

Aplicación de la técnica RULA en el área de empaquetado mediante tecnología Kinect.

Application of the RULA method in the area of packaging using Kinect technology.

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Resumen

En México, en el artículo 513 de la Ley Federal del Trabajo, en su tabla de enfermedades de trabajo legalmente reconocidas, indica los Factores Mecánicos y variaciones de los elementos del medio ambiente, aunado a esto, en el artículo 130 del Capítulo V. Salud Ocupacional de la Ley General de Salud, se encuentran lineamientos a través de los cuales se vincula la importancia de estudios e investigaciones relacionadas con la prevención y control de enfermedades profesionales ocasionadas por las diferentes cargas laborales. Derivado de lo anterior se lleva a cabo un estudio en el área de empaque de una empresa del ramo alimentario, el cual, mediante la utilización de la técnica RULA (Rapid Upper Limb Assessment), cuya metodología divide al cuerpo humano en dos grupos, el grupo A que incluye los miembros superiores (brazos, antebrazos y muñecas) y el grupo B, que comprende las piernas, el tronco y el cuello. El objetivo de esta investigación es el medir el grado de fatiga y los trastornos ocasionados al sistema musculo-esquelético, producidos por la carga postural a la que son expuestos los trabajadores, utilizando la tecnología del Kinect y sensores inerciales junto con la reproducción a nivel laboratorio, permitirán visualizar a detalle la repetitividad de movimientos y la inadecuada aplicación del método de trabajo. Los resultados obtenidos siete cargas posturales se encuentran en un nivel 2, cinco en el nivel 3 y 2 en el nivel 4, siendo estas últimas en las que se observan niveles críticos en la espalada, los brazos y las muñecas de los operadores.

Palabras clave: Enfermedades, musculo-esqueléticos, RULA, sensores.

Abstract

In Mexico, in article 513 of the Federal labour law, in its work legally recognized diseases table, it indicates the mechanical factors and variations of the elements of the environment, in addition, article 130 of the chapter V. Occupational Health of the General Health Law, are guidelines through which are linked the importance of studies and research related to the prevention and control of occupational diseases caused by different labour costs. Derivative of this a study is carried out in the area of packaging of a company in the food industry, which, using the technique RULA (Rapid Upper Limb Assessment), whose

methodology divides the human body into two groups, Group A that includes the upper limbs (arms, forearms and wrists) and Group B, which includes legs trunk and neck. The goal of this study is to measure the degree of fatigue and caused disorders to the musculoskeletal system, produced by postural load which exposed workers, using the technology of the Kinect and inertial sensors along with playback at the laboratory level, will allow viewing to detail the repetitiveness of movements and the inadequate application of the work method. The results obtained seven postural loads that are in a level 2, five in level 3 and 2 in the level 4, being the latter in which critical levels are seen in the back, arms, and wrists of the operators.

Key words: Diseases, musculoskeletal, RULA, sensors.

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Introduction

Today the concept of ergonomics has joined the industrial lingo, derived from its presence in different areas of opportunity for all organizations with aspirations of economic, competitive and human growth.

Within the economic growth can be seen among other items: reductions in compensations, insurance premium and absenteeism derived from both accidents at work and occupational diseases. Using an analysis of economy of movements that will produce an increase in productivity.

On the other hand, the development of new techniques, innovations in the design of equipment, machines and the increase of the quality, encourages the competitive growth of the company.

While human growth is recognized from the importance that the Organization estimates its human capital through motivation and continuous attention of the conditions under which it is working.

Work-related musculoskeletal disorders are a set of inflammatory or degenerative injuries of muscle, tendons, nerves, joints and tissues in general, caused or aggravated primarily by work and the effects of the environment in which it develops.

Most of musculo-skeletal disorders are cumulative disorders, resulting from a repeated exposure to loads during a long period of time. They are slow-onset and seemingly harmless until they become chronic and permanent damage occurs. These lesions can appear on any body region although it is located most often in back, neck, shoulders, elbows, hands and wrists.

The present study was derived from the symptoms reported by some workers the packing a biscuit company (sore shoulders, wrists and hands) Conducting an analysis and assessment of ergonomic risk factors through application of RULA (Rapid Upper Limb Assessment) technique in the packaging area of a food company, will measure the degree of fatigue and disorders in the musculoskeletal system caused by the postural load that exposed workers in the area a packaging company in the food branch, using Kinect technology and inertial sensors along with playback at laboratory level.

Development

As a first step of this study, carried out the identification process subject of study, which is called "packing process type Maria cookies," which for all practical purposes, was divided into three sets of actions, which I call them in turn: I thread 1. Armed cash; 2. Fill box thread and thread 3. Sealing box. Figure 1 shows the actions involved in these three threads, whose overall length was 24.96 s.



Armed box

The operator takes the case of a stack of them.
Carry case and leads to support for armed.
Box joins the bottom thereof.



Filling box. (The cycle described in this section is repeated twice to gramje compliance with respect to the box).

The operator turns the band and biscuits takes 5 tubes thereof, taking them and depositing them in the box.

The operator turns the band and making biscuits 6 tubes of the same, taking them and depositing them in the box



Box sealing

The operator closes the small tabs of the box.
The operator closes the box long eyelashes.
The operator slides the box closing machine.

Figure 1. Process type María biscuit packaging.

Reference: Authors.

1. Analysis of movements






To conduct a thorough analysis of the process subject of study, it was used to techniques used by the engineering methods through which you can see the movement and micro movements holding the operator in carrying out their tasks and time consumed for them, reinforced with studies through Kinect technology and inertial sensors in order to analyze the trajectories of the joints, which reinforces the study.

a. Development of a process diagram

In order to have an overview of actions (using macro techniques methods), which makes the worker process diagram, same as shown in Table II it is developed, which contains the movements of the entire process Maria biscuits packaging type using five basic elements.

A process diagram a graphical representation of the steps used in a whole sequence of activities within a process or procedure, identifying them by symbols according to their nature; also it includes all the information deemed necessary for the analysis, such as distance traveled, amount considered and time required. Symbology using this diagram shown in Table I:

Table I. Symbols of the process diagram.
reference: (Meyers, 2000)

SÍMBOLO	DESCRIPCIÓN	INDICA	SIGNIFICADO
	Círculo	Operación	Ejecución de un trabajo en una parte del producto.
	Cuadrado	Inspección	Utilizado para trabajo de control de calidad.
	Flecha	Transporte	Utilizado para mover material.
	Triangulo	Almacenamiento	Utilizado para almacenamiento a largo plazo.
	D grande	Retraso	Utilizado como lo almacenado es inferior a un contenedor.

As can be seen, the study shows 21 items: 12 operations 05 transport delays 0, 4 and 0 storage inspections, themselves covering the entire packaging process María biscuit-type, with a time of 26.75 s.

Table II. Process diagram type Marias biscuit packaging.
Reference: Prepared.

Ubicación: AREA EMPAQUE		Resumen						
Actividad: Empaque de Galletas		Evento	Presente	Presupuesto	Ahorros			
Fecha: Noviembre 2014		Operación	18.10					
Operador:	Analista:	Transporte	05.89					
Método: <u>Presente</u> Propuesta Tipo: <u>Trabajador</u> Material Maquina		Retrasos	0.00					
		Inspección	2.76					
		Almacenamiento	0.00					
Comentarios		Tiempo (S)	26.75					
		Distancia (pies)						
		Costo						
Descripción de los eventos	Símbolo					Tiempos (en segundos)	Distancia (en pies)	Recomendaciones al método
Alcanzar caja.	●	⇒	D	□	▽	1.02		
Armar caja.	●	⇒	D	□	▽	2.19		
Posicionar caja.	●	⇒	D	□	▽	0.54		
Tomar producto	●	⇒	D	□	▽	1.90		
Inspeccionar producto.	○	⇒	D	■	▽	0.64		
Transportar producto a caja.	○	⇒	D	□	▽	1.01		
Depositar producto en caja.	●	⇒	D	□	▽	0.64		
Tomar producto.	●	⇒	D	□	▽	1.94		
Inspeccionar producto.	○	⇒	D	■	▽	0.95		
Transportar producto a caja.	○	⇒	D	□	▽	1.02		
Depositar producto en caja.	●	⇒	D	□	▽	2.35		
Tomar producto	●	⇒	D	□	▽	1.96		
Inspeccionar producto.	○	⇒	D	■	▽	0.64		
Transportar producto a caja.	○	⇒	D	□	▽	1.20		

Descripción de los eventos	Símbolo	Tiempos (en segundos)	Distancia (en pies)	Recomendaciones al método
Depositar producto en caja.	● → D □ ▽	1.43		
Tomar producto	● → D □ ▽	2.23		
Inspeccionar producto.	○ → D ■ ▽	0.53		
Transportar producto a caja.	○ → ■ D □ ▽	1.33		
Depositar producto en caja.	● → D □ ▽	1.17		
Cerrar caja.	● → D □ ▽	0.73		
Transportar caja a sellado.	○ → ■ D □ ▽	1.33		
Tiempo Total		26.75 s.		

Bimanual development diagram

For purposes of depth of this study was used to develop three bimanual (study technique micromovement) diagrams using therbligs, which correspond to each of the threads to observation: Armed box, filled with box and box sealing , same as corresponding to those shown in Table III, Table IV and Table V, these threads consume time. 3.75 s, 20.94 s. and 2.06s respectively.

Bimanual process diagram is a Flowchart in which the activity of the hands (and in some cases also of the feet) of the operator and the relationship between them is indicated. (Sánchez, 2014)

Frank and Lilian Gilbreth were the founders of modern art movement study, which can be defined as the study of body movements that are used to perform an operation to improve the operation by eliminating unnecessary movements, movements necessary simplification and subsequently determining the most favorable sequence for maximum efficiency movements. As part of the analysis of movements, Gilbreth concluded that all work, whether productive or not, is carried out by using 17 combinations of basic elements that they called therbligs. The therbligs can be efficient or inefficient. The first directly stimulate the progress of work and often can be shortened, but usually can not be

eliminated completely. Inefficient therbligs not represent a breakthrough in the progress of work and should be removed. (Nievel & Freivalds, 2014)

Table III. Bimanual diagram thread: Armed box.
Reference: Prepared.

Método: <u>Actual.</u>					
Operación <u>Armado de caja.</u>					
Referencia _____			Producto <u>Galletas</u>		
Fecha _____		Noviembre de 2014		Analista _____	
-					
MANO IZQUIERDA					MANO DERECHA
Descripción	S	T.	T.	S	Descripción
Alcanzar caja.	AI				
Esperar segunda mano.	DI			AI	Alcanzar caja.
Tomar caja por uno de los extremos.	T			T	Tomar caja por un extremo.
Mover caja.	M			M	Mover caja.
Posicionar en área de armado	P			P	Posicionar en área de armado.
Abrir cartón de caja.	M			M	Abrir cartón de caja.
				AI	Alcanzar pestaña inferior chica.
				T	Tomar pestaña inferior chica
Alcanzar 2da pestaña inferior chica.	AI			M	Doblar pestaña inferior chica.
Tomar 2da pestaña inferior chica.	T				
Doblar 2da pestaña inferior chica.	M			AI	Alcanzar pestaña inferior grande.
				T	Tomar pestaña inferior grande.
Alcanzar 2da pestaña inferior grande.	AI			M	Doblar pestaña inferior grande.

Tomar 2da pestaña inferior grande.	T				
Doblar 2da pestaña inferior grande.	M			SL	Soltar caja.
Sostener caja por parte superior.	SO			Al	Alcanzar extremo lateral derecho.
Sostener caja por parte superior.	SO			Al	Tomar extremo lateral derecho.
Girar caja 180°	M			M	Girar caja 180°
Posicionar caja	P			P	Posicionar caja
Doblar pestaña chica hacia afuera	M			M	Doblar pestaña chica 2 hacia afuera.
Sostener caja.	SO			M	Doblar hacia afuera pestaña grande.
Soltar caja	SL			SL	Soltar caja.
Tiempo Total			3.75 s.		

Table IV. Bimanual diagram thread: Armed box.
Reference: Prepared.

Método: <u>Actual.</u>					
Operación <u>Llenado de caja.</u>					
Referencia _____			Producto: <u>Galletas</u>		
Fecha <u>Noviembre de 2014</u>			Analista: _____		
MANO IZQUIERDA					MANO DERECHA
Descripción	S	T.	T.	S	Descripción
Alcanzar paquetes de galletas.	AI			AI	Alcanzar paquetes de galletas.
Seleccionar paquetes a tomar.	S			S	Seleccionar paquetes a tomar.
Inspeccionar paquetes seleccionados	I			I	Inspeccionar paquetes seleccionado
Tomar paquetes de galletas	T			T	Tomar paquetes de galletas.
Sostener los paquetes de galletas.	SO			SO	Sostener los paquetes de galletas.
Mover los paquetes hacia la caja.	M			M	Mover los paquetes hacia la caja.
Inspeccionar paquetes.	I			I	Inspeccionar los paquetes.
Colocar los paquetes en la caja.	P			P	Colocar los paquetes en la caja.
Soltar los paquetes.	SL			SL	Soltar los paquetes.
Alcanzar paquetes de galletas.	AI			AI	Alcanzar paquetes de galletas.
Seleccionar paquetes a tomar.	S			S	Seleccionar paquetes a tomar.
Inspeccionar paquetes seleccionados	I			I	Inspeccionar paquetes seleccionado
Tomar paquetes de galletas	T			T	Tomar paquetes de galletas.
Sostener los paquetes de galletas.	SO			SO	Sostener los paquetes de galletas.
Mover los paquetes hacia la caja.	M			M	Mover los paquetes hacia la caja.

Inspeccionar paquetes.	I			I	Inspeccionar los paquetes.
Colocar los paquetes en la caja.	P			P	Colocar los paquetes en la caja.
Soltar los paquetes.	SL			SL	Soltar los paquetes.
Alcanzar paquetes de galletas.	AI			AI	Alcanzar paquetes de galletas.
Seleccionar paquetes a tomar.	S			S	Seleccionar paquetes a tomar.
Inspeccionar paquetes seleccionados	I			I	Inspeccionar paquetes seleccionado
Tomar paquetes de galletas	T			T	Tomar paquetes de galletas.
Sostener los paquetes de galletas.	SO			SO	Sostener los paquetes de galletas.
Mover los paquetes hacia la caja.	M			M	Mover los paquetes hacia la caja.
Inspeccionar paquetes.	I			I	Inspeccionar los paquetes.
Colocar los paquetes en la caja.	P			P	Colocar los paquetes en la caja.
Soltar los paquetes.	SL			SL	Soltar los paquetes.
Alcanzar paquetes de galletas.	AI			AI	Alcanzar paquetes de galletas.
Seleccionar paquetes a tomar.	S			S	Seleccionar paquetes a tomar.
Inspeccionar paquetes seleccionados	I			I	Inspeccionar paquetes seleccionado
Tomar paquetes de galletas	T			T	Tomar paquetes de galletas.
Sostener los paquetes de galletas.	SO			SO	Sostener los paquetes de galletas.
Mover los paquetes hacia la caja.	M			M	Mover los paquetes hacia la caja.
Inspeccionar paquetes.	I			I	Inspeccionar los paquetes.
Colocar los paquetes en la caja.	P			P	Colocar los paquetes en la caja.

Soltar los paquetes.	SL			SL	Soltar los paquetes.
Tiempo Total:		20.94			
		s.			

Table V. bimanual diagram thread: sealing box.
Reference: Prepared.

Método: <u>Actual.</u>					
Operación <u>Sellado de caja</u> .					
Referencia _____				Producto:	
<u>Galletas</u>					
Fecha <u>Noviembre de 2014</u>				Analista:	

MANO IZQUIERDA					MANO DERECHA
Descripción	S	T.	T.	S	Descripción
Alcanzar pestaña chica 1.	AI			AI	Alcanzar pestaña chica 2
Tomar pestaña chica 1.	T			T	Tomar pestaña chica 2.
Cerrar pestaña chica 1.	M			M	Cerrar pestaña chica 2.
Sostener la pestaña.	SO			SL	Soltar pestaña chica 2.
				AI	Alcanzar pestaña grande 1.
				T	Tomar pestaña grande 1.
Soltar pestaña chica 1.	SL			M	Cerrar pestaña grande 1.
Alcanzar pestaña grande 2.	AI			SO	Sostener la pestaña.
Tomar pestaña grande 2.	T				
Cerrar pestaña grande 2.	M				
Sostener caja por extremo superior.	SO			SL	Soltar caja.
				AI	Alcanzar extremo lateral derecho
				T	Tomar extremo lateral derecho.

Empujar caja.	M		M	Empujar caja.
Mover caja.	M		M	Mover caja.
Soltar caja.	SL		M	Empujar caja.
			SL	Soltar caja.
Tiempo Total de la operación.		2.06		
		s.		

a. Kinect technology application

The technological analysis, involves the partial reproduction of the laboratory activity level using Kinect technology, inertial sensors and application software in order to get a database containing the coordinates in space (Xi, Yi and Zi), which represent the movement of the upper limbs of the human body, knowing through measurement paths that cross these tips.

The analysis was performed with SQL INERCIAL and SKELETON-BASICS-WPS programs and capture is performed with the Microsoft Kinect sensor through its RGB camera Kinect sensor captures the image of the individual and plays a simulation with coordinates of various body extremities. 2 shows an example of obtaining a coordinate of limbs affected by the packaging process Mary type cookie.

K	L	M	N	O	P	Q	R
-9	236	20	-45	220	20	-41	222
-8	229	17	-44	193	18	-35	203
-7	225	18	-44	191	21	-35	205
-6	223	20	-38	192	22	-37	198
-7	215	17	-41	174	17	-41	201
-5	215	6	-24	207	8	-23	213
-5	222	20	-32	207	25	-30	209
-5	225	25	-42	204	28	-33	207
-5	224	27	-37	202	28	-31	206
-5	224	28	-33	204	29	-29	210
-5	224	25	-31	205	27	-28	210
-6	226	36	-34	223	32	-35	227
-8	227	17	-32	196	18	-28	205
-8	221	8	-42	189	9	-37	196
-7	218	11	-43	191	11	-39	196

Figure 2. Coordinates left.

Reference: Authors.

Application of technical RULA

a. Identifying positions

By the above diagrams, 14 positions were selected, of which they were identified as requiring greater effort to apply the technique. Figure 3 refers to the above positions, this figure is supplemented by Table VI where a brief description of the positions is done, it is worth mentioning that the number of tubes of cookies that the operator takes two cycles is variable.



Figure 3. Positions requiring greater effort.

Reference: Authors.

Table VI. Positions that demand greater effort
Reference: Prepared.

POSTURA	DESCRIPCIÓN
1	Armado de caja.
2	Coloca caja en posición.
3	Toma de producto. 1 ^{er} ciclo.
4	Depósito de producto en la caja cinco tubos.
5	Lleva el producto hacia el cuerpo del operador.
6	Depósito de producto en la caja seis tubos.
7	Alcance de producto en la banda transportadora.
8	Toma de producto con ambas manos.
9	Depósito del producto en caja.
10	Alcance de producto (mayor esfuerzo) en la banda transportadora.
11	Toma del producto con ambas manos.
12	Depósito del producto en la caja.
13	Cerrado de caja.
14	Transporte de la caja para ser sellada.

a. Score for each position, according to the technical RULA

As a next step, the technique was applied RULA to give them scores to each position, depending on the immersed to the same members and the group to which they belong: Group A: Members scores above; Group B: ratings for leg, trunk and neck.

Table VII. Score each group by applying the technique RULA
Reference: Authors.

PUNTUACION.							
POSTURA	GRUPO A			GRUPO B			
	BRAZO	ANTEBRAZO	MUÑECA	CUELLO	TRONCO	PIERNAS	GIRO DE LA MUÑECA
1	3	2	3	2	1	1	1
2	2	2	2	2	1	1	1
3	2	2	3	3	3	1	2
4	1	2	4	2	2	1	2
5	1	2	3	3	2	2	1
6	2	3	3	3	3	2	2
7	4	3	3	3	4	2	1
8	2	3	3	3	3	2	2
9	1	2	3	2	2	1	2
10	4	3	4	4	4	2	1
11	1	2	3	3	3	2	2
12	2	3	3	2	2	1	2
13	2	2	3	2	3	1	1
14	3	3	3	3	3	2	2
Mediana							

As shown in the above table, in group A, the positions with the highest score of involvement are: position 4 - wrist - 4 points; position seven - arm - 4 points; 10 position - arm and wrist - 4 points. Also, the group B, the positions with high scores were: position 7 - trunk - 4 points and position 10 - neck and trunk - 4 points each.

a. Overall score per group, according to the technical RULA

Subsequently, using pre-established ergonomic tables, overall scores were obtained, tables VIII and IX show the overall scores of two members of each group.

Table VIII. Scoring position 3 Group A,
Reference: Authors.

Brazo	Antebrazo	Muñeca							
		1		2		3		4	
		Giro de Muñeca		Giro de Muñeca		Giro de Muñeca		Giro de Muñeca	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table IX. Posture score for two group B
Reference: Prepared.

Cuello	Tronco											
	1		2		3		4		5		6	
	Piernas	Piernas	Piernas	Piernas	Piernas	Piernas	Piernas	Piernas	Piernas	Piernas	Piernas	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Overall rating group A: 4

Overall rating group B: 2

a. Rating C and D, as technique RULA

Following the application of the technique, scores C and D are obtained by adding to each of the scores muscle activity developed and applied force, where 1 point is assigned for being repetitive and 0 points activity muscle strength if not exceeded 2 kilograms.

Table X. Score C y D,
Reference: Prepared.

POSTURA	GRUPO. A	REPETITIVIDAD	PUNTUACIÓN. C	GRUPO. B	F. MUSCULAR	PUNTUACIÓN. D
1	4	1	5	2	0	2
2	3	1	4	2	0	2
3	4	1	5	4	0	4
4	3	1	4	2	0	2
5	3	1	4	4	0	4
6	4	1	5	5	0	5
7	5	1	6	6	0	6
8	4	1	5	5	0	5
9	3	1	4	2	0	2
10	6	1	7	7	0	7
11	3	1	4	5	0	5
12	4	1	5	2	0	2
13	3	1	4	4	0	4
14	5	1	6	5	0	5

a. Final Scores

The scores of the 14 evaluated positions are shown in the following graph:

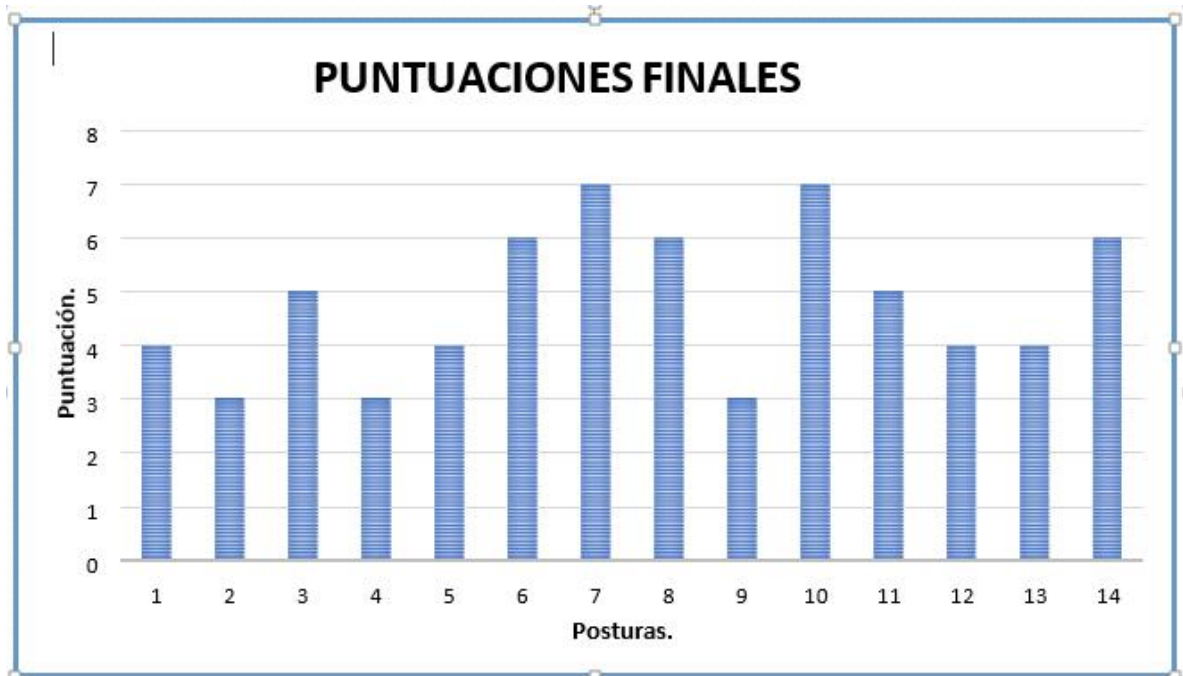


Figure 4. Concentrate final scores.

Reference: Authors.

This study is a first approach in the evaluation of jobs in the company, which was selected the packing area and a small sample.

In the above figure shows the scores obtained through the technique RULA evaluated fourteen positions on the package of cookies in this area.

The positions 02, 04 and 09 had a score of 3; the positions 01, 05, 12 and 13 got a score of 4; positions 03 and 11 are 5; the positions 06, 08 and 14 obtained a score of 6; and the highest score was obtained by the positions 07 and 10.

Each score obtained corresponds to a level of performance as the RULA technique, these are classified into 4 levels; The following chart shows for each position corresponding performance level.

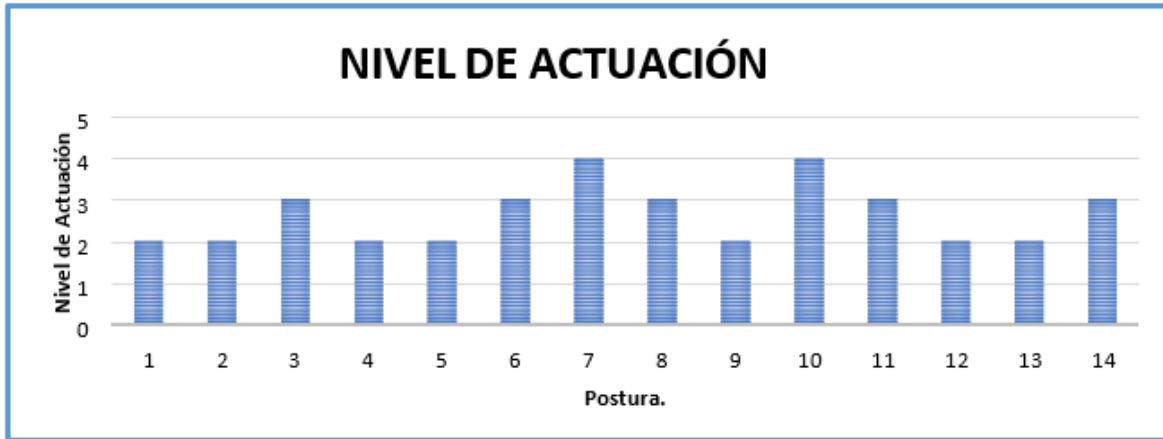


Figure 5. Levels of Performance of the fourteen positions.

Reference: Prepared

Action levels provided by the technical RULA are as follows:

Table XI. Performance levels,
Source: RULA.

Nivel	Actuación
1	Cuando la puntuación final es 1 o 2 la postura es aceptable.
2	Cuando la puntuación final es 3 ó 4 pueden requerirse cambios en la tarea; es conveniente profundizar en el estudio
3	La puntuación final es 5 o 6. Se requiere el rediseño de la tarea; es necesario realizar actividades de investigación.
4	La puntuación final es 7. Se requieren cambios urgentes en el puesto o tarea.

The results are that seven of the positions studied are at level 2 where you need to do additional research and changes in the work may be required.

Five positions fall at level 3 which indicates that an investigation and changes are required soon. The positions 07 and 10 according to their score get a performance level 4 being the highest level handled by the ergonomic technical RULA meaning that urgent changes are required in these positions as they are or could develop musculoskeletal injuries in the extremities higher worker. The positions 7 and 10 critical efforts arms and wrists of women workers in the packing area to perform their activities which would involve the risk of

musculo-skeletal injuries are seen in the back, so these positions should be changed to reduce the risk.

Conclusions

The ergonomic evaluation of jobs is a key element in the primary prevention of musculoskeletal disorders. The application of RULA in the area of packaging of biscuits contributed to obtaining reliable results, risk levels observed with the method, indicates a poor posture for the performance of filling packaging of cookies, this analysis is divided into two groups: group A that includes the upper limbs (arms, forearms and wrists) and group B (legs, trunk and neck), the results obtained from postural loads 14 7 loads are at a level II, 5 level III and 2 at level IV, because of this, the performance of operators in the packaging area is high risk for musculoskeletal injuries to the upper extremities of the body. These positions require a redesign analyzed in the work area.

The technology involved in this project, based on the inertial sensors and motion sensors, which programmatically is possible to carry out track the movements made for carrying out the work, the coordinates in space (x_i, y_i, z_i), it allows through a database, monitor each of the positions that are executed by the employee (Group A and B).

The combination of technology and ergonomic method favors a powerful tool in the operator postural analysis by risk analysis may suggest new ways of working to reduce the dangers developed by musculoskeletal disorders.

Bibliography

- Almirall P. (2000). Ergonomía cognitiva apuntes para su aplicación en trabajo y salud, Instituto nacional de salud de los trabajadores, La Habana Cuba.
- Arenas, L. & Cantú, O. (2013). Factores de riesgo de trastornos músculo-esqueléticos crónicos laborales, Artículo Medicina Interna de México volumen 29.
- Escalona, E. (2001) Trastornos músculo-esqueléticos en miembros inferiores: condiciones de trabajo peligrosas y consideraciones de género, salud de los trabajadores, volumen 9 N°1, Enero
- García, R. (1999) Estudio del Trabajo. Ingeniería de métodos y medición del trabajo, 2ª Edición McGraw-Hill Interamericana.
- McAtamney L. & Nigel E. (1993). RULA: a survey method for the investigation of work-related upper limb disorders, Applied Ergonomics.
- Mondelo, P. (1999) Ergonomía 1 Fundamentos. Edicions UPC.
- Montiel, M.(2005). Valoración de la carga postural y riesgo musculo esquelético en trabajadores de una empresa metalmecánica. Salud de los trabajadores volumen 14.
- Natarén, J. et a.l. (2004) Los trastornos musculoesqueléticos y la fatiga como indicadores de deficiencias ergonómicas en la organización del trabajo. Artículo Salud de los trabajadores volumen 12.
- Nieble, B & Freivalds, A. (2009) Ingeniería Industrial. Métodos, estándares y diseño del trabajo, 12ª Edición McGraw-Hill Interamericana.
- Rodríguez Y. & Guevara C. (2011). Empleo de los métodos ERIN y RULA en la evaluación ergonómica de estaciones de trabajo, Ingeniería Industrial.