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TASKS ANALYSIS IN SPECIALIZED CONSTRUCTION WORK IN THE ALTOS NORTE REGION OF JALISCO

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Resumen: Los trabajadores de la construcción en México están expuesto a riesgos ergonómicos que, en mediano o largo plazo, se asocian con trastornos musculoesqueléticos tanto en miembros superiores como inferiores. El realizar actividades manuales por encima del nivel del hombro representa un factor más que se puede asociar a la fatiga muscular de los miembros superiores, lo cual lleva a una reducción del rendimiento físico de los trabajadores. En la región Altos Norte de Jalisco, la construcción tradicional del techo consiste en la colocación manual de “cuñas” para formar una bóveda que posteriormente se limpia para eliminar el exceso de mezcla y dejar una vista aparente. En dicha actividad interviene un operador especializado cuyas principales actividades las realiza de pie y con los brazos por encima del nivel del hombro para eliminar el exceso de mezcla, utilizando una pequeña herramienta manual. Al realizar el análisis de tareas se clasifican y priorizan las posturas que adopta el trabajador para determinar cuáles son las posturas que requieren un mayor análisis, después de la clasificación realizada de acuerdo a la metodología utilizada se detectaron 3 actividades como relevantes, que en su conjunto acumulan el 90% de las imágenes analizadas, además, al utilizar el software Humantech® Industrial Ergonomics, se valoran los miembros involucrados en la operación y determina mediante una escala de riesgo el nivel al cual están expuestos, con esta herramienta se identificaron ambos miembros superiores con un nivel de riesgo elevado acumulando una calificación global de 33 puntos, en una escala de 30 a 49 para el nivel alto.

Palabras clave: Postura forzada, movimientos repetitivos, nivel del hombro, construcción

Aportaciones a la ergonomía: Los trabajadores de la construcción están expuestos a diversos riesgos ergonómicos, el llevar a cabo un análisis de tareas detallado para identificar cuantitativamente el nivel de riesgo al que están expuestos ayudará a identificar áreas de oportunidad y para la generación de propuestas para intervenir en la tarea para tratar de generar mejoras en sus condiciones de trabajo y tratar de disminuir la exposición a los factores de riesgo. Con un adecuado análisis de tareas se puede identificar puntualmente las posturas y los miembros del cuerpo que presentan un mayor riesgo para los trabajadores.

Abstract: Construction workers in Mexico are exposed to ergonomic risks that, in the medium or long term, are associated with musculoskeletal disorders in both upper and lower limbs. Performing manual activities above shoulder level represents one more factor that can be associated with muscle fatigue of the upper limbs, which leads to a reduction in the physical performance of workers. In the Altos Norte region of Jalisco, traditional roof construction consists of the manual placement of "wedges" to form a vault that is later cleaned to eliminate excess mixture and leave an apparent view. This activity involves a specialized operator whose main activities are performed standing up and with his arms above shoulder level to remove the excess mixture, using a small hand tool. When performing the task analysis, the postures adopted by the worker are classified and prioritized to determine which postures require further analysis, after the classification performed according to the methodology used, 3 activities were detected as relevant, which together accumulate 90% of the images analyzed, in addition, by using the Humantech® Industrial Ergonomics software, the members involved in the operation are evaluated and the level to which they are exposed is determined by means of a risk scale. With this tool, both upper members were identified as having a high risk level, accumulating an overall rating of 33 points, on a scale of 30 to 49 for the high level.

Keywords: Forced posture, repetitive motions, shoulder level, construction.

Relevance to Ergonomics: Construction workers are exposed to various ergonomic risks, carrying out a detailed task analysis to quantitatively identify the level of risk to which they are exposed will help to identify areas of opportunity and for the generation of proposals to intervene in the task to try to generate improvements in their working conditions and try to reduce exposure to risk factors. With an adequate task analysis, it is possible to identify the postures and body members that present a greater risk to workers.

1. INTRODUCTION

Construction work presents several ergonomic risks relevant to the workers who perform it (Zepeda Quintana et al., 2016). According to León Cruz (2011), more than 75% of construction workers in Mexico are exposed to multiple risks that were associated with musculoskeletal disorders of upper and lower limbs. One of the main risk factors is to develop repetitive manual activities above shoulder level (Grzywiński et al., 2014), which can directly impact negatively on the worker's fatigue level; since, as the fatigue level increases the worker's performance decreases (Hernandez Arellano et al., 2015). Fatigue is an indicator that work conditions need to be addressed.

According to information from the National Institute of Statistics, Geography and Informatics (INEGI, 2019), in Mexico there were 19,501 companies dedicated to construction, in which around 676,301 people work in this sector; in the state of

Jalisco 62,797 were dedicated to this activity, that is, almost 10% of the total number of workers in the country work in this state.

According to Ramírez Ponce, (2002), the technique of vault construction in Mexico dates back to the second part of the 19th century, and even mentions the municipality of Lagos de Moreno, Jalisco, as one of the possible sites where the technique originated. In the Altos Norte region of Jalisco, the traditional system of construction of the roofs of houses is developed in two phases: the gluing of the wedges and the cleaning of the vaults when they are finished. The first phase consists of placing small bricks called "wedges", which are glued one by one by hand to form a vault, while the second phase consists of removing the excess cement mixture to give the vault a more aesthetic appearance. These activities are carried out by specialized construction workers known as "maestros bovederos".

According to the literature review, it was found that there are no studies, at least documented, that characterize and analyze the tasks of specialized construction workers.

1.1. Objectives

- Classify the manual activities performed by a specialized construction worker.
- Identify the postures that represent the greatest risk to the worker.
- Carry out a biomechanical analysis of the most affected limbs when performing the activities.

1.2. Delimitation

The observation and analysis work will focus on the postures of the upper limbs, although there are several risk factors in other parts of the worker's body.

2. METODOLOGY

The methodology of the study consists of 4 sections:

2.1 Study design

- a. Delimitation of activity of interest; it will focus on activities that present forced postures preferably with the upper limbs above shoulder level.

2.2 Participants

- a. Search and invitation of subjects to participate. The profile sought is that of specialized construction workers who perform manual activities and are dedicated to the artisan elaboration of vault ceilings, with at least 5 years of experience in construction in the Altos Norte region of Jalisco.

2.3 Materials

- a. Analysis of global activities; conduct field visits and visualize at the work site the activities they normally perform during the workday.
- b. Videotaping of the activities to conduct a task analysis. Once the activity of interest has been identified, a video recording of the activity in question is made using the camera of the personal cell phone. The video is then analyzed using the GOM Player® media player.
- c. Task analysis in specialized software Humantech® Industrial Ergonomics. To identify the members of the body and the level of risk they present when performing the analyzed activity.

2.4 Methods

- a. Classification and characterization of activities. To follow the task analysis methodology of Gómez-Bull (2015) to identify the highest risk postures in the analyzed activity.

3. RESULTS

The study focused on the standing manual activities performed by construction specialists, where forced postures with repetitive movements and with the upper limbs above shoulder level were present. There is an interest in the gluing of "cuñas" for the construction of vault (see Figure 1).



Figure 1. Vault ceiling construction

3.1 Contact and search for participants

Visits were made to several places where construction work was being carried out and the person in charge of each site was contacted to invite them to participate in the study. In the municipality of Lagos de Moreno, Jalisco, 12 visits were made and only one site manager agreed to participate in the study, however, the activities

they were carrying out at that time did not correspond to the activities of interest of this study, so 2 more sites were visited in the municipality of Union de San Antonio, Jalisco, where a positive response was obtained from the site manager.

Once the participation of the group of construction workers was confirmed, a subsequent visit was made to observe at a glance the activities they commonly carry out during their workday. Only two workers were working at the site; the person in charge of the work and an assistant, where basic information was collected as shown in Table 1.

Table 1. Basic information on workers

Position	Age range	Experience (in years)
Person in charge	50 – 60	45
Assistant	30 – 40	8

3.2 Filming of activities

The activities performed by the construction workers during their workday of approximately 10 hours a day were observed and it was detected that the helper is in charge of eliminating the excess mixture from the vault ceiling, an activity he performs for at least 4 hours a day, standing on a support, for which he usually keeps both arms above shoulder level (see Figure 2). This activity adds value to the construction by leaving an apparent finish, which is why its execution is essential.



Figure 2. Vault ceiling cleaning

3.3 Task analysis

Once the activity of interest for the project was identified, a task analysis was developed; in this activity, the person in charge of performing it does it standing up, keeping his arms above his head, making movements and exerting a little pressure on the grooves of the mixture to eliminate the excess. According to the methodology of Gómez-Bull et al (2015), a separation of the activity into subtasks was performed with the images captured frame by frame, resulting in Table 2.

Table 2. Separation into subtasks

1. Surface cleaning with right arm
2. Removing excess mixture with tool
3. Surface cleaning with right arm
4. Rotate body and move to new position
5. Surface cleaning with left arm
6. Change tool control
7. Surface cleaning with right arm
8. Removing excess mixture from tool
9. Surface cleaning with right arm
10. Removing excess mixture on tool
11. Surface cleaning with right arm
12. Lift both arms (one cleans and the other holds)

After the separation into subtasks, a classification of the captured images was made to identify those postures that are adopted most of the time, according to the methodology being followed, 3 activities were identified that accumulate more than 10% of the photographs (see Table 3); these activities should be analyzed with greater detail.

Table 3. Classification of photographs

Subtask	Number of pictures	%
1. Surface cleaning with right arm	17	34%
2. Removing excess mixture with tool	2	4%
3. Rotate body and move to new position	2	4%
4. Cleaning surface with left arm	9	18%
5. Lift both arms (one cleans and one holds)	19	38%
6. Change tool control	1	2%

3.4 Biomechanical analysis

To identify the exposed limbs and the associated risk level, the Humantech® Industrial Ergonomics software (n. d.) was used, which considers the variables of strength, posture, duration and frequency of the activity to assign an individual rating to the limbs involved in the activity according to the scale shown in Figure 3, then accumulates the individual points to assign an overall weighting and assign a priority level, according to Figure 4.



Figure 3. Individual scale



Figure 4. Overall scale

Using the software to analyze the video of the vault cleaning activity yielded the results shown in Figure 5.

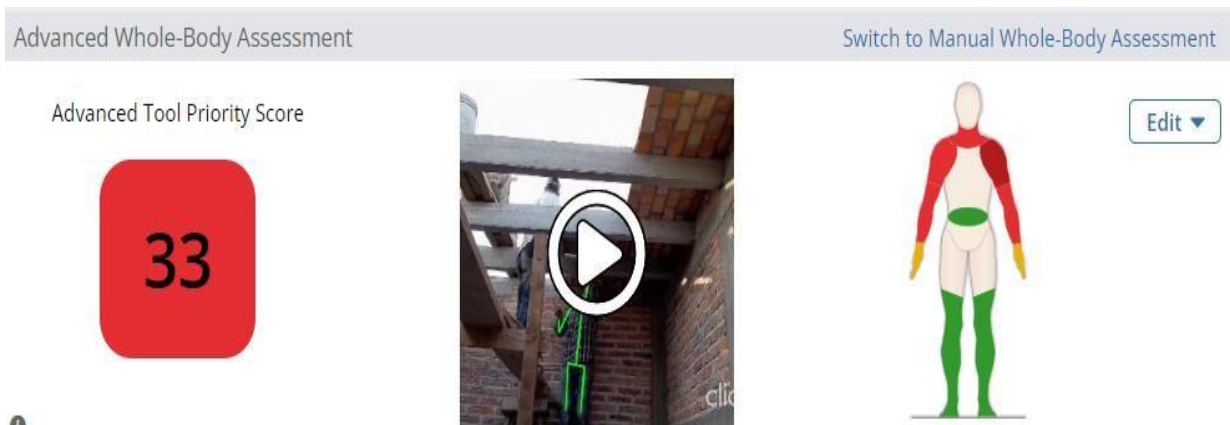


Figure 5. Software analysis

According to the result obtained, it is verified that both arms are in a high priority scale, which indicates that urgent modifications in the activity are necessary, in addition, the left shoulder is the member with the highest risk level, while the hands and wrists present a moderate risk. The lower limbs were not considered for the analysis of this project. Figure 6 shows the rating scale assigned by the software to the individual limbs.

Advanced Tool Assessment

	Hands/Wrists		Elbows		Shoulders		Neck	Back	Legs
	Left	Right	Left	Right	Left	Right			
Score ▲	3	3	6	4	7	4	4	1	1
Force	0	0	0	0	0	0	0	0	0
Posture	1	1	3	3	3	3	3	1	1
Duration	1	1	2	0	3	0	0	0	0
Frequency	1	1	1	1	1	1	1	0	0
Risk Rating	Mod	Mod	High	High	Higher	High	High	Lower	Lower

Figure 6. Individual rating scale

4. CONCLUSIONS

The tasks that were identified with the highest risk according to the classification of photographs were "Lifting both arms; one cleans and is supported by the other" with 38% and "Cleaning surface with the right arm" with 34%, which indicates that the right arm is kept above shoulder level during a little more than 70% of the execution of the activity. However, according to the biomechanical analysis performed in the software, the moment of greatest risk occurs in the left shoulder, when the worker raises and maintains his arm above shoulder level.

Ergonomic risks can always exist in manual activities, however, with proper and early detection, controls can be created to reduce them. Task analysis accurately identifies the activities that cause the greatest risk in an activity, and Humantech® Industrial Ergonomics software performs an analysis and assessment of the members involved, assigning a risk level according to its scale for their attention. By using these two tools, it is certain that the activities and members most exposed to ergonomic risk have been fully identified, so that research can continue to develop solutions focused on reducing the level of risk.

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