Ergonomic Risk Assessment with NIOSH and JSI Application in a Flour Processing Industry in the State of Sonora, Mexico

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RESUMEN

En este trabajo se presenta la metodología y los resultados de un procedimiento de evaluación ergonómica en una estación de trabajo de la empresa Molino la Fama S.A.de C.V., el proyecto nace en base a las quejas de los mismos empleados al realizar la tarea de empaque en sacos de harina de 22 Kg., esto debido a que la estación está diseñada para realizar el empaque de sacos de 45 Kg., sin embargo se realizan las dos actividades, se aplican dos métodos para la evaluación, el método NIOSH para las cargas posturales y el método JSI para los riesgos ergonómicos en las extremidades superiores, siendo estos los principales objetos de estudios del trabajo, se obtuvieron resultados en los cuales se marca la necesidad de un rediseño del puesto de trabajo, y por ultimo en este articulo se mencionan algunas de las modificaciones que serian necesarias realizar para mejorar el área de empaque y la planta en general.

ABSTRACT

This article introduces the methodology and results of an ergonomic assessment procedure in a work station of a flour industry in the state of Sonora. The reason for this project is the inquiry of the employees during the twenty two kilogram flour packing task, in a work station designed for a forty five kilogram packing, which provokes a negative impact in the employees´ occupational health. This work covers the application of two different tools, the NIOSH method which evaluates human capacity working loads, and the JSI method that evaluates ergonomic risks in the employees' upper limbs. The results of both applications show a redesign necessity of the work station, and advices the pertinent modifications needed to improve the packing activities.

The main objective of this article is to carry out an analysis and evaluation of the employees' ergonomic risks in the packing department of the company, as well as offering a framework explaining how the tasks should be done in order to prevent injuries and accidents in labor.

This study was developed in the twenty two kilogram flour packing which takes place in a work station designed for another capacity packing. This department plays a fundamental role between production and warehouse department.

This study is mainly focused in two factors the first one involve back problems generated by weight lifting and RWL (recommended weight limits) for the task, evaluated by the NIOSH equation, this technique is based on an equation involving seven variables which include distance, displacement, asymmetry, frequency and type of grip with the aim of providing the recommended weight limit and lifting index is obtained based on the recommended weight limits, and the second one evaluated by the Job Strain Index method, will analyze the exposure of the employees to generate injuries, product of repetitive movements in the upper limb. It will include an approach of hand, wrist, elbow, and forearm diagnose. The method is based on the measurement of six variables, which provides the Strain Index, value indicates the risk of upper limb disorders.

As a result of the NIOSH equation was a RWL of 2 kilograms which is smaller than the actual weight, the lifting rate is 20 which is more than the limit 3, that represents a risk for most workers, the recommendations are corrections in the type of grip and the vertical displacement factor, and for the JSI evaluation the results was 9.0 which means that the activity is potentially dangerous, the recommendation are adjustment in the intensity of effort and hand-wrist position. The adjustments can be corrected by a redesign of the workstation, then it have to be evaluated again whit the same methods, workers and operators have to be informed about the risk and diseases related to ergonomics and what

working conditions can cause serious injury, prevent and detect the risk and do something about it.

Key Words: Occupational Health, Fatigue, Industrial Ergonomics.

Introduction

Low back pain and injuries attributed to manual lifting activities are one of the leading occupational health and safety issues, According to the Department of Labor of United States report, back injuries accounted for nearly 20% of all injuries and illnesses in the workplace, and nearly 25% of the annual workers compensation payments. A more recent report by the National Safety Council (1990) indicated that overexertion was the most common cause of occupational injury, accounting for 31% of all injuries. The back, moreover, was the body parts most frequently injured (22% of 1.7 million injuries) and the most costly to workers compensation systems. (Thomas, et al, 1994)

Cumulative trauma disorders due to performance of repetitive tasks account for more than 50% of all occupational illnesses in the United States today. Employees affected by these disorders frequently experience substantial pain and functional impairment that may require a change in occupation. For the employer, these injuries result in loss of productivity and increased costs in the form of higher medical expenses and disability payments for injured workers. Successful treatment of work-related repetitive tissue injuries depends on early diagnosis and appropriate therapy. Prevention requires identifying sites and tasks that place employees at risk of injury and supporting efforts to develop safer work environments. (Rempel, et al, 1992)

More than ten years ago, the National Institute for Occupational Safety and Health (NIOSH) recognized the growing problem of work-related back injuries and published the Work Practices Guide or Manual Lifting (NIOSH WPG, 1981). The NIOSH WPG (1981) contained a summary of the lifting-related literature before 1981; analytical procedures and a lifting equation for calculating a recommended weight for specified two-handed, symmetrical lifting tasks; and an approach for controlling the hazards of low back injury from manual lifting. The approach to hazard control was coupled to the Action Limit (AL), a resultant term that denoted the recommended weight derived from the lifting equation. (Thomas, et al, 1994)

The JIS method is based on existing knowledge and theory of the physiology, biomechanics, and epidemiology of distal upper extremity disorders, a semiquantitative job analysis methodology was developed. The methodology involves the measurement or estimation of six task variables (intensity of exertion, duration of exertion per cycle, efforts per minute, wrist posture, speed of exertion, and duration of task per day); assignment of an ordinal rating for each variable according to exposure data; then assignment of a multiplier value for each variable. The Strain Index is the product of these six multipliers. Preliminary testing suggests that the methodology accurately identifies jobs associated with distal upper extremity disorders versus jobs that are not; however, large-scale studies are needed to validate and update the proposed methodology. (Moore, Garg, 1995)

During a inquiry of different work stations in a flour industry of the state of Sonora we found one on the packing area to focus because the employees during the twenty two kilogram flour packing task, complain about pain and we found that the work station was designed for a forty five kilogram packing, which provokes a negative impact in the employees´ occupational health, also its important the safety and health of the employees on this department because they play a fundamental role between production and warehouse department.

ASSESSMENT AND RESULTS

Ergonomic Assessment: work postures

Nowadays there are some authors that in their publications indicates a big number of kilograms that an human can pick or carry. That is the shield of enterprises to tell their employs to work in those conditions. They don’t consider the angles between the worker and the object to pick, number of repetitions of the activity in a day, and many other important factors that affect the work postures in workstations.

We chose NIOSH method that involves psychophysics studies, physiology and biomechanics to measure the exposure of workers in their workstations.

The equation we used is this one:

$$LCR= LC*HM*VM*DM*AM*FM*MC \quad \textbf{(1)}$$

:

Figure 1. NIOSH values

LC = Load Constant	CC = 23 kg	--
HM = Horizontal Multiplier	MH = (25/H)	see Table 1
VM = Vertical Multiplier	MV = 1-(0.003(V-75))	see Table 2
DM = Distance Multiplier	MD = 0.82+(4.5/D)	see Table 3
AM = Asymmetry Multiplier	MA = 1-(0.0032*A)	see Table 4
FM = Frequency Multiplier	--	See Table 5
MC = Multiplier Coupling	--	See Table 6

Tabla 1. Multiplicador HM

HM =25/H	
H(cm)	HM
< 25	1.00
28	0.89
30	0.83
32	0.78
34	0.74
36	0.69
38	0.66
40	0.63
42	0.60
44	0.57
46	0.54
48	0.52
50	0.50
52	0.48
54	0.46
56	0.45
58	0.43
60	0.42
63	0.40
>63	0.00

Tabla 2. Multiplicador VM

VM =1-0,003 [V-75]	
V(cm)	VM
0	0.78
10	0.81
20	0.84
30	0.87
40	0.90
50	0.93
60	0.96
70	0.99
80	0.99
90	0.96
100	0.93
110	0.90
120	0.87
130	0.84
140	0.81
150	0.78
160	0.75
170	0.72
175	0.70
>175	0.00

Tabla 3. Multiplicador desplazamiento

DM =0,82 + 4,5 /D	
D(cm)	DM
<25	1.00
40	0.93
55	0.90
70	0.88
85	0.87
100	0.87
115	0.86
130	0.85
145	0.85
160	0.85
175	0.85
>175	0.00

Tabla 5. Multiplicador de Frecuencia (FM)

Frecuencia	t < 1 h		1 h < t < 2 h		2h < t < 8 h	
lev / min	V < 75 cm	V > 75	V < 75	V > 75	V < 75	V > 75
>0,2	1	1	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.8	0.8	0.6	0.6	0.35	0.35
6	0.75	0.75	0.5	0.5	0.27	0.27
7	0.7	0.7	0.42	0.42	0.22	0.22
8	0.6	0.6	0.35	0.35	0.18	0.18
9	0.52	0.52	0.3	0.3	0	0.15
10	0.45	0.45	0.26	0.26	0	0.13
11	0.41	0.41	0.23	0.23	0	0
12	0.37	0.37	0.21	0.21	0	0
13	0	0.34	0	0	0	0
14	0	0.31	0	0	0	0
15	0	0.28	0	0	0	0
16	0	0	0	0	0	0

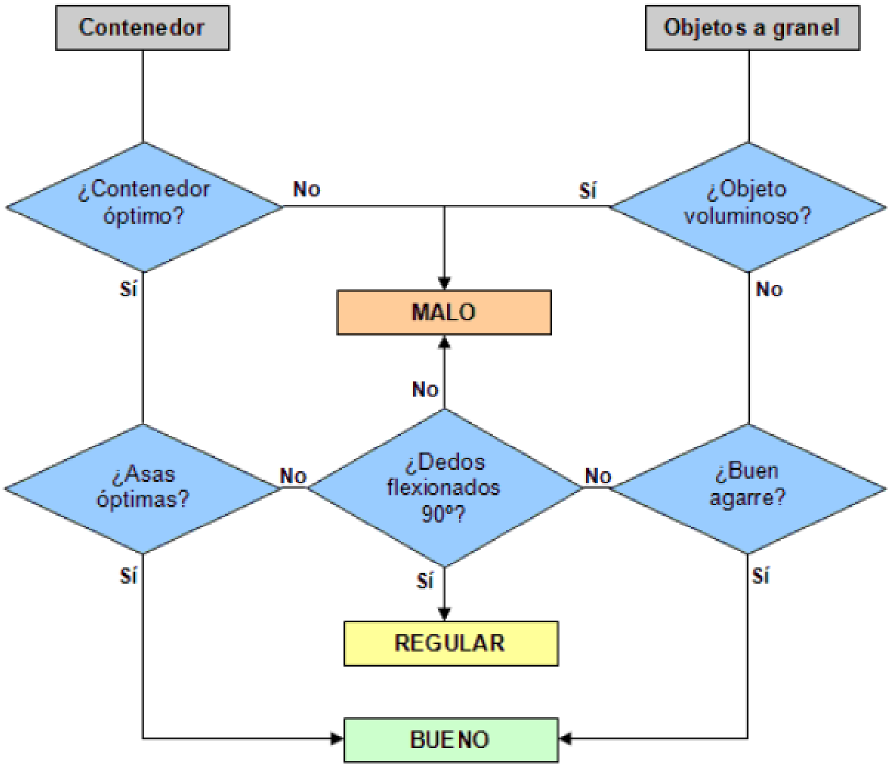
Tabla 4. Multiplicador de asimetría

AM =1 - 0,0032 A	
A (º)	AM
0	1.00
15	0.95
30	0.90
45	0.86
60	0.81
75	0.76
90	0.71
120	0.62
135	0.57
>135	0.00

Tabla 6. Multiplicador de Acoplamiento (CM)

Tipo de Acoplamiento	CM	
	V < 75 cm	V > 75 cm
BUENO	1.00	1.00
REGULAR	0.95	1.00
MALO	0.90	0.90

Figure 2. Decision three to determinate the type of grip



OBTAINED VALUES:

Table 7. Obtained values from the assessment.

LC	Load Constant	22 kg
HM	Horizontal Multiplier	57 cm
VM	Vertical Multiplier	136 cm
DM	Distance Multiplier	14 cm
AM	Asymmetry Multiplier	0 degrees
FM	Frequency Multiplier	8 picks/minute
CM	Multiplier Coupling	Bad

Results

Horizontal distance factor

$$HM = 25/H = 25/57 \mathbf{= 0.4385}$$

Vertical distance factor

$$VM = 1 – 0.003 (V – 75) = 1 – 0.003 (136 – 75) = \mathbf{0.817}$$

Vertical displacement factor

$$DM = 0.85 + (4.5/D) = 0.85 – 4.5/14 = \mathbf{1.17 = 1}$$

Asymmetry factor

AM= 1, there is no turns

Grip factor

CM= 0.90

Substituting in equation (1):

$$LCR = (22)\ (0.4385)\ (0.817)\ (1)\ (1)\ (0.18)\ (0.90) = \mathbf{1.334}$$

NIOSH propose a second equation, lifting index:

IL = WEIGHT OF LOAD / LCR **(2)**

Substituting in equation (1):

$$IL = 22 / 1.334 = \mathbf{20.66}$$

If IL > 3.0 represents a risk

Ergonomic Risk Assessment in the upper extremities

To determine if packing personnel is exposed to develop cumulative disorders we used the JSI method.

We fellow this steps to make the assessment:

- Determinate work cycles and watch the worker during a few cycles
- Determinate tasks to evaluate and determinate watching time
- Watch every task and give a value to each variable as the method propose
- Determinate a value to equation multipliers in accordance to the values of each variable
- Obtain JSI value and determinate risks menace
- Evaluate results to determinate changes that can minimize risks
- Redesign workstations and evaluate with JSI method one more time

Variable values were calculated with the tables of values of JSI method and calculating multipliers and the STRAIN INDEX.

Using table 7 we obtained the Intensity of effort.

Table 7. Intensity of effort

Intensidad del esfuerzo	%MS[2]	EB[1]	Esfuerzo percibido	Valoración
Ligero	<10%	<=2	Escasamente perceptible, esfuerzo relajado	1
Un poco duro	10%-29%	3	Esfuerzo perceptible	2
Duro	30%-49%	4-5	Esfuerzo obvio; sin cambio en la expresión facial	3
Muy duro	50%-79%	6-7	Esfuerzo importante; cambios en la expresión facial	4
Cercano al máximo	>=80%	>7	Uso de los hombros o tronco para generar fuerzas	5

[1] Comparación con la escala de Borg CR-10

[2] Comparación con el porcentaje de la fuerza máxima (Maximal Strength)

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 1. Intensidad del esfuerzo

The Intensity of effort in packing station is hard. The value obtained is 3

To determine the effort duration we used this equation:

% effort duration= 100* all efforts duration/ observation time **(3)**

We obtained a 30%, using the next table we can see the value:

Table 8. Effort Duration Values

% Duración del esfuerzo	Valoración
<10%	1
10%-29%	2
30%-49	3
50%-79%	4
80%-100%	5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 2. % de duración del esfuerzo

The corresponding value is 3.

To determinate the number of efforts per minute, its necessary determine the frequency, and number of efforts. And using the Table 9 we can obtain the value.

Table 9. Efforts per minute

Esfuerzos por minuto	Valoración
<4	1
4-8	2
9-14	3
15-19	4
>=20	5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 3. Esfuerzos por minuto

To determinate the anatomic position of the hand voila Table 10.

Table 10. Anatomic position of hand

Postura muñeca	Extensión	Flexión	Desviación	Postura percibida	Valoración
Muy buena	0°-10°	0°-5°	0°-10°	Perfectamente neutral	1
Buena	11°-25°	6°-15°	11°-15°	Cercana a la neutral	2
Regular	26°-40°	16°-30°	16°-20°	No neutral	3
Mala	41°-55°	31°-50°	21°-25°	Desviación importante	4
Muy mala	>55°	>50°	>25°	Desviación extrema	5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 4. Postura mano-muñeca

In function with work rhythm by us, we chose the value of table 11.

Table 11. Qualitative Velocity Estimation of worker performance

Ritmo de trabajo	Comparación con MTM-1[1]	Velocidad percibida	Valoración
Muy lento	<=80%	Ritmo extremadamente relajado	1
Lento	81%-90%	Ritmo lento	2
Regular	91%-100%	Velocidad de movimientos normal	3
Rápido	101%-115%	Ritmo impetuoso pero sostenible	4
Muy rápido	>115%	Ritmo impetuoso y prácticamente insostenible	5

[1] Ritmo observado dividido por el ritmo predicho por MTM-1 y expresado como porcentaje

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 5. Velocidad de trabajo

The multipliers values were obtained using table 12. Results of packing station showed here:

Effort (IE) = 2

during Effort (DE) = 1.5

Efforts per minute (EM) = 1

Hand work posture (HWP) = 2

Speed of worker (SW) = 1.5

during per day (DD) =1

Table 12. The multipliers values in JSI method.

Esfuerzos por minuto	
Valoración	EM
1	0,5
2	1
3	1,5
4	2
5	3

% postura mano-muñeca	
Valoración	HWP
1	1
2	1
3	1,5
4	2
5	3

Velocidad de trabajo	
Valoración	SW
1	1
2	1
3	1
4	1,5
5	2

Duración por día	
Valoración	DD
1	0,25
2	0,5
3	0,75
4	1
5	1,5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 7. Cálculo de los factores multiplicadores

Obtaining Strain Index:

To obtain Strain Index value we replaced values using the next equation:

$$JSI = IE \times DE \times EM \times HWP \times SW \times DD \quad \textbf{(4)}$$

JSI= 9.0

Interpretation of results

Under method JSI judgment, we consider that packing station in the enterprise is probably dangerous. We recommend some corrections in the work station. After redesign the workstation its required to make the assessment to assure the well practices in the facilities of the enterprise.

Conclusions and recommendations for further

Studying ergonomic risks in the workplace area is one of the most important part in the field of ergonomics. It is crucial to the enterprise to have the knowledge needed to develop the ability of auto evaluation and identification of ergonomic risk in our work stations. We consider that evaluating all the work stations is the safer way to identify the exposure of the workers into an ergonomic risk.

Enterprises could have consequences when they are exposed to an ergonomic risk; enterprise should consider ergonomics to improve productivity also quality. It is time to remove all the paradigms that enterprises think about ergonomics; it is not only another barrier to them.

Knowing the exposure of everyone in the workstations it is easier to develop efficiently preventive measures to risks.

The knowledge of the cumulative trauma disorders, their causes and the symptoms in humans it is not a preventive measure, it is necessary to recognize every risk evaluating possible disorders in people, using ergonomic methods as we did in our research.

Ergonomic data and information must be shared to everyone, including symptoms and principal causes. That could help to prevent risks by acting before the exposure win the battle against the worker.

Once we finish the evaluation with both methods, we consider some aspects that we saw to enlist many recommendations to the enterprise to consider in future ergonomic evaluations in their facilities.

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