cambiar tipo de envase	4
Llenar cajas	Cuello flexionado más de 20 grados Tronco flexionado a más de 60 grados. Cuello flexionado más de 20 grados	6	Elevar la altura de la superficie de trabajo	4

Source: Own elaboration

Discussion

Among the elements that still present deficiencies in the entity and that do not allow maximum integration with the business management of the human capital system, are the work organization (WO) and OSH management. Among the weaknesses of the analysis are detected:

- Problems with compliance with established work rules.
- No studies have been carried out on energy expenditure in the activities that make up the processes or to determine the ergonomic conditions required by the positions.
- The physical work capacity of the workers involved in the various activities is unknown.
- Workers have submitted medical certificates for ailments related to their work activities.

The lack of such studies constitutes nonconformities for QMS certification, according to points 7.1.3, "Infrastructure" and 7.1.4, "Environment for process operation" noted in internal and external audits.

In line with the problems identified Graph 2 shows that both absences per employee and the amounts paid for social security due to health problems caused by the work activity have a tendency to increase and exceed the figures conceived in the planning, a fact that has an unfavorable impact on the organization's results. Considering that the processes developed in the UEB PDLS are classified as key and, therefore, in the future, they should be subject to inspections to achieve their quality certification, the above-mentioned situation is of great interest. In the increase, in the period 2022-2023, of the presentation of medical certificates in the same, the "packaging" line stands out as the most complex point.

The applied guide takes into account the basic ergonomic requirements to be considered in jobs, processes and work activities, valid to ensure the safety, health and welfare of the worker and established in NC 116:2001.

The following is a summary of the main deficiencies detected from the ergonomic point of view in the selected area, which showed the need to carry out this type of research to improve the quality and efficiency of the work and are related to the gaps previously diagnosed:

- There are problems with body posture.
- No studies have been conducted on energy expenditure.
- The physical work capacity of workers is unknown.
- The design of the workplace does not guarantee the adoption of adequate postures.

The RULA method has demonstrated high reliability; it is considered a reliable method for postural evaluation in cases where there is a high demand and repetition of movement in upper extremity muscles. The results for postures are evaluated between 6 and 7, these figures imply immediate improvements from the ergonomic point of view, and these scores represent a risk level between 3 and 4 and demand urgent changes.

Authors such as López et al. (2014), among others, have exposed postural overload as an important cause of the appearance of musculoskeletal injuries in the worker and therefore a factor in generating absenteeism, decrease in productivity, economic losses and permanent damage to health. They highlight among the problems, the presence of pain symptoms, inflammation, dysesthesia, paresthesia and limitation to perform their work, even preventing the performance of daily activities and requesting temporary disability. They conclude that most musculoskeletal injuries occur as a result of small and repeated trauma and are the main reason for disability.

The calculation of the energy expenditure required by the activity takes into account the duration of the tasks and the repetitiveness of the same, the work cycles or static activities exercised by the workers in the operation, as well as the posture and conditions in which it is carried out. The results obtained in Tables 1 and 2 show that there are no problems with energy expenditure in the activity analyzed ($GE_{activity} < GE_{man}$), and it is affirmed that workers are fit to perform the tasks required by their job. "Good ergonomic conditions are intrinsically linked to worker satisfaction, high productivity and reduced cost offsets due to accidents or occupational diseases" (López et al., 2014, p. 9). In this sense, it is important to "take into account the worker and the task to be performed in order for it to be carried out comfortably, smoothly and efficiently" (Guimarães, 2014, p.11).

The operation analyzed is performed standing on a table whose height the workers consider causes them discomfort because it is not placed at the same height as the workers. The average elbow height of the workers is 1.12 m with a standard deviation of 0.05 m, which implies that for the work surface to adjust to 95% of the workers and according to the expression $P95 = \bar{X} + Z * \sigma$ it should have a height of 1.20 m. However, the work surface has only 0.83 m, which causes flexion of the shoulder and neck above 60° and 20° respectively, elements that cause postural problems.

Alonso (2006), López et al. (2014) and Guimarães (2014), have addressed the consequences of poor workplace design. Among those mentioned by them are: limitation of blood circulation, fatigue in certain muscle groups and different ailments, decreased productivity and quality, increased errors and increased probability of occurrence of incidents and / or accidents at work.

From the analysis carried out, inadequate postures are identified; the levels according to RULA, the possible proposals for improvement in the activities analyzed and the levels are projected after the implementation of the recommendations (see Table 3). Based on the suggestion given above, the postural analysis is performed again with the application of the e-Rula software. It is verified that the redesign of the work surface (table), causes the reduction of the corresponding action levels, constituting an improvement for the health and welfare of the worker, thus enhancing the increase in productivity, compliance with current legislation, reduction of social security expenses and a better work environment and infrastructure since it contributes to the elimination of other problems detected.

It is considered that in addition to the postural factor, there are other factors that also have an influence. In line with this, it is important to establish adequate rest periods and/or guidelines to maintain productivity and avoid injuries. Considering these criteria and the unfulfilled elements, it is also recommended to place seats in the work place so that the operator can alternate the sitting and standing posture during the breaks during the working day and, on the other hand, as far as the economic situation makes it possible, to replace the current type of packaging of the products, since it is difficult to handle and implies longer duration of the forced posture in the tying stage and therefore increases the exposure to ergonomic risk.

In this sense, Sierra (2017, p. 426), states that: "The financial benefits resulting from the implementation of ergonomic programs are visible both in industrialized countries and in those that are still developing, the latter being the most notorious".

Conclusions

In the current Cuban context, Ergonomics is of vital importance for compliance with current standards and the achievement of superior results in organizations. One of the fundamental causes that affect the increase in the absenteeism rate and the increase in social security expenses in the organization is the presentation of medical certificates. The UEB PDLS is, until now, the one with the highest number of workers with sickness problems, being the packaging workers the most affected, although they are fit to undertake the activity, there are problems associated with the design of the workplace and the body posture that causes injuries. The proposed measures lead to worker welfare, cost reduction, increased productivity, compliance with current labor legislation and elimination of nonconformities associated with quality certification.

Bibliographic references

- Alonso, A., Ciscail, W., Dopico, E., Jáuregui, D., Labrada, A. (2006). *Ergonomía*. Pueblo y Educación.
- Cuesta, A. (2021). *Tecnología de gestión de recursos humanos*. Félix Varela.
- Decreto Ley 326 Reglamento del Código de Trabajo. (2014, 12 de junio). Consejo de Ministros. Gaceta Oficial. <https://www.gacetaoficial.gob.cu/es>
- Gomes, J. O. (2014). El papel de la ergonomía en el cambio de las condiciones de trabajo: perspectivas en América Latina. *Revista ciencias de la salud* 12,5-8.http://www.scielo.org.co/scielo.php?pid=S1692-72732014000400001&script=sci_arttext
- Guimarães, L. B. de M. et al. (2014). Worker evaluation of a macroergonomic intervention in a Brazilian footwear company. *Applied Ergonomic* 45 (4), 923-935. <https://www.sciencedirect.com/science/article/abs/pii/S0003687013002330>
- Ley 116. Código de Trabajo. (2013, 20 de diciembre). Asamblea Nacional del Poder Popular. Gaceta Oficial. <https://www.gacetaoficial.gob.cu/es>
- López, B. P., González, E. L., Colunga, C., y Oliva, E. (2014). Evaluación de sobrecarga postural en trabajadores: revisión de la literatura. *Ciencia y trabajo* 16 (50), 111-115. https://www.scielo.cl/scielo.php?pid=s0718-24492014000200009&script=sci_arttext
- Mateo, J. A. y García, A. (2023). Mejora de la organización en el proceso del carbón en la Empresa Agroforestal de Cienfuegos. *Revista Científica Agro ecosistemas* 11(3), 72-185. <https://aes.ucf.edu.cu/index.php/aes>.
- NC 116. Requisitos ergonómicos básicos a considerar en los puestos, procesos y actividades de trabajo. (2001). Oficina Nacional de Normalización. <http://plataforma-educativa.gesta.cu/pluginfile/N...>
- NC 3000: Sistema de Gestión del Capital Humano-Vocabulario. (2007). Oficina Nacional de Normalización. [https://ftp.isdi.co.cu/NC 3000 a2007 27p cxkPDF](https://ftp.isdi.co.cu/NC%203000%20a2007%2027p%20cxkPDF)
- NC 3001: Sistema de Gestión del Capital Humano-Requisitos. (2007). Oficina Nacional de Normalización. [https://ftp.isdi.co.cu/Biblioteca/2007/NC 3001 ...PDF](https://ftp.isdi.co.cu/Biblioteca/2007/NC%203001...PDF)
- NC ISO 9001: Sistemas de Gestión de la Calidad - Requisitos, 3ra edición. (2015). Oficina Nacional de Normalización. [https://ftp.isdi.co.cu/Biblioteca/2015/nc iso 900...PDF](https://ftp.isdi.co.cu/Biblioteca/2015/nc%20iso%20900...PDF)
- Real, G. L (2011). Modelo y procedimientos para la intervención ergonómica en las camareras del piso del sector hotelero. Caso Varadero, Cuba. [Tesis Doctoral, Universidad de Matanzas]. <https://rein.umcc.cu/bitstream/handle/123456789/32/MODELO%20Y%20PROCEDIMIENTOS%20PARA%20LA%20INTERVENCION%20ERGONOMICA%20EN%20LAS%20CAMARERAS%20DEL%20PISO%20DEL%20SECTOR%20HOTELERO.%20CASO%20VARADERO%20c%202011.pdf>

OCUBA.%28MSc.%20Grether%20Luc%c3%ada%20Real%20P%c3%a9rez%29.pdf?sequence=1&isAllowed=y

- Riesco, L. (2019). *Mejora de la organización del trabajo en el proceso de fabricación de tabaco en la UEB Tabaco Torcido Cienfuegos*. [Tesis de Postgrado, Universidad de Cienfuegos]. http://biblioteca.ucf.edu.cu/biblioteca/tesis/tesis-de-maestria/maestria-en-ingenieria-industrial/ano-2019/Tesis_M%20Lilian%20de%20la%20Caridad%20Riesco%20Villavicencio%20.pdf
- Sierra, L. C. (2017). Análisis De Riesgo Ergonómico En Una Empresa Automotriz En México. *EuropeanScientificJournal*13 (21).<https://core.ac.uk/download/pdf/236410907.pdf>