https://doi.org/10.47460/uct.v26i112.540

Evaluation of ergonomic models and methods applicable in basic industries

Escalante Magally
https://orcid.org/0000-0001-9794-7900
mcescalante.doctorando@unexpo.edu.ve
UNEXPO-Puerto Ordaz
Ciudad Guayana, Venezuela

Guaita Wilfredo
https://orcid.org/0000-0001-8181-0977
wguaita@uneg.edu.ve
Universidad Nacional Experimental de Guayana
Ciudad Guayana, Venezuela

Recibido (06/12/21) Aceptado (03/01/22)

Abstract: There are multiple ergonomic models and methods to perform ergonomic evaluations. However, knowing which ones to apply are the most common questions, so this research aims to evaluate different models and methods to know the key factors for improvement in the workplace. An extensive bibliographic review was carried out, being from the methodological point of view a descriptive study. It was determined that the methods applied evaluate the efforts in function of the postures that determine musculoskeletal disorders in a general way, indicating only the risk levels without considering actions for change, and as for the models, these are focused on safety, quality and labor productivity to increase the effectiveness of the improvements. Finally, a holistic model is presented that synthesizes the key variables for evaluations and improvement actions in the basic industrial sector

Keywords: Ergonomic Models, Ergonomic Methods, Basic Industries, Job Evaluation.

Evaluación de Modelos y Métodos Ergonómicos Aplicables en Industrias Básicas

Resumen: Para realizar las evaluaciones existen múltiples modelos y métodos ergonómicos. Sin embargo, saber cuáles aplicar son las interrogantes más comunes, por lo cual la presente investigación tiene como objetivo evaluar distintos modelos y métodos para conocer los factores claves de mejoras en los puestos de trabajo. Se realizó una extensa revisión bibliográfica siendo desde el punto de vista metodológico un estudio de carácter descriptivo. Se determinó que los métodos aplicados evalúan los esfuerzos en función de las posturas que determinan los trastornos musculo-esqueléticos de manera general indicando solamente los niveles de riesgos sin considerar acciones de cambio y en cuanto a los modelos, estos se enfocan hacia la seguridad, la calidad y la productividad laboral para incrementar la efectividad de las mejoras. Finalmente, se presenta un modelo holístico que sintetiza las variables claves para evaluaciones y acciones de mejora en el sector industrial básico.

Palabras Clave: Modelos Ergonómicos, Métodos Ergonómicos, Industrias Básicas, Evaluación de Puestos de Trabajo.

I.INTRODUCTION

Ergonomics is a science that was born as a consequence of the musculoskeletal ailments or disorders that workers manifest when performing their tasks or activities. [1] defines ergonomics as the interaction of a multidisciplinary team with the aim of adapting products, systems and artificial environments to the needs, limitations and characteristics of their users, optimizing efficiency, safety and well-being.

In order to carry out evaluations to determine the risks associated with the postures adopted by the worker, researchers created ergonomic evaluation methods. Each method was created by a multidisciplinary team in order to incorporate variables and factors that allow comprehensive data to be analyzed and improvement actions to be taken.

Regarding the methods, they are classified according to their applicability. For example, there are those that allow the evaluation of general working conditions, load handling, repetitiveness, postural load, among others. For the purposes of the research, it was determined to evaluate those of postural load because they are the most used according to [2]. It could be inferred that this could be because the most common occupational disorders are musculoskeletal disorders, which represent the highest proportion other than cancer [3].

It is appropriate to quote [4] where they concluded that the most reported diseases in 2004 were musculoskeletal diseases. It could be inferred that these figures are increasing from previous years.

However, according to theoretical and practical evaluations carried out with each of the methods, it was detected that to evaluate postural loads it is necessary to apply more than one method because the information generated is very ambiguous. This situation leads to apply other methods in order to have more reliable results. However, it was also determined that applying several methods to the same task generates results that lead to confusion regarding the actions to be considered in relation to the level of risk obtained.

[5] points out that there are innumerable methods proposed for the recording and evaluation of postural loads, or other factors associated with musculoskeletal disorders, but they are applied to specific cases, which limits a comprehensive evaluation and thus more effective actions.

[6] state that both REBA and RULA do not consider organizational factors, a fundamental aspect for ergonomic evaluations. In addition, they do not consider the pace of work, the duration of recovery periods, or the number of breaks during the workday. Therefore, it is recommended that these methods be applied to obtain preliminary information and then use other methodologies to better specify the information and the action to be taken.

Regarding OWAS [7] they state that it is one of the most used methods because it is useful for the identification of inadequate postures, however, it cannot be used to determine the precision of the degrees of inclination that the body would have when performing the tasks. They also indicate that, although it allows a combination of encodings representing posture as well as strength, the results are very general.

Due to the above considerations, the research aims to evaluate the ergonomic models and methods in basic industries, with the purpose of knowing the key factors to make decisions to improve the workstations.

For the determination of the factors, a bibliographic review and research of works where ergonomic methods were applied were carried out. From the methodological point of view, the study is of a documentary and descriptive nature in order to validate the applicability of the models. Thus, a comparative analysis was carried out which generated conclusive results.

II.MATERIALS AND METHODS

In order to validate the results of the methods applied to different tasks, several evaluations were made at the documentary level based on the search for data, its capture and critical analysis to interpret data from primary and secondary sources reflected in reports and informations of the subject matter of study in the company taken as a reference.

The sources and documents obtained were of a secondary nature from the works of other authors referenced where appropriate, and in view of their research nature, the sources came from textbooks, specialized articles, reports and case studies.

Due to the above conditions, the research is descriptive because the characteristics were identified, which allowed comparisons between the methods and analysis of the models, in order to determine the variables contained in each one and to define the advantages and disadvantages. In this aspect [8] states that the study of the variables independently is part of describing the characteristics, in addition to determining the behavior of the variables.

In addition, it is determined that the research is of the documentary type because bibliographic sources were used to be analyzed and evaluated in order to respond to the topic under study. [9] states that this type of research is related to the documentary review of the topic of interest where comparisons are made between several writings. Thirty-five papers were evaluated, co-

rresponding to undergraduate theses, internships and articles in indexed journals.

III.RESULTS

There are several models and methods used by specialists in order to evaluate jobs according to the risks that may be present in the inherent activities towards the worker. Each one has different variables to consider in order to obtain feasible results that contribute to improve and minimize risks and musculoskeletal disorders.

Regarding the methods as each one has its purpose, [10] made several classifications, such as: Postural Load, Load Handling, Forces and Biomechanics, Repetitiveness, Office Positions; Global Assessment; Thermal Environment and Utilities.

For the purposes of the research, the authors considered evaluating those classified in the Postural Load. Having made the above observation, the methods to be developed are: EPR, OWAS, RULA and REBA. In this order of ideas we have the following:

A.EPR Method (Rapid Postural Evaluation)

The productive processes of companies are carried out by technological equipment and the intervention of human labor. In the activities or tasks in which the worker is involved, he/she has to adopt dynamic or static postures in order to make the product. This condition can eventually lead to ailments or conditions that affect the worker's quality of life.

According to [11], the EPR is a tool that allows a general and preliminary evaluation to determine the static load. It is necessary to point out that the assessment system used is the LEST method, so the EPR proposes a performance level between 1 and 5. It is convenient to indicate that the EPR performs a global assessment of the different postures adopted and the time they are maintained. Fourteen possible generic postures are specified.

Depending on the result obtained and because it is preliminary diagnostic information, it is advisable to carry out a more in-depth study using one of the postural loading methods such as OWAS, REBA, RULA, in that order of application.

B.OWAS Method (Ovako Working Posture Analysis System)

OWAS was created in 1977 by a multidisciplinary team in order to promote postural evaluations due to the fact that workers were suffering from ailments and thus had little effectiveness in performing their tasks. [12] indicates that this method is based on observation with the purpose of defining the posture and classifying it. The code is established according to classification and an assessment of the risk level is obtained in order to specify corrective actions to improve the workplace. It is a method that has generated important contributions, as well as other methods.

With reference to the methods already mentioned, [13] points out that the most commonly applied methods to evaluate the physical postural load are OWAS, RULA and REBA.

C.RULA Method (Rapid Upper Limb Assessment)

RULA is a method developed by McAtamney and Corlett for use in assessments involving the human body, specifically the upper limbs.

To apply it, the division of the body must be considered, i.e., right and left side separately. Based on the posture, a score is established which leads to a total value according to the crossing of the variables. Thus determining the level of risk and the action considered in order to take the necessary steps for improvement in order to minimize the possible musculoskeletal disorder.

It should be added that [14] indicated that RULA does not provide detailed information, such as finger position. They state that it is advisable to collect information in a general way and then use other more comprehensive ergonomic assessment tools.

D.REBA Method (Rapid Entire Body Assessment)

This method is based on the RULA parameters in order to incorporate variables that allow more viable results towards postural load evaluations.

The purpose of the method is to determine the levels of risks associated with the task performed by the worker, which is why individual postures are considered for its application. It should be noted that the correct posture is the Neutral position, so those that are outside this condition are considered, in addition to the duration or frequency. For this purpose, the method allows a comprehensive evaluation of the positions adopted by the upper body members (arm, forearm, wrist), trunk, neck and legs. In addition to this, it considers other variables such as the force performed at the moment of manipulating a load, as well as the type of grip performed.

[15] states that this method is the most widespread in practice because it is especially sensitive to tasks that involve unexpected changes in posture. Likewise [16] point out that there are many studies that support the REBA as one of the most widely used tools in postural load analysis.

In short, it can be said that the method generates im-

portant contributions in the evaluations, however, it is necessary to contrast it in order to detect its advantages and disadvantages, for example, one of the ways to evaluate is to observe the posture and see the angle of inclination that it has in the joint of the evaluated part. Regardless of the angle, the method tells you to consider a fixed score.

The aforementioned methods allow a broader perspective of risk situations with a view to an integral or holistic model in ergonomic matters.

E. Ergonomic Management Models

[17] He proposed a model of occupational health and safety with integrated management for the sustainability of organizations with the purpose of promoting healthy lifestyles among workers, as well as improving working conditions and care of the environment with quality and productivity. Figure 1 shows the model and it can be seen that one of the factors considered was ergonomics.

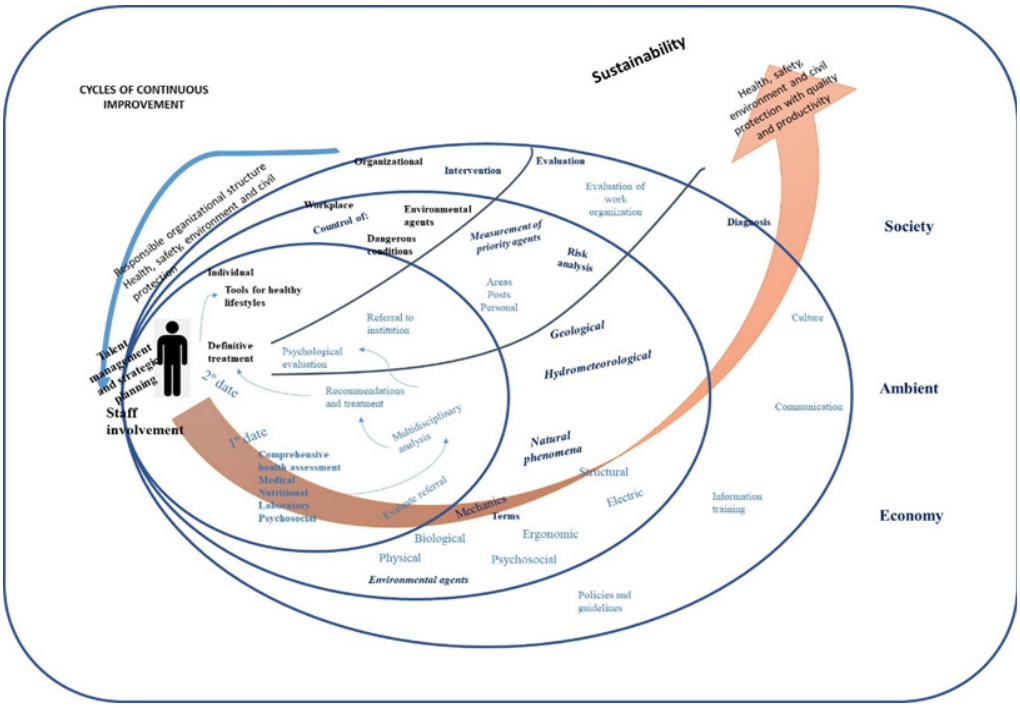

Fig. 1. SSeTGIS model. Components by levels of action and process. Source: Anaya Velasco, A. (2017, p. 103).

For the development of the model, the author considered as important components health, hygiene conditions at work, safety conditions at work, environmental care, as well as quality and productivity as integral management. It should be noted that among her conclusions she states that her model differs from others because it focuses on taking health and safety at work as a perspective centered on people as the first beneficiaries and participants in the work culture it promotes.

On the other hand, it is mentioned [18] who developed the ergonomics maturity model for companies with the purpose of evaluating the capabilities they possess, and based on the results, they are able to draw strategies aimed at introducing, applying and developing ergonomics in companies, integrating it into the processes and contributing to the fulfillment of the organization's objectives.

The aforementioned authors considered several levels where a set of characteristics related to the recognition of ergonomics were proposed for each level, thus generating the model represented in Figure

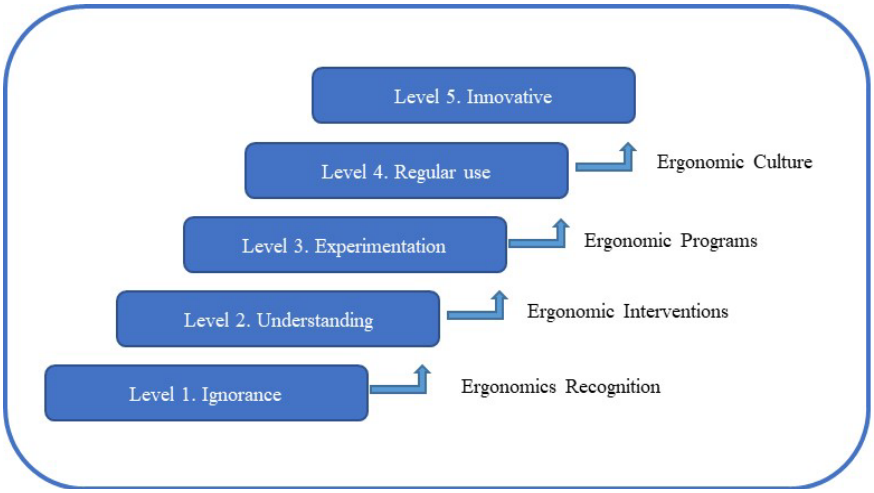

Fig. 2. Ergonomics Maturity Model for Enterprises.
Source: Rodríguez Ruíz, Pérez Mergarejo, & Montero Mártinez, (2012, p. 24).

Level 1 refers to the lack of knowledge of ergonomics and the benefits it generates for the development of production processes, as well as improvements in the worker's quality of life.

Levels 2 and 3 emphasize the benefits and application of ergonomics in order to minimize possible illnesses, as well as worker safety. Towards level 3, small projects are developed, guided by the ergonomist and the engineer.

Level 4 focuses on training and qualification of workers, but mainly to senior management with the purpose of assuming commitments and recognizing ergonomics as a means that contributes to the achievement of objectives. And finally, level 5 promotes the successful integration of ergonomics as part of management strategies. At this level, the employee plays a very important role because his or her opinions are the basis for the implementation of improvements. Likewise, there are already indicators to monitor and make adjustments according to the deviations that may occur.

Now, for the evaluation of the model they considered a company where the maximum level reached was Level 2, however, of the elements evaluated, two of them were positioned in level 1; then, they concluded that their classification is located in the lower level 1 (N-1 Ignorance). The information obtained from the model allows the companies to see how they are doing and thus carry out improvement actions towards the implementation of ergonomic programs.

[19] They designed a strategic model for the implementation of ergonomics in operations management. Based on it, they stated that the implementation will allow organizations to apply ergonomics knowledge to production operations, in relation to technologies, work organization and human resources.

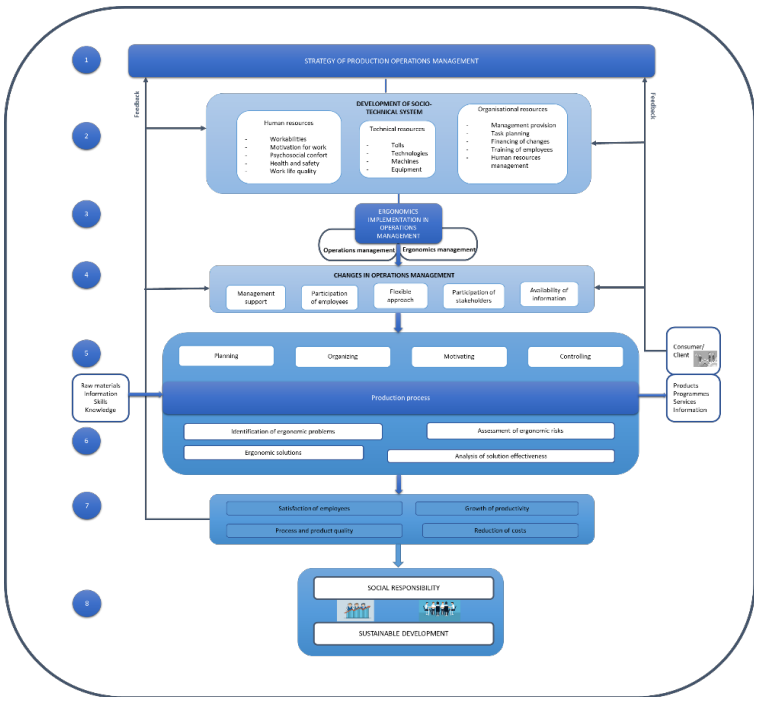

Fig.3 Model "Ergonomics Implementation in operations management. Source: [19]

Figure 3 shows that the application of the model leads companies to achieve Social and Sustainable Development as a result.

The authors state that the application of ergonomics should be carried out in terms of operation and ergonomics management. That is why in level 3 they present the integration of both. They state that the results will be more effective because the quality standards will also be taken into account.

In addition to the above, they considered at level 4 aspects such as worker participation, management support, flexibility, availability of information and stakeholder participation. Indicating that the lack of any of them would significantly decrease the effectiveness of ergonomic solutions.

In addition to the above, the aspects at level 6 were considered because they are the ones that will allow to control the deviations in the process. Because at this level it will be possible to identify problems and thus analyze them in order to carry out corrective actions aligned with management strategies.

However, they also considered the client as a fundamental element, since he is the main consumer and therefore the one that allows feedback towards management improvements.

Finally, they express that the elements indicated by levels add up to a whole and influence each other, generating results towards a social responsibility that is the basis for the sustainable development of the organization.

On the other hand, in [20] they express that the ISO 45001 (safety management system standard) provides a new model that can be used as an effective system to manage ergonomics.

ISO 45001 is an international safety management system standard that was published on March 15, 2018. Its content is aligned to the Deming Cycle.

The model for managing ergonomics, based on ISO 45001 states that all levels of the company, must be engaged and empowered in the ergonomics processes. Each responsibility must be well defined and with it also their ergonomics education and training.

In addition to the above, it indicates that effective risk reduction controls must be applied, both in the workstations and in the task performed by the worker. And with this, the necessary resources should be established, as well as the review of ergonomic operations.

IV.DISCUSSION OF RESULTS

Each method has important contributions towards the evaluation of risks associated with postural load, so it is necessary to contribute with other variables and factors that strengthen the postural load evaluations. Table 1 below presents the details of the methods showing the advantages and disadvantages of each one, as well as their objectives.

Table 1. Characteristics of the methods.

Method	Target	Features	Advantages	Disadvantages
ERP (Rapid Postural Evaluation)	It allows a first and brief assessment of the posture sadopted by the worker throughout theday.	• EPR uses theLEST methodstatic load rating system.	• Performs anoverall assessment of the different postures adoptedandthe timethey are maintained.	• It does not evaluate any specific position. • It considers 14 generic positions.
OWAS (Ovako Working Analysis System)	Improve work methods, based on th e identification and elimination of force d postures.	• It has the ability to assess all the postures adopted during the performance of the task as a whole. • The observedpostures are classified into 252 possible combinations. • It distinguishes four risk categories for each posture. • Validated in situations of risky tasks, for the lumbar area derived from the working posture.	• Determines the risk category individually. • the results are estimated to have an accuracy greater than or equal to a 90% confidence level. • Identifies themain inadequate postures. • It is verydidactic, so it is easy to apply. • Applicable for different types of jobs • More dangerous situations alert	• Provides less accurate ratings than REBA and RULA • The task posture record ranges from 20 to 40 minutes. • A minimum of 100 samples is required. • The evaluation of postures is done using very wide intervals of categories, as well as the estimation of forces.
RULA (Rapid Upper Limb Assessment)	To evaluate the exposure of workers to risk factors that cause a high postural load and that can cause disorders in the upper limbs of thebody.	• Evaluates individual positions. • The measurements on the posturesadopted are fundamentally angular. • Evaluations of the sides (right and left) are performe d separately . • Observations are made for several cycles.	• Evaluates a working posture and the associated risk level in a short period of time and without the need for equipment, just paper an dpencil. • Generates preliminary results of possible previous musculoskeletal injuries. • It is useful for comparing existing andproposed workstation designs.	• Applies only to postural load evaluations • Assesses only the upper extremities • It was notdesigned toprovide detailed postural information, e.g., fingers. • Generates general information, so it is advisable to apply other methods. • Does notprovide a subclassificatio n for different regions of the body

A (Rapid Entire Body Assessment)	Assess the degree of exposure of the worker to risk due to the adoption of inadequate postures.	• Based on RULA • Evaluation of the upper extremities. • Analyzes as a whole taken by the upper limbs (arm, forearm and wrist), thetrunk, neck and legs. • Evaluates the load and grip • It assesses the muscular activity developed by the worker (both in static and dynamic postures). • It provides a coding system for muscle activity originating from static, dynamic, rapidly changing or unstable postures.	• Particularly sensitive to musculoskeletal risks. • Analyzes the impact on the postural load of handling loads with the hands or other parts of the body. • Allows to assess postures with abrupt or unexpecte dchanges • Generates a level of action with indication of priority or urgency.	• Applies only to postural load evaluations. • It evaluates individual postures andnot a set or sequence of postures. • It does not provide a subclassificatio n for different regions of the body. • evaluates left and right side separately.

Thirty-five papers from different universities and journals were evaluated, where it was found that 75% recommend applying the methods because they provide general information on the conditions in which the jobs are located. However, 47% recommend that the results should be deepened because the evaluator could have errors in the actions to be considered due to the evaluation criteria of each method. For example, the REBA method has a score ranging from 1 to 15, while RULA presents 7 as the highest value.

[21] point out the difference in the previous section in terms of score levels, but state that the RULA in most cases has greater severity. Although they finally conclude that both methods give similar results. Table 2 shows some activities and the results of the methods applied in ergonomic evaluations.

Table 2. Results of the REBA and RULA methods in ergonomic evaluations.

Activity	REBA	RULA
Plumbing	Score: 7 Risk Level: Medium Action: Action is necessary.	Score: 4 Risk Level: Low Action: Changes in the task may be required; further study is desirable.
Maintenance of green areas	Score: 10 Risk Level: High Action: Action is needed as soon as possible	Score: 7 Risk Level: High Action: Urgent changes in the task are required.
Building maintenance	Score: 9 Risk Level: High Action: Action is needed as soon as possible	Score: 7 Risk Level: High Action: Urgent changes in the task are required.
Tanker position	Score: 6 Risk Level: Medium Action: Action is necessary.	Score: 6 Risk Level: High Action: Redesign of the task is required.
Motor grader stand	Score: 4 Risk Level: Medium Action: Action is necessary.	Score: 4 Risk Level: Low Action: Changes in the task may be required; further study is desirable.
Oil and filter change	Score: 5 Risk Level: Medium Action: Action is necessary.	Score: 7 Risk Level: High Action: Urgent changes in the task are required.
Air conditioning belt replacement.	Score: 4 Risk Level: Medium Action: Action is necessary.	Score: 4 Risk Level: Low Action: Changes in the task may be required; further study is desirable.

Each method has an action level, it means, both present a score that must be contrasted with the information collected in the ergonomic evaluations of postural loads. Depending on the score, the level of risk is considered, as well as the action to be taken to minimize or eliminate the condition affecting the worker.

It can be seen in the table above that some activities have different levels of performance, for example, when changing the air conditioning belt, REBA indicates that action is necessary, while RULA suggests that the study should be carried out in depth. Results such as those shown in table 2 are the ones that generate confusion when applying the methods.

However, with respect to the application of the OWAS method in conjunction with some of the two previous methods, the same drawbacks arise in terms of risk levels and actions. Table III shows the evaluation of some activities and their results according to the method considered.

Table 3. Results of the OWAS, RULA and REBA methods in ergonomic evaluations. REBA methods in ergonomic evaluations.

Activity	OWAS	RULA
Butt welding	**Score: 4** Risk Level: Very High Action: Corrective action is required immediately.	**Score: 6** Risk Level: High Action: Redesign of the task required
Activity	**OWAS**	**REBA**
Oven Crust Breaking	**Score: 2** Risk Level: Medium Action: Corrective actions are required in the near future.	**Score: 2** Risk Level: Low Action: Action may be required
Positioning Lid, to cover cells	**Score: 3** Risk Level: High Action: Corrective action required as soon as possible	**Score: 3** Risk Level: Low Action: Action may be required

Like the previous methods, OWAS also presents risk levels in order to indicate the required action. This method differs from the others because its technique is based on coding the posture, allowing the assessor to determine the risk category.

Table 3 shows different levels of risk for the same task, which could be said to be a consequence of the technique or procedures that each method has. However, such a situation could influence the decisions and improvement actions in the tasks or activities.

[22] also states that the OWAS method is excellent for postural load assessment. However, it has limitations, it does not allow discerning between different degrees of flexion or extension when evaluating posture. In addition to considering as the only risk factor the fact of working with the arms above shoulder level, there are other relevant factors. He concludes that the OWAS method should be applied as a first evaluation, which should be complemented with another method.

It should be noted that the methods do not indicate in depth the action to be taken, so it will be the evaluator in conjunction with a multidisciplinary team who will decide the changes to be made to improve the conditions of the worker. However, it is important to continue with studies and research that generate methods that include variables that allow the collection of more in-depth information, as well as recommend, broader actions towards the effectiveness of the processes.

As for the models in general, some of them allow companies to be evaluated in a comprehensive manner in order to determine their management capabilities, so that improvement actions can be taken towards the im-

plementation of ergonomic programs, as in the case of this study.

The purpose of the models is to integrate each department of the company because they consider that the commitment must be promoted from the top management in order to assume the cultural changes of the worker. In addition, they promote an integral strategic management where health, environment, hygiene at work, quality, productivity, but above all, worker's commitment, are considered as fundamental pillars. Finally, it becomes evident the importance of creating a model that considers the interrelation of the strengths of the methods already created with the purpose of having an advance of results in the evaluations of the postural loads.

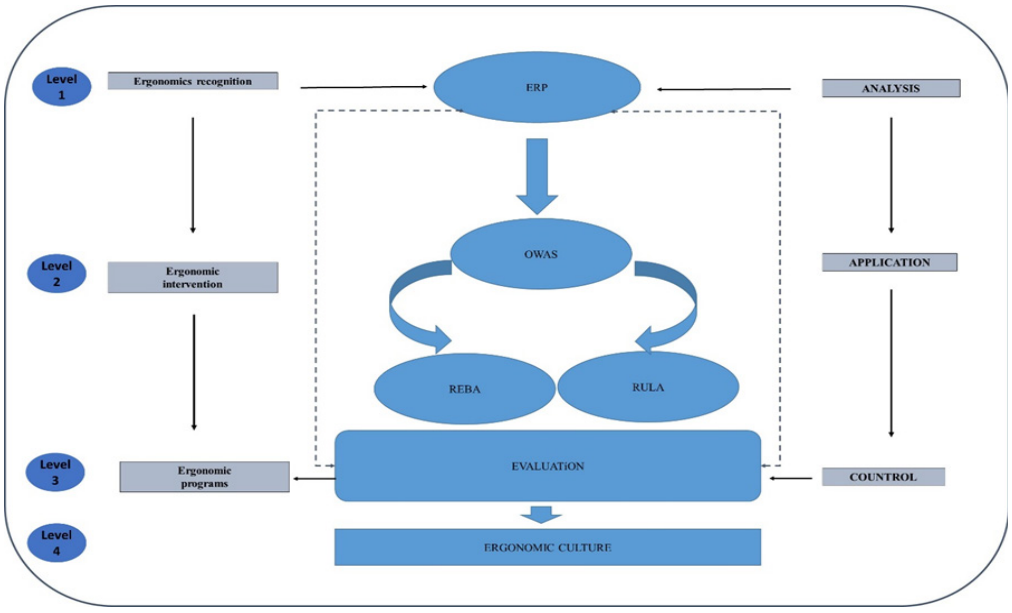

Fig.4: Ergonomic management evaluation model for manufacturing processes
Source: Authors

V.CONCLUSIONS

1.The study reflects, after a comparative analysis, some methodologies that evaluate the efforts according to the determining postures in musculoskeletal disorders, based on general evaluations that only indicate risk levels without considering actions for change, while other methodologies focus on safety at work, quality and business productivity.

2.In particular, the Rapid Postural Evaluation (RPE) methodology allows for a general and preliminary evaluation in order to determine the static load. In this sense, the RPE performs a global assessment of the different postures adopted and maintained over time and the result obtained is preliminary information that recommends a more in-depth study using one of the postural load methods.

3.The Ovako Working Posture Analysis System (OWAS) methodology starts with observation in order to define the posture and classify it. It establishes a code according to classification and facilitates an assessment of the level of risk, and thus the corrective actions to improve the work posture are specified.

4.The Rapid Upper Limb Assessment (RULA) method evaluates actions that involve the human body, specifically the upper limbs. It is applied considering the division of the body into right side and left side separately. Based on the posture, a score is established which leads to a total value, according to the crossing of the variables, thus determining the level of risk and the action considered for the management of improvement in minimizing possible musculoskeletal disorders.

5.As for the Rapid Entire Body Assessment (REBA) method, it determines the levels of risks associated with the task performed by the worker, which is why it considers individual postures for its application. The method allows a comprehensive evaluation of the positions adopted by the upper body members (arm, forearm, wrist), trunk, neck and legs, and the strength of the worker when handling a load, as well as the type of grip.

6.The comparative evaluation of ergonomic study methodologies, revealed a gap that is filled by integra-

ting into one model the multiple methodologies that contemplate the key variables in the ergonomic management of the basic industrial sector.

7.In its first phase, the model allows a recognition of ergonomics in the company with the EPR methodology. In a subsequent step, it proposes to carry out the ergonomic intervention combining the OWAS, RULA and REBA methods that give the framework of integrality. Finally programs are applied to consolidate the ergonomic culture.

REFERENCES

[1]Asociación Española de Ergonomía, "¿Qué es la ergonomía?" http://ergonomos.es/ergonomia.php#:~:text=Según la Asociación Española de,la eficacia%2C seguridad y bienestar.

[2]J. A. Diego Mas, "Evaluación Postural Mediante el Método REBA," Ergonautas, Universidad Politécnica de Valencia, 2015. http://www.ergonautas.upv.es/metodos/reba/reba-ayuda.php.

[3]Organización Mundial de la Salud, "Trastornos musculoesqueléticos," 2021. https://www.who.int/es/news-room/fact-sheets/detail/musculoskeletal-conditions.

[4]M. García Gómez and R. Castañeda López, "ENFERMEDADES PROFESIONALES DECLARADAS EN HOMBRES Y MUJERES EN ESPAÑA EN 2004," Salud Pública, vol. 4, pp. 361–375, 2006, [Online]. Available: https://www.mscbs.gob.es/gl/biblioPublic/publicaciones/recursos_propios/resp/revista_cdrom/vol80/vol80_4/RS804C_361.pdf.

[5]Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT), Posturas de trabajo. Madrid.

[6]CENEA, "MÉTODO EVALUACIÓN ERGONÓMICA RULA: ¿CONOCES LOS RIESGOS DE UNA INCORRECTA APLICACIÓN?," Centro de Ergonomía Aplicada. https://www.cenea.eu/metodo-evaluacion-ergonomica-rula-conoces-los-riesgos-de-una-incorrecta-aplicacion/.

[7]Instituto Nacional de Seguridad e Higiene en el Trabajo, "NTP 452 : Evaluación de las condiciones de trabajo : carga postural," Cent. Nac. Condiciones Trab., 1995, [Online]. Available: https://saludlaboralydiscapacidad.org/wp-content/uploads/2019/05/NTP-452-Evaluación-de-las-condiciones-de-trabajo-Carga-postural.pdf.

[8]F. G. Arias, El Proyecto de Investigación. Introducción a la metodología científica, 6a. Caracas. Venezuela: Episteme, 2012.

[9]R. Pino Gotuzzo, Metodología de la Investigación. Elaboración de diseños para contrastar hipótesis. Perú: San Marcos, 2018.

[10]Ergonautas, "Métodos de evaluación de la ergonomía de puestos de trabajo," Ergonautas, Universidad Politécnica de Valencia. https://www.ergonautas.upv.es/metodos-evaluacion-ergonomica.html.

[11]M. C. Barba Morán, El dictamen pericial en ergonomía y psicosociología aplicada. Madrid: Tébar, 2007.

[12]M. G. Obregón Sánchez, Fundamentos de Ergonomía, Primera. México: Patria, 2016.

[13]I. Sánchez Barragán, "Prevencionar.com," Evaluación de la Carga Física Postural: ¿OWAS, RULA o REBA?, 2017. https://prevencionar.com/2017/11/30/evaluacion-la-carga-fisica-postural-owas-rula-reba.

[14]N. Stanton, A. Hedge, K. Brookhuis, E. Salas, and H. Hendrick, Handbook of Human Factors and Ergonomics Methods © 2005. United States of America: CRC PRESS, 2005.

[15]M. Escalante and M. (+) Núñez Bottini, "Evaluación ergonómica en la producción. Caso de estudio: Sector Aluminio, Estado Bolívar. Venezuela," Ing. Ind. Actual. y Nuevas Tendencias, vol. VI, No 21, no. 2610–7813, pp. 73–90, 2018, [Online]. Available: http://servicio.bc.uc.edu.ve/ingenieria/revista/Inge-Industrial/index.htm.

[16]S. Asensio Cuesta, J. Bastante Ceca, and J. A. Diego Más, Evaluación Ergonómica de Puestos de Trabajo. Madrid: Paraninfo, 2012.

[17]A. Anaya-velasco, "Modelo de Salud y Seguridad en el Trabajo con Gestión Integral para la Sustentabilidad de las organizaciones (SSeTGIS)," Cienc. Trab., vol. 59, pp. 95–104, 2017, [Online]. Available: https://scielo.conicyt.cl/pdf/cyt/v19n59/0718-2449-cyt-19-59-00095.pdf.

[18]Y. Rodríguez Ruíz, E. Pérez Mergarejo, and R. Montero Martínez, "Modelo de Madurez de Ergonomía para Empresas (MMEE)," El Hombre y la Máquina, vol. 40, 2012, [Online]. Available: https://www.redalyc.org/pdf/478/47826850003.pdf.

[19]H. Kalkis and Z. Roja, "Strategic Model for Ergonomics Implementation in Operations Management," J. Ergon., vol. 6, no. 4, 2016, doi: 10.4172/2165-7556.1000173.

[20]W. Rostykus and R. Barker, "ISO 45001: un modelo para la gestión de la ergonomía en el lugar de trabajo," EHSToday, 2018. https://www.ehstoday.com/health/article/21919619/iso-45001-a-model-for-managing-workplace-ergonomics.

[21]M. García-garcía, A. Sánchez-lite, A. M. Camacho, and R. Domingo, "Análisis de métodos de valoración postural en las herramientas de simulación virtual para la ingeniería de fabricación.," DYNA, vol. 80, pp. 5–15, 2013, [Online]. Available: https://www.redalyc.org/articulo.oa?id=49628728001.

[22]Secretaría de Salud Laboral de CCOO de Madrid, métodos de evaluación ergonómica. Madrid, 2016.

CURRICULUM SUMMARY

Escalante, Magally Magister in Management, mention operations and production. Industrial Engineer. Professor of the Master's degree program of the Faculty of Mechanical Engineering, Universidad del Callao. Lime. Academic experience in public universities, greater than 15 years. Currently doing doctoral studies in Engineering Sciences.

Guaita, Wilfredo, Doctor in Business Administration and Master in Production Administration. Professor at the National Experimental University of Guayana. Researcher Promotion Program level I. Consultant engineer in training of entrepreneurs, recruitment and selection of personnel, process simulation, optimization methods, decision making, production planning and control systems, supply chains and quality control.