How to perform an ergonomic analysis of a workstation

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Abstract

In the face of numerous complaints about upper limb pain of employees involved with a printed circuit board (PCB) assembly line, there was a need to assess the level of Work-Related Musculoskeletal Disorders (WRMD). To solve this problem, the research aimed to perform an ergonomic analysis in a workstation of an assembly line of a company X of the Manaus Industrial Pole (PIM). Therefore, the risks of WRMD were evaluated and the problems faced were diagnosed, to propose improvement actions to adapt the work environment to the workers. With the aid of the Ergonomic Work Analysis (EWA) method and the Rapid Entire Body Assessment (REBA) method for the assessment of the risks of WRMD, it was found that the operator was subjected to an average risk of WRMD and that the intervention for resolution or risk minimization was required. The operator's complaints were a pain in the shoulders, arms, and neck. In the end, five recommendations were suggested to company managers to solve or mitigate the problem.

Keywords: Ergonomic analysis, REBA, and EWA method, Improvement actions;

1. Introduction

Since ancient civilizations, primitive man has been concerned with improving his everyday tools and utensils to facilitate their handling and provide more comfort, safety, and effectiveness.

According to Gomes Filho (2003), it can be inferred that ergonomics were born informally at the moment when primitive man, through his creative intuition and common sense, created his first objects used to survive.

From the eighteenth century, with the emergence of the industrial revolution, the workers were subjected to work in subhuman conditions, in poorly-hygienic places, being exposed to noisy, dirty environments and a high daily workload, causing numerous accidents in the workstation.

For Moraes (2003), ergonomics emerged during World War II when there was the need to bring together engineers, psychologists, and physiologists to work together, aiming at adapting work to man, that is, to adapt machinery and equipment to the characteristics of man (physical, cognitive and psychic).

Iida (2005) adds that ergonomics was officially born on July 12, 1949. On that date, a group of scientists and researchers met in England with an interest in formalizing and discussing this new branch of interdisciplinary application of science. And from the early 1950s with the creation of the Ergonomics Research Society in England, ergonomics was formalized.

According to Dul and Weerdmeester (2004), in 1961 the International Ergonomics Association (IEA) was created, which represents many ergonomics associations in several countries.

According to Soares (1989) apud Gomes Filho (2003), ergonomics was introduced in the early 1960s in Brazil, by Professor Sergio Augusto Penna Kehl, at the Polytechnic School of the University of São Paulo and later developed in various institutions of teaching and study and research bodies. Dul and Weerdmeester (2004) report that in 1983 the Brazilian Association of Ergonomics (ABERGO) was founded, which is affiliated to the IEA.

Ergonomics is currently practiced in many countries around the world and there is greater respect for workers' individualities, needs, and group norms. The worker most often participates in decisions about his work (IIDA, 2005).

In this context of adapting work to man, designing tasks and mechanisms that will facilitate and provide more comfort in its performance, ergonomics has become a fundamental piece to ensure the health and well-being of workers and research related to this theme are becoming increasingly valuable.

The company here named X, where this research was conducted, produces printed circuit boards (PCB), computer and TV subsets and peripherals of Manaus Industrial Pole (PIM), having as part of its process, manual assembly lines of electronic components. The object of study of this research was a manual insertion line of electronic components, chosen because of the number of complaints from workers regarding upper limb pain, so there was a need to perform an analysis to assess the risks inherent in the activities and identify the causes of the problems.

Given this problem, the objective of this paper is to present an ergonomic analysis in an assembly line of a company from the Manaus Industrial Pole (PIM). For this, the risks of Work-Related Musculoskeletal Disorders (WRMD) were assessed and the problems faced were diagnosed to propose improvement actions to reduce the risks, ie, adapt the work environment to the workers.

The research will help the company implement improvement actions to solve ergonomic problems, and will also propose actions aimed at reducing unnecessary movement and fatigue at work. Through these actions, it is expected to reduce the risks of WRMD, preserving the health of the worker.

For the academic area, the importance of this work is that it can be used as a reference for other issues and related research.

2. Theoretical Referential

2.1 Ergonomics Definitions

The word ergonomics is derived from the Greek words ergon (work) and nomos (rules). It is a discipline with a systemic approach to all aspects of human activity (ABERGO, 2013).

According to Masculus and Vidal (2011), ergonomics is an occupation of qualified people to respond to demands about work activity. The goal of ergonomics is to adapt work to man, relating all interactions that influence the performance of work, such as machines, equipment, methods, environment, aiming to preserve the health of the worker, providing safety and productivity.

According to ABERGO (2013), ergonomics aims to modify work systems to adapt the existing activities to the characteristics, skills, and limitations of people to achieve efficient, comfortable and safe performance.

2.2 Ergonomics Division

Ergonomics are characterized in four types according to the occasion when it is performed (WISNER, 1987 apud IIDA, 2005, p. 13):

a) Design ergonomics occurs when ergonomics contributes at the beginning of the product, machine, environment or system design. This is the best situation, as the alternatives can be widely examined, and a well-designed ergonomic analysis can help to avoid ergonomic problems;

b) Correction ergonomics: it is applied in real situations, where there is a previous problem, looking for its solution. Many times, the adopted solution is not completely satisfactory, because it can demand high implantation cost, therefore it is necessary to look for solutions that adapt to the reality and conditions of the organization;

c) Awareness ergonomics: seeks to enable workers to identify and correct everyday or emergency problems. Empowering workers is important since the problems are not always fully resolved in the design phase and the correction phase;

d) Participation ergonomics: aims to involve the system user in the ergonomic problem-solving process. The worker participates based on the idea that he has practical knowledge, the details of which may go unnoticed by the analyst or designer.

2.3 Ergonomic Work Analysis (EWA)

After World War II, a new aspect of ergonomics emerged in Europe, spurred by the need for the reconstruction of the destroyed European industrial park. Renault's car factory in France was the first to set up an ergonomic industrial laboratory. Later, the French school originated, which had its question: how to properly develop a workstation from an existing situation? According to Masculus and Vidal (2011), given this concern, in 1966, A. Wisner formalized the Ergonomic Work Analysis (EWA).

EWA is based on a request made by management or manager about a problem of production, occupational health, product performance or organizational effectiveness (MÁCULO & VIDAL, 2011). Iida (2005) reports that EWA aims to apply ergonomic knowledge to analyze, discover the causes and correct a real work situation.

The method consists of five steps (GUÉRIN et. Al, 2001 apud IIDA, 2005, p. 60):

First) Demand Analysis: This step consists of trying to understand the nature and dimension of the problems presented. There must be an agreement between all parties involved (managers, workers, ergonomists, supervisors) so that the problem can be delimited, deadlines set, costs for problem resolution;

Second) Task Analysis: At this stage, the ergonomist will analyze the differences between the work that is prescribed and what is done. There may be some discrepancy due to mismatched machines, uneven materials and also because not all workers strictly follow the method described;

Third) Activity analysis: refers to the behavior of the worker in the accomplishment of the task, that is, the actions that the worker takes to achieve the goals assigned to him. Activity is influenced by internal and external factors. Internal factors are located in the worker himself and external factors refer to the conditions under which the activity is performed;

Fourth) Formulation of the diagnosis: seeks to discover the causes that cause the problem described in the demand. They may have several works and company-related factors that influence work activity;

Fifth) Ergonomic recommendations: refers to the steps that should be taken to solve the diagnosed problem. Recommendations should be specified with all the steps needed to solve the problem. An action plan indicating who is responsible for the actions, deadlines, costs, etc. is required.

2.4 The Rapid Entire Body Assessment (REBA) method

The REBA method was proposed by Sue Hignett and McAtemney Lynn and was published in Applied Ergonomics magazine in 2000. It is the result of the joint work of a team of ergonomists, physiotherapists, occupational therapists who identified about 600 different postures for its elaboration (PIRES, 2000 and 2011). This method allows the joint analysis of the positions taken by the arms, forearms, fist, trunk, neck, and legs. It also defines other very important factors for ergonomic analysis such as the final assessment of posture, load or strength required to hold and the type of muscle activity performed by the worker. This method includes a new factor that evaluates whether the adopted upper limb posture is for or against gravity, considering that this circumstance increases or decreases the risk of postural associated WRMD (PIRES, 2011).

For Pires (2011), one of the strengths of the REBA method is related to the division of the body into two groups, which are:

• Group A: trunk, neck, legs and even load and strength;
• Group B: arms, forearms and fists and type of grip.

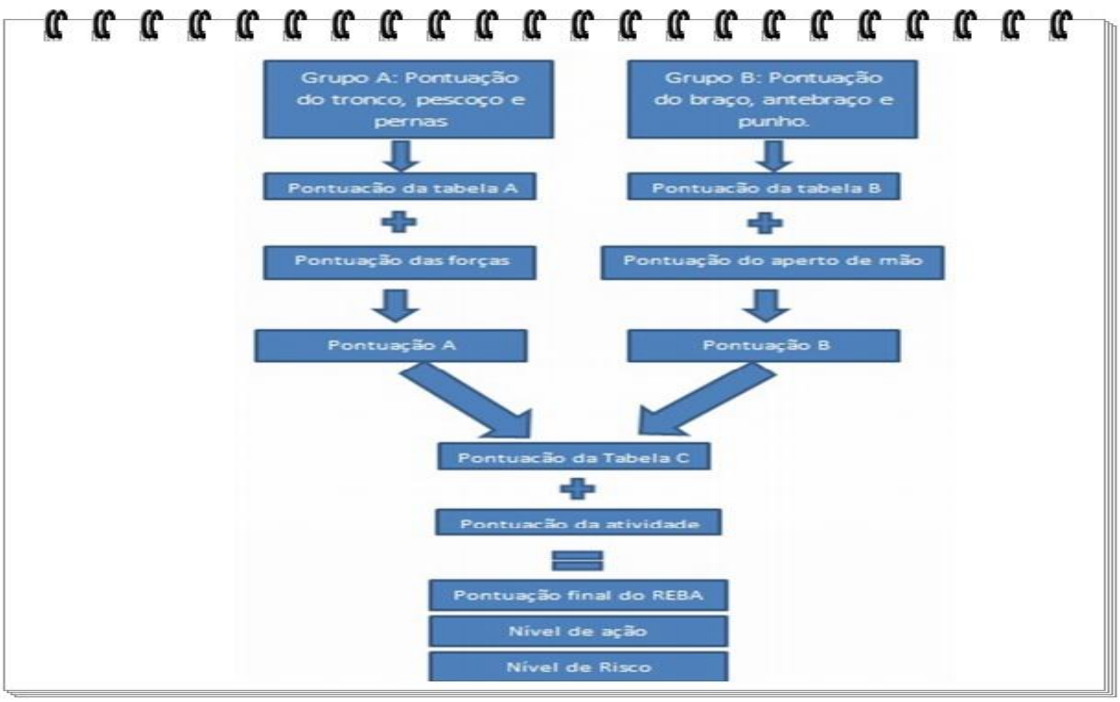


Figure 1 – REBA Flowchart
Source: Adapted from PIRES (2011, p. 128)

The REBA method first consists of evaluating the two groups of the division separately. First, it gets the score of group A and then that of group B.

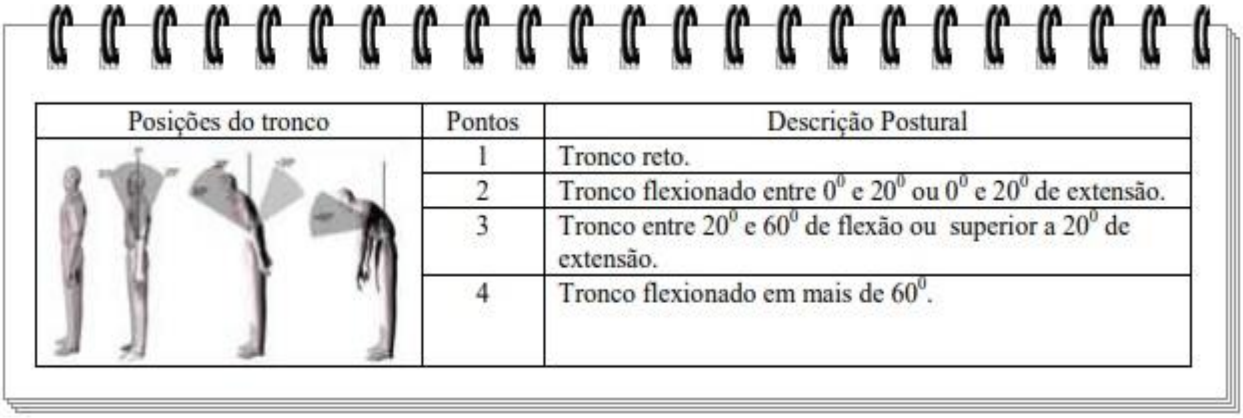
These two scores correlate and a C score is obtained, which may or may not be increased due to the activity score.

This final score is the result of the REBA method, which indicates the level of risk and action.

2.4.1 Scoring for group A

Figure 1 shows the activities for performing the REBA method. Basically, in group A, the method starts with the individual assessment and score for the trunk, neck, and legs.

Trunk Score: For the trunk score, one must observe whether the worker performs the tasks with the trunk straight or not. If the trunk is not upright, indicate the degree of flexion or extension as shown in Chart 1.

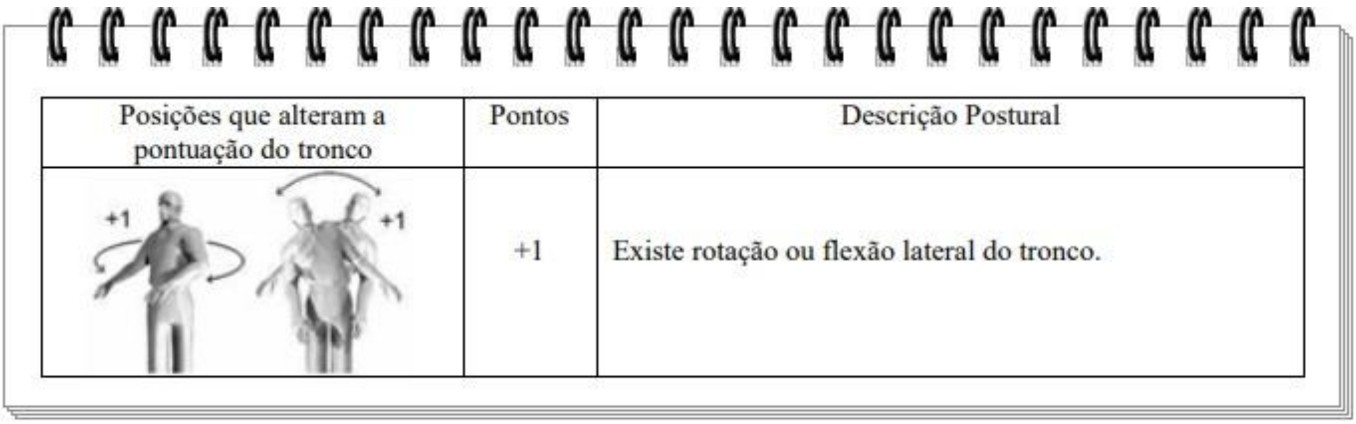


Posições do tronco	Pontos	Descrição Postural
	1	Tronco reto.
	2	Tronco flexionado entre 0^0 e 20^0 ou 0^0 e 20^0 de extensão.
	3	Tronco entre 20^0 e 60^0 de flexão ou superior a 20^0 de extensão.
	4	Tronco flexionado em mais de 60^0.

Chart 1 – Trunk Score

Source: Adapted from Pires (2011, p. 119)

The trunk score will be increased if there is lateral rotation or inclination of the trunk as shown in Chart 2.



Posições que alteram a pontuação do tronco	Pontos	Descrição Postural
+1 +1	+1	Existe rotação ou flexão lateral do tronco.

Chart 2 – Values that change trunk score

Source: Adapted from Pires (2011, p. 120)

The second member to be evaluated from group A is the neck. The method considers two neck positions and the score is applied according to Chart 3.

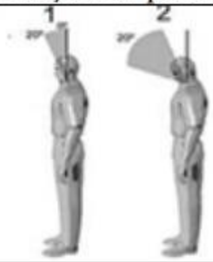
Posições do pescoço	Pontos	Descrição Postural
	1	Pescoço entre 0^0 e 20^0 de flexão.
	2	Pescoço flexionado ou em extensão de 20^0.

Chart 3 – Neck Score. Source: Adapted from Pires (2011, p. 120)

If there is a lateral inclination of the neck, the score may be increased according to Chart 4.

Posições que alteram a pontuação do pescoço	Pontos	Descrição Postural
	+1	Com flexão ou rotação lateral do pescoço

Chart 4 – Values that change the neck score

Source: Adapted from Pires (2011, p. 120)

Legs are the last members to be evaluated and scored from group A. Chart 5 shows the score for leg position as a function of weight distribution.

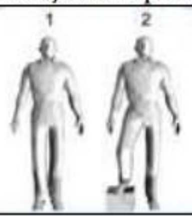
Posição das pernas	Pontos	Descrição Postural
	1	Suporte bilateral, em pé ou sentado.
	2	Suporte unilateral, suporte ligeiro ou postura instável.

Chart 5 – Legs Score

Source: Adapted from Pires (2011, p. 121)

Leg scoring may be increased if one or two knees are flexed as shown in Chart 6.

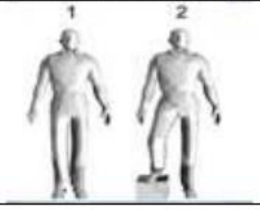
Posições que alteram a pontuação das pernas	Pontos	Descrição Postural
	+1	Com flexão de um ou ambos os joelhos entre 30^0 e 60^0.
	+2	Com flexão de um ou ambos os joelhos em mais de 60^0 (exceto postura sentada).

Chart 6 – Values that change the legs score

Source: Adapted from Pires (2011, p. 121)

Tronco	Pescoço											
	1				2				3			
	Pernas				Pernas				Pernas			
	1	2	3	4	1	2	3	4	1	2	3	4
1	1	2	3	4	1	2	3	4	3	3	5	6
2	2	3	4	5	3	4	5	6	4	5	6	7
3	2	4	5	6	4	5	6	7	5	6	7	8
4	3	5	6	7	5	6	7	8	6	7	8	9
5	4	6	7	8	6	7	8	9	7	8	9	9

Chart 7 – Final Score for Group A

Source: Pires (2011, p. 124)

At the end of each group A item score, Chart 7 is used to obtain the final group score. This chart correlates the values to obtain the final group score, for example, if the trunk score is 3, the neck score is 2, and the leg score is 3, the final score for group A is 6. When considering the load or strength score, the final score for group A may be increased as shown in Chart 8.

Score	Position
0	The applied load or force is less than 5kg.
+1	The load or force is between 5 and 10 kg.
+2	The load or force is higher than 10 kg.

Chart 8 – Load or force Score

Source: Adapted from Pires (2011, p. 125)

The score for the loads can still be changed if the force is applied abruptly, in this case, +1 is added.

2.4.2 Scoring for group B

In group B evaluation, the upper limbs (arm, forearm, and fist) should be evaluated and scored. Arm Scoring: To determine the arm rating, the flexion angle should be observed. Chart 9 displays the different positions and angles considered by the method.

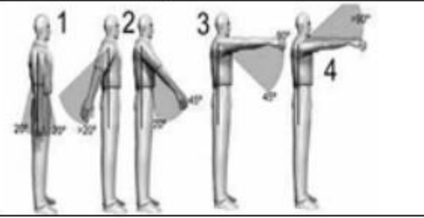
Posições do braço	Pontos	Descrição Postural
	1	Braço entre 0^0 e 20^0 de flexão ou 0^0 e 20^0 de extensão
	2	Braço entre 21^0 e 45^0 de flexão ou superior a 20^0 de extensão.
	3	Braço entre 46^0 e 90^0 de flexão.
	4	Braço flexionado acima dos 90^0.

Chart 9 – Arm Score. Source: Adapted from Pires (2011, p. 122)

The arm score can be modified according to Chart 10.

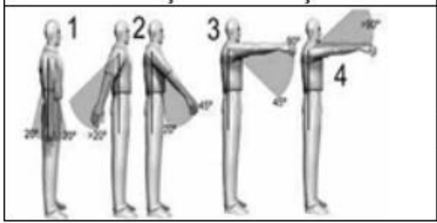
Posições do braço	Pontos	Descrição Postural
	1	Braço entre 0^0 e 20^0 de flexão ou 0^0 e 20^0 de extensão
	2	Braço entre 21^0 e 45^0 de flexão ou superior a 20^0 de extensão.
	3	Braço entre 46^0 e 90^0 de flexão.
	4	Braço flexionado acima dos 90^0.

Chart 10 – Positions that change arm score

Source: Adapted from Pires (2011, p. 122)

Forearm Score: For analysis of arm position, Chart 11 shows the score according to the flexion angle.

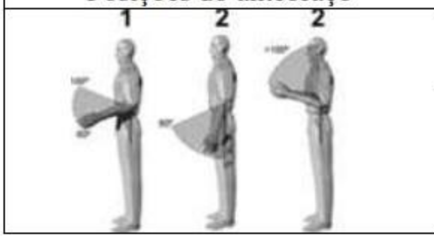
Posições do antebraço	Pontos	Descrição Postural
	1	O antebraço está entre 60^0 e 100^0 de flexão.
	2	O antebraço está flexionado abaixo dos 60^0 ou acima dos 100^0.

Chart 11 – Forearm position

Source: Adapted from Pires (2011, p. 123)

Fist Scoring: Two fist positions are considered, with score described in Chart 12.

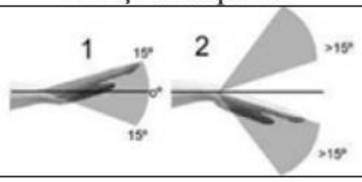
Posições do punho	Pontos	Descrição Postural
	1	Punho entre 0^0 e 15^0 de flexão ou extensão.
	2	Punho flexionado ou em extensão acima de 15^0.

Chart 12 – Pontuação do punho

Source: Adapted from Pires (2011, p. 123)

The value assigned to the fist may be increased as described in Chart 13.

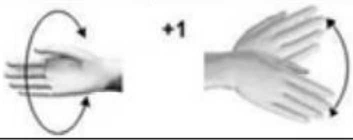
Posições que alteram a pontuação do punho	Pontos	Descrição Postural
	+1	Se houver rotação ou desvio lateral do punho.

Chart 13 – Positions that alter fist score

Source: Adapted from Pires (2011, p. 123)

At the end of the group B score, Chart 14 is used. To assist the final score of group B, simply correlate the values obtained by each member analyzed, for example, if the arm score is 2, the forearm score is 2 and the fist is 3, the final score of group B will be 4.

Braço	Antebraço					
	1			2		
	Punho			Punho		
	1	2	3	1	2	3
1	1	2	2	1	2	3
2	1	2	3	2	3	4
3	3	4	5	4	5	5
4	4	5	5	5	6	7
5	6	7	8	7	8	8
6	7	8	8	8	9	9

Chart 14 – Final Score for group B

Source: Adapted from Pires (2011, p. 124)

Handle Type Score: Handle type may increase the final score of group B, as per Chart 15.

Score	Position
0	Great Handle: When the applied force is sufficient, it does not need other regions of the body.
+1	Regular handle: It is acceptable, but not ideal, the grip is aided by other parts of the body.
+2	Bad Handle: the grip is possible but the load is heavy and the handle is unstable.
+3	Unacceptable Handle: If the grip is unsafe, it is necessary to use other parts of the body to move the load.

Chart 15 – Handle Type Score.

Source: Adapted from Pires (2011, p. 125)

Pontuação A	Pontuação B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Chart 16 – Score C

Source: Adapted from Pires (2011, p. 126)

The score C can be found with total scores A and B as shown in Chart 16. For example, if score A is 4 and B is 3, score C is 4.

Obtaining the score from Chart 16, the value of score C may be increased due to the type of muscle activity as described in Chart 17.

Score	Activity
+1	One or more body parts remain static (for example, support for more than one minute).
+1	Repetitive movements (repeat the same movements more than 4 times per minute, excluding walking).
+1	Postural changes are significant or unstable.

Chart 17 – Muscle activity score

Source: Adapted from Pires (2011, p. 126)

At the end of the REBA method there is the classification shown in Chart 18.

Final Score	Action level	Risk level	Action
1	0	None	No action or intervention required
2 – 3	1	Low	Intervention/action may be required
4 – 7	2	Medium	Intervention/action required
8 – 10	3	High	Intervention/action is required as soon as possible.
11 – 15	4	Very High	Intervention/action is urgently needed

Chart 18 – Action and risk levels according to final score

Source: Adapted from Pires (2011, p. 127)

At the end of the REBA method, the activity risk level and the action/intervention level for risk resolution or minimization are obtained.

3. Methodology and results

The methodology has an applied nature and consisted of theoretical foundation, the realization of the phases of the demand analysis, the task and the constituent activities of the Ergonomic Work Analysis methodology. The methods used for the analysis of the activity were: filming, photographs, observations, measurements. In the elaboration and execution of this work, was used:

a) bibliographic research through consultation of books, scientific articles, and dissertations to assist and direct the ergonomic analysis of this work; b) descriptive study aiming to describe the working conditions of a given group of workers; c) quantitative approach: seeking to translate into numbers to better classify and analyze data.

3.1 Research Planning

By management decision, it was defined that the target audience of the survey would be the employees of the TV PCB assembly line, as this line has the largest number of complaints from employees.

At this stage, a literature review was conducted to find scientific articles, dissertations, theses, and books by prestigious authors in the field of ergonomics. Several scientific articles addressing EWA were found in various industrial and service sectors, such as the research by Leu and Frasson (2012), as well as the study by Oliveira et. al. (2010). The research was developed following the EWA method, which is composed of the analysis of demand, task, and activities, followed by diagnoses and recommendations (IIDA, 2005). The ergonomic analysis tool used in this study was the REBA because it was considered the most comprehensive and it was possible to evaluate both the upper and lower limbs. In the following items, each of the EWA phases will be presented.

3.2 Demand Analysis

Demand analysis consists of defining the problem to be studied for the various social actors involved (IIDA, 2005). The analysis was performed in the manual assembly sector of electronic components, more precisely in the assembly line of TV cards. The electronic components manual assembly line is made up of eight women between the ages of 20 and 40 and have completed high school. They all perform the same procedure, which is to mount electronic components on the board, differing only the types of components, the values, and mechanical positions. All of them are supervised by the production line reservation which is in turn subordinated to the Production Manager.

A post was selected for the EWA, considering that the post assembler constantly went to the occupational doctor, complaining of pain in his arms, shoulders, and neck. During the investigation, it was found that the former operator of the same job was on sick leave due to pain in the upper limbs.

Vieira (2007) recommends that if a more serious situation is identified, and a more critical post, this situation should be tackled with priority. Then through a meeting between the production manager, the occupational physician, the Internal Accident Prevention Commission (CIPA) and process engineering, it was established that this assembly post would be a priority in the ergonomic analysis of the work and that the proposals for improvement would apply to all other posts on the production line.

3.3 Task Analysis

The task is a set of prescribed goals that the worker must fulfill. Task analysis consists of analyzing the work prescribed to the automaker and the work that it performs (IIDA, 2005). Each workstation contains a document formulated by process engineering called the Standard Operating Procedure (SOP).

The SOP contains all the operations that must be performed on the workstation, their duration cycle, the sequence of tasks and instructions on how to perform them. Chart 19 contains the activities of the workstation selected for analysis.

ITEM	DESCRIPTION OF INTEGRATED CIRCUIT BOARD (PCB) PREPARATION
1	Pick up 100nF capacitor and place in position C13 (right hand).
2	Take diode FR 117 and place in position D2 (left hand).
3	Take 2.2kOhm resistor and place in position R12 (right hand).
4	Pick up transistor BC337 and place in position Q4 (left hand).
5	Stabilize components for welding and cutting (both hands).

Chart 9 – Standard Operating Procedure (SOP)
Source: Company X

The cycle time of the station in question was 10 seconds, ie the operator had 10 seconds to be able to perform all tasks of the assembly station. The time of the workday was 9 hours and 48 minutes, with an interval of 1 hour for lunch and rest. The time at work for labor gymnastics was 10 minutes. Workers had 7 minutes in the morning and 7 minutes in the afternoon to go to the bathroom and drink water, so the worker spent 8 hours and 24 minutes at his workstation.

While observing the workstation, it was found that the operator was following all POP instructions correctly. There was also a slight difficulty that the operator had to perform items 2 and 4. When asked about the reason for the difficulty, the operator replied that the components had polarity and that to be assembled correctly, it is necessary to place the components according to the indication on the plate. The components of steps 1 and 3 had no polarity. Using a Minipa MT-241 reference hygrometer, the ambient temperature and humidity were measured:

Ambient temperature: minimum 210 and maximum 230 and humidity: minimum 52% and a maximum of 58%. Ambient temperature and humidity were within the range prescribed by NR-17 which is temperature between 200 and 230 ° C and relative air humidity of not less than 40%.

3.4 Activity Analysis

The activity refers to the automaker's behavior in performing the tasks of his workstation to achieve the objectives of the production process (IIDA, 2005). The methods used for the analysis of the activity were: filming, photographs, observations, measurements. The analysis of this post focused on the operator's movements for the assembly of components, where the movements of the arms, forearms, fists, trunk, and neck were analyzed.

First, through the stopwatch, the real-time for the activity was measured. The average time taken to perform all actions in the post was 8.7 seconds, but the POP prescribed as the cycle time 10 seconds. For the analysis of work activities, the REBA method was used, which assesses the risks of WRMD in specific positions and independently, resulting in the level of action required and the need for urgency. Currently, a large number of researches are based on results obtained by the REBA method, making it one of the most used tools in the postural analysis (PIRES, 2011).

According to Pires (2011), to evaluate an activity it is necessary to select the most representative postures, either by repetition in time or precariousness. Selecting the correct postures for the assessment will determine the results provided by the method and the actions to be taken in the future. By recording the execution of the task through photos, videos and observations, three postures that best represent the work activity were selected. To assist in the use of the REBA method, a free version of the Ergolândia 3.0 software, with a 30-day license, was used. This software was developed by FBF Systems and has been widely used in studies and research, such as Takeda et al. (2011).

The activity analysis proceeded as follows:

3.4.1 First Posture Analysis

Chart 20 displays data from the first posture selected for REBA assessment.

Neck position	0 to 20 degrees	
Trunk position	0 to 20 degrees	
Leg position	Bilateral support	
Load	Less than 5 Kg	
Left arm position	45 to 90 degrees	Shoulder lift
Forearm position	60 and 100 degrees	
Fist position	15 degrees	
Handle	Good	
Activity	Repetitive movements	

Chart 20 – Data regarding the first posture

Source: Company X

Figure 2 – First posture

Source: Company X

With the data obtained by the posture evaluation, the REBA method was applied, which had the result equal to 4 (Chart 21) with average risk level requiring intervention or action.

Final Score	Action Level	Risk level	Action
1	0	None	No action or intervention required
2 – 3	1	Low	Intervention/action may be required
→ 4 – 7	**2**	**Medium**	**Intervention/action required**
8 – 10	3	High	Intervention/action is required as soon as possible.
11 – 15	4	Very high	Intervention/action is urgently needed

Chart 21 - First posture score and risk level

Source: Author

3.4.2 Second Posture Analysis

Chart 22 displays data from the second posture selected for REBA assessment.

Neck position	Greater than 20 degrees	Rotated sideways
Trunk position	0 to 20 degrees	
Legs position	Bilateral Support	
Load	Less than 5 Kg	
Left arm position	20 to 45degrees	Shoulder lift
Forearm position	60 and 100 degrees	
Fist position	15 degrees	Offset from neutral line
Handle	Good	
Activity	Repetitive moviments	

Chart 22 – Data for the second posture

Source: Company X

Figure 3 presents the second posture analyzed, whose final score was considered 5, similar to the previous case.

Figure 3 – Second posture

Source: Company X

3.4.3 Third Posture Analysis

Chart 23 displays data from the second posture selected for the REBA assessment.

Neck position	Greater than 20 degrees	Rotated sideways
Trunk position	0 a 20 degrees	Rotated sideways
Legs position	Bilateral support	
Load	Less than 5 Kg	
Left arm position	45 to 90 degrees	
Forearm position	60 and 100 degrees	
Fist position	15 degrees	Offset from neutral line
Handle	Good	
Activity	Repetitive movements	

Chart 23 – Data for the third posture

Source: Company X

Figure 4 presents the third posture analyzed, whose final score was considered 6 which also corresponds to medium risk, so and intervention in the activity is necessary.

Figure 4 – Third posture
Source: Company X

3.5 Diagnosis

The diagnosis of the problems found was elaborated and the improvement proposals were recommended aiming at reducing the risks of the workstation and preserving the health of the operators.

Based on the results obtained by the REBA method for the three most representative postures of the activities performed at the workstation, it was verified that the operator was subjected to medium risk of WRMD and that the intervention to solve or minimize the risk was necessary. The operator's complaints were a pain in the shoulders, arms, and neck.

During the observation of activities and risk analysis of WRMD by the REBA method, it was observed that the angle formed by the left arm in the first posture and the right arm of the second posture concerning the trunk was approximately 90 degrees. Kroemer and Grandjean (2005), as well as Masculus and Vidal (2011), recommend that the arms extended forward and side should be avoided, as these postures generate fatigue and reduce the overall level of accuracy and dexterity of operations performed with hands and arms, and keeping the shoulder-high causes pain in it. The operator worked with her arms raised to pick up the components because the place where the components were stored was high.

The third posture shows the rotational movement of the trunk and neck. In this case, Kroemer and Grandjean (2005), as well as Masculus and Vidal (2011) report that any bent body posture should be avoided, lateral curvature of the trunk or head forces more than forward bending movements and should avoid cross-arm movement as shown by posture. According to Dull and Weerdmeester (2004), twisted trunk postures cause unwanted tensions in the vertebrae.

4. Final Considerations with Recommendations

The EWA method is started when there is a demand, that is, when a problem arises that needs to be investigated, analyzed, diagnosed and subsequently solved or minimized. This research came from the complaints of operators who claimed to feel pain in the upper limbs. As a result of the research, it was found that the problems related to pain and discomfort of the upper limbs reported by the operators were directly related to the execution of their activities, which needed to be eliminated to preserve workers' health and decrease and/or eliminate the risks of WRMD.

The analysis of the workstation using the EWA method and the REBA tool allows assessing the degree of risk that the operator was undergoing. Thus, it was found that the workstation was improperly designed as the operator needed to stay with the arms extended to pick up the components with both hands. Moreover, the repetitive nature of the operations during the workday caused discomfort in the arms, shoulders, fists, and muscle fatigue. It was also found that the operator's activity required movement of rotation and curvature of the trunk and neck, which over time caused pain in the shoulder and neck.

To alleviate or remedy the problem, five recommendations were made:

First) Arrange the work area so that manual operations can be done with the low elbows and forearms at an angle of 85 to 110 degrees, according to the guidance of the authors Kroemer and Grandjean (2005) and Masculus and Vidal (2011). The work area required the arms to be raised, with the elbows raised, causing repetitiveness to cause discomfort throughout the working day;

Second) Shrink the work area: Because both hands and arms are used for work, the work area should spread as little as possible on each side. The automaker's work area was comprehensive and caused her to rotate the trunk to the left, a smaller work area would prevent such movement (KROEMER & GRANDJEAN, 2005; MÁCULO & VIDAL, 2011);

Third) Perform postural training so that the operator is not in postures that may cause discomfort;

Fourth) Switch to sitting work positions with standing work, as the authors Kroemer and Grandjean (2005) report that this is the most recommended;

Fifth) Avoid zigzag movement with the arms. Each operation must end in one position to start another (KROEMER & GRANDJEAN, 2005).

As a proposal for future work, a new ergonomic analysis is recommended to verify if the ergonomic problems were solved after the company managers had executed the recommendations.

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