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ERGONOMIC PROPOSAL IN THE STORAGE AREA OF A PLASTIC INDUSTRY COMPANY TO REDUCE INDUSTRIAL RISKS

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Ergonomic Proposal in the Storage Area of a Plastic Industry Company to Reduce Industrial Risks

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Abstract. This research was aimed at identifying ergonomic risks for the warehouse operators in the workstation of a plastics industry company, it also explained the reason for the ailments caused by bad posture and proposed ergonomic design solutions. It is an applied, quasi-experimental, exploratory and descriptive research; with a mixed approach where a Nordic Questionnaire and the REBA methodology were used, as they detect musculoskeletal symptoms prematurely and a posture analysis is performed when carrying out tasks, as well as measurements of lighting and noise. Ailments caused by uncomfortable postures with a high risk rating were found in activities such as order preparation, revision and accommodation, mainly in parts of the body such as the neck, wrists, lower back and hips. As a result, postures that are viable in the warehouse with the use of equipment were proposed, reducing the risk to negligible and medium rating. No risks were found in relation to lighting and noise.

Keywords. Ergonomics, warehouse, ergonomic risk, REBA, ergonomic proposals

1. Introduction

The plastic industry companies have large warehouses for their raw material and finished products where different tasks are performed such as reception, revision and arrangement, storage, inventory control, preparing orders, order fulfilment and distribution. Furthermore, the forklift truck is the main equipment implemented for transportation in and out of the warehouse, its function is to lift, move and locate the load inside the warehouse [1].

The warehouse workers, during the performance of their activities, are exposed to risk factors such as lifting heavy objects, uncomfortable or static postures, and repetitive movements [2]. About 6300 workers die every day due to work-related accidents or illnesses. In addition, there are about 360 million people a year affected by non-fatal injuries caused at work which result in an average of 4 days of absenteeism from work [3].

The Company where the research was carried out makes polyethylene-based products. In the production area the manufacture of these products is mainly done with special machinery, workers mainly perform one activity which is to supervise, its proper functioning and does not need much effort. The ergonomic difficulty appears in the warehouse where there are 6 workers. Thus, it seeks to answer the following question. What are the workers ergonomic work conditions in the warehouse area in a plastic

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industry company? In this area, the handling of 25 kg net content sacks mainly of polyethylene pellets is performed [4].

The research is carried out to develop a proposal for ergonomic improvement to reduce ergonomic risks related to the operators' work condition in the warehouse from a company in the plastic industry. Thus, lowering risks related to ergonomics, such as repetitive activities, carrying heavy weight or oversized objects, and therefore, avoid musculoskeletal injuries [2].

The presence of musculoskeletal injuries is related to manual load handling, repetitive actions and gender, where the most common ailments are in the neck, shoulders and back [5]. Consequently, to lower the MSD prevalence, is recommended to reduce the biomechanics risk factors and to improve the work environment. The lack of lighting and a spacious area to do their specific jobs are also factors that affect workers' comfort and health [6].

In terms to a Nordic questionnaire applied to 12 workers from the printing area of a company, it was found that the illnesses or discomfort mostly present in parts of the body are the back, the upper part of the right arm and the left forearm caused by the manual handling of materials or loads [7].

Manual handling of material in a warehouse has a great impact in the operators' roles [8]. Implementing a tray with wheels as a moving equipment between work stations helps reducing the impact of manual load handling [9].

The task of lifting weight had a significant impact in workers' lumbar spine pain [10]. The parts of the operators' bodies that have a high risk level during work are the back, neck, and upper part of the arms with a REBA score of 9 which shows that actions must be taken to reduce the risk level [7]. In a sugar bag warehouse the classification and bag lifting process present a medium to very high-risk level that fluctuate from 5 to 11 according to the REBA method. It is, therefore, necessary to improve female workers' posture in this activity [11].

In addition, it exists a meaningful relationship between workers' dissatisfaction and lack of ergonomics implementation in the companies [12]. Thus, implementing ergonomic proposals will allow to set up a safe and appropriate work environment for employers as well as for employees [13].

2. Methodology

This was an applied research to propose possible solutions to the ergonomic problem in a warehouse of a company that produces plastic products. Likewise, the study paradigm was positivist with exploratory and descriptive scope.

The Nordic Questionnaire was applied to 6 operators, with a prior informed consent, applied directly to each operator for the development of the study, through non-probabilistic sampling. This questionnaire is designed for the detection and analysis of musculoskeletal symptoms in order to identify if there are physical discomforts that have not become a disease or require medical attention [14]. In addition, it is a multiple-choice questionnaire and validation should be performed post musculoskeletal pain with a pain scale [15]. This allowed to identify the most affected body parts of the operators in their job positions.

This study had a mixed approach with quantitative and qualitative data analysis. Quantitative data were used for ergonomic studies and applying the REBA method, which divides the body into group A (neck, legs and trunk) and B (arms, forearms and wrists). In addition, load, strength and grip can be added according to each evaluated posture and corresponding weight to find a previous result and a score is added for each activity (static, repetitive or unstable postures). Finally, the risk level is interpreted [16]. This methodology allowed to analyze the whole body and thus, identify the ailments of each posture under evaluation through fieldwork and observation.

The independent variable was the ergonomic proposal, which had two dimensions. The first one is the structure, which refers to the physical distribution of the warehouse

where lighting and noise levels were measured. A fieldwork was carried out in the warehouse area during working hours by using a luxmeter and a decibelmeter, in order to detect ergonomic risk factors. In addition, the physical load and the effort related were analyzed to the different dynamic and static tasks, evaluating the number of manual loading and equipment activities.

The dependent variable refers to the job position in the warehouse, considering the development of storage process which consists of receiving, revising and arranging, inventory control, preparing orders, order fulfilment and distribution stages, where the manual weight load and with equipment were studied. Finally, how equipment is used, based on the quantity of well-employed equipment.

The methodological design was quasi-experimental. Additionally, a systematic observation was made with photos and videos. Moreover, equipments such as decibelmeter and luxmeter were used, and the Angle Meter app to measure the angles in the body.

3. Results

The warehouse process involves handling different loads according to the materials used and finished products manufactured in the company.

Table 1. Load Handled in the storage area

Load handled		
Materials/products	Weight	Presentation
Polyethylene pellets bags	25 kg	Unit
Masterbatch additive bags	25 kg	Unit
Road barriers	6 kg	Unit
Containers	3.5 – 4 kg	Unit
Traffic safety cones	2.3 – 3 kg	Unit
Pallets	6.4 – 14 kg	Unit
Cylinder	9 kg	Unit
Tray	1 – 2 kg	Unit
Kayaks	20 – 30 kg	Unit
Aquatank	17 kg	Unit

The materials or products with greater load rotation are polyethylene pellet bags and masterbatch additives, since they are the raw material for different products such as containers that are the highest rotation finished product in the warehouse. These loads can be manually handled, and the other ones can be load using equipment according to the activities.

Table 2. Possible evaluation activities in the storage area

Possible evaluation activities	
Activities	Type of activities
Reception	Use of equipment
Revision and arrangement	Load handling
Storage	Use of equipment
Inventory control	Load handling
Preparing orders	Load handling
Order fulfilment	Use of equipment
Distribution	Use of equipment

It was found that 4 of the loading activities are done using equipment and 3 by manual load handling.

The Nordic Questionnaire was applied in the ergonomic study, which allowed to gather information to identify the operators' body parts where discomfort and/or ailment prevails the most.

Table 3. Total accumulated pain by body part

Body part	Total accumulated pain
Neck	3

Shoulders	0
Elbows	0
Wrists	3
Upper back (thorax)	0
Lower back (lumbar)	2
Hips or thighs	1
Knees	0
Ankle or feet	0

The main discomfort and/or ailments are in the neck, wrists, lower back or lumbar spine, the most frequent pains are in the neck and wrists. On the other hand, the operators have not shown any impediment to do their usual routines in the last 12 months. However, they have started to exhibit ailments in the above mentioned parts of the body for 1 to 7 days in the last 12 months. Also, neither one of the operators needed physiotherapy or had gone to the doctor because of the ailment. It is important to mention that 5 of them are right-handed and only 1 is left-handed.

According to the analysis of the Nordic questionnaire and a periodic observation in the warehouse, these are mainly due to the handling of the loads, mainly carrying raw material bags that can weigh up to 25 kg. Similarly, the operators mentioned that the uncomfortable postures adopted when doing these activities influence in neck pain.

The REBA method [16] was used to determine the ergonomic risk level, and the uncomfortable identified postures were analyzed.



Figure 1. Measurement of angles in the activities under evaluation.

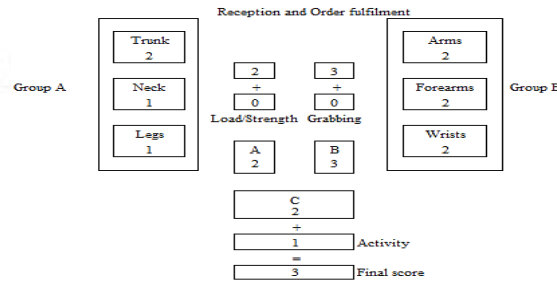


Figure 2. REBA score in reception and order fulfilment activity.

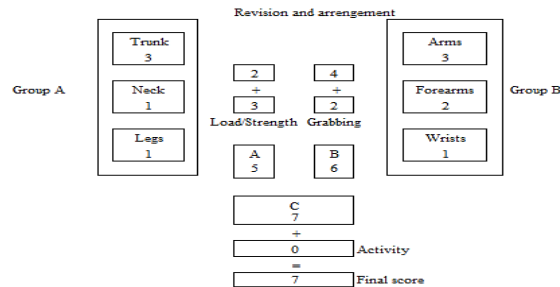


Figure 3. REBA score in revision and arrangement activity.

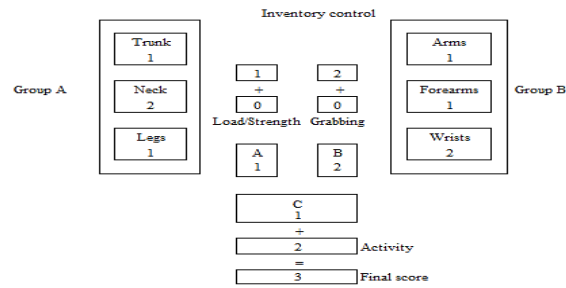


Figure 4. REBA score in inventory control.

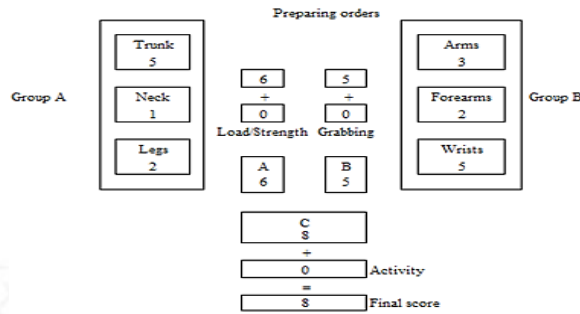


Figure 5. REBA score in preparing orders activity.

According to the evaluated postures, it was found that two of the postures required an immediate ergonomic proposal, they are in preparing orders and revision, and arrangement activities. Therefore, new postures that are appropriate to the activities above mentioned were proposed, and that will not imply a high-risk level to the one operators are exposed to.



Figure 6. Ergonomic proposal posture for preparing orders activity.

Table 4. Improvement of REBA score after the ergonomic proposal for preparing orders activity

	Before	After
Neck	1	1
Legs	2	1
Trunk	5	2
+ Load/Strength	0	0
Total score A	6	2
Forearm	2	2
Wrist	3	1
Arm	3	1
+ Grabbing	0	0
Total score B	5	1
Score C	8	1
+ Activity	0	0
Final Score	8	1

It is proposed to use a manual wrapper to do this activity in order to reduce overexertion adopted in the initial position.

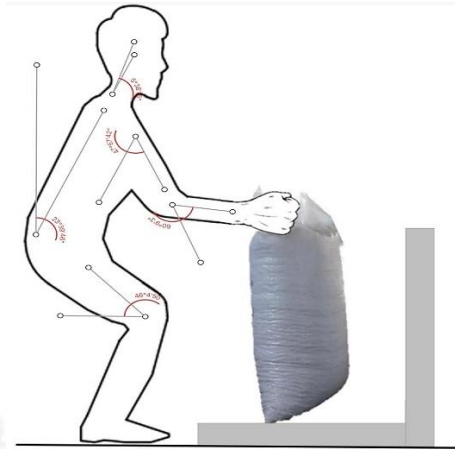


Figure 7. Ergonomic proposal posture for revision and arrangement activity.

Table 5. Improvement of REBA score after the ergonomic proposal for revision and arrangement activity

	Before	After
Neck	1	1
Legs	1	2
Trunk	3	2
+ Load/Strength	3	2
Total score A	5	5
Forearm	2	1
Wrist	1	1
Arm	3	2
+ Grabbing	2	0
Total score B	6	1
Score C	6	4
+ Activity	0	0
Final Score	7	4
Risk Level	High	Medium

Training and coaching are suggested to implement these new postures to assure the correct use of the proposed equipment and change to the new suggested postures, so operators adopt the new postures reinforcing the importance of ergonomics in doing their activities.

Additionally, an evaluation of the lighting level was made using the luxmeter Testo 540 in order to detect values that are not within the established limits in Ministry Resolution N°375-2008-TR [17]. These values are 50 lux for general indoor areas and 200 lux acceptable limit for staff service areas.

In the case of the warehouse under study, the lighting found was 300 lux minimum, and 356 lux maximum with an average of 328 lux which shows that the lighting levels are just above the standard, therefore, it does not mean risk for the operators.

On the other hand, noise measurement was done in the warehouse using the decibelmeter Testo 816 to detect if it exceeds the established limits in Ministry Resolution N°375-2008-TR which determines that the acceptable limit is 85 dBA for an 8-hour working day [17].

A maximum value of 57.3 decibels and a minimum value of 52 decibels were found to obtain a total of 55.41 decibels in an 8-hour working day. This noise comes from the forklift trucks and the traffic from loading and unloading trucks. However, it does not

imply high risk since the operators are at a non-risk exposure, and at 1 degree as stipulated in the Technical Manual: Health surveillance of workers exposed to noise [18]. Additionally, it was suggested to wear ear plugs in the warehouse.

4. Discussion and Conclusions

Applying the Nordic Questionnaire, ailments in the neck, wrists and low back were found because of manual load handling. The warehouse area operators suffer from ailments in lower back and neck which can become musculoskeletal injuries [5]. After applying this questionnaire, the most detected injury in operators in a printing area was the lower back mainly for manual handling of material or loads [7].

In the revision and arrangement stage where 25 kg bags are carried, the REBA score was 7 which is considered of high risk. On the other hand, during the 16 kg sugar bag lifting process, the score was 11, it means, that the operators are exposed to a very high risk level, and an immediate intervention was necessary; therefore, it is concluded that an improvement in posture should be done to reduce the level of risk workers are exposed to [11].

In the revision and arrangement stage, it is feasible to implement the proposed posture since it is easy for the operators to adapt, and it only requires adjustment on the way to perform it. In addition, for the preparing orders activity with the help of a manual wrapper proposal, the posture is easy to adapt since this equipment reduces the operators overstrain. Likewise, implementing equipment to avoid operators overexertion; helped reducing manual load handling using a tray with wheels to avoid muscular effort and inappropriate postures [9].

The lack of lighting in the operators' work environment is a factor that affects their health [6]. According to the lighting and noise study, the warehouse operators from a plastic industry company are not exposed to risk since the average was 328 lux and in terms of noise 55.41 dBA, both of them within the permitted limits.

It is concluded that by drawing up proposals for ergonomic problems found in the warehouse and based on the application of engineering according to REBA methodology, operators of the warehouse area can reduce the occupational risk by adopting better postures for the fulfilment of these activities, being important and feasible for the company, and the wellbeing of the operators.

It was possible to identify the most relevant risk factors in the warehouse, and to relate the ailments to the activities; being the main ones the postures adopted in the revision and arrangement activity and preparing the orders. In both activities, the neck, low back, and wrists are compromised.

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