Musculoskeletal Injuries which Masapan Craftsmen are Exposed

Alexis Suárez del Villar[1,3], *Ana Àlvarez*[1,3], *Mireya Zapata*[1,2]

[1] Facultad de Ingeniería y Tecnologías de la Información y la Comunicación
Universidad Tecnològica

Indoamèrica, Machala y Sabanilla, Quito - Ecuador

[2]Centro de Mecatrònica y Sistemas Interactivos – MIST
Universidad Tecnològica
Indoamèrica, Machala y Sabanilla, Quito - Ecuador

[3]Grupo de investigación en Sistemas Industriales,Software y Automatización-SISAu
Universidad Tecnològica Indoamèrica,
Machala y Sabanilla, Quito - Ecuador

ABSTRACT

The results of repetitive and prolonged trauma are reflected in most musculoskeletal injuries, which are pathologies that can be articular, due to the maintenance of forced postures or the excessive use of the affected joint. These injuries, regardless of the classification, affect the intervertebral ligaments or discs, tendons, bones and muscles. The present research was carried out on masapan craftsmen in Calderón parish, Ecuador, which is characterized by manufacturing decorative figures that have

survived over time. The efforts in the joints as a result of repetitive actions in the production process were analyzed. The results associated four risks: Lifting excessive weights very frequently; operate the masapan sheeter manually until the dough takes the necessary consistency to develop the crafts; maintain forced or fixed postures for hours; and perform the same movement pattern every few seconds for hours at a time. With the application of BIOMEC Software it was identified which are the areas of the body that are overloaded, which will allow taking corrective actions to avoid associated injuries.

Keywords: Musculoskeletal, Pathologies, Postures, Overload ·Trauma

INTRODUCTION

Human life extension is one of the characteristic features of our technological age. A positive appreciation of old age is part of the very roots of Western culture. However, in technologically advanced societies it begins to be burdened with negative elements: far from giving a positive value to old age, a new unethical myth has been shaped: the «young», «productive» man. Society tends to deprive the elderly of almost all obligations, relegating them when their work is no longer desired (Velázquez, 2020). Osteoporotic fractures increase with age and constitute one of the most relevant problems in the elderly due to the mortality and morbidity that they generate (Martíneza, 2017) (Abusleme, 2018). Evaluating whether an effort in a specific posture can cause overload in some structure of the locomotor system is a complex task (Diego-Mas J. A., 2015). The objective of this research is to determine the prevalence of musculoskeletal injuries by sociodemographic variables and to evaluate the ergonomic risk due to forced postures, identifying the areas of the body that suffer overload in an artisanal process, applying the BIOMEC software to the population under study of fourteen craftsmen belonging to Calderón parish in Quito, Ecuador, with an observed sample of ten workers who have an age range between 50 to 80 years.

MATERIALS AND METHODS

The calculation tool offered in Ergonauts (BIOMEC) performs biomechanical evaluations of static coplanar stresses based on the posture adopted, the load and the frequency and duration of the stresses. It allows to know the risk of overloading per joint, the maximum recommended load, and the stability of the posture [6] allows to perform physical calculations and the application of the biomechanics model based on a series of data about the task: Sex of the worker, Height, Weight, Angle of the body segments in the analyzed posture, Weight of the supported load or exerted force, If the load is supported with one or two hands, Time during which the efforts are made and Frequency of the efforts; providing as a result: the level of effort in each joint, the maximum recommended load, the percentage of protected population, in addition to the stability of the posture, the possibility of slipping and the possibility of overturning of the worker under the supported loads (S, 2020)

The BIOMEC calculation tool is offered in Ergonauts and also allows to perform the physical calculations and the application of the model from the input data, providing as results: the level of effort in each joint, the maximum recommended

load, the percentage of protected population, in addition to the posture stability, the possibility of sliding and the possibility of overturning of the worker under the supported loads.

PRINCIPLE

Recent research has been incorporating ergonomic principles into design processes, as a strategy to anticipate solutions to problems and include users in decision making processes (S, 2020). For the case study, a large part of the working day of masapan craftsmen are in a sitting position, carrying out their daily work activities (P. Salazar, 2019).

The diagram of the process of making the dough and kneading is shown in Fig. 1. In order to carry out this operation, the craftsman stands up for ten minutes, an activity that is repetitive in each production cycle, and in relation to the demand they have will be the number of times they perform it in the 8-hour workday (Diego-Mas J. A., 2021). Constantly mixing the ingredients without stopping is considered a forced posture, that is, they go from a natural position to a position of articular hyper rotation, then they remain standing to give the dough homogeneity in a period of 10 minutes more (Guillén, 2015) (R. Vasconez, 2020)

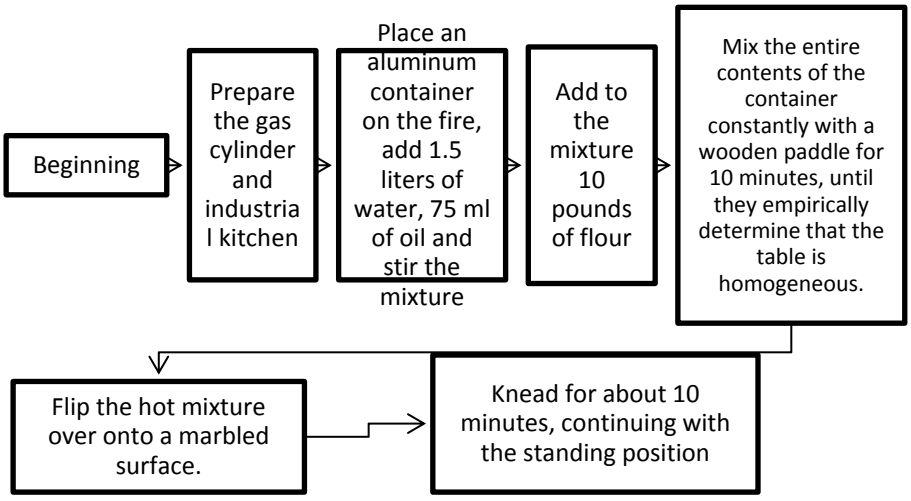


Figure1: Dough and kneading manufacturing process diagram

DEVELOPMENT

Body distribution can be carried out in multiple ways depending on the object of study (Unidas, 1948) (Barzola, 2017). Figure 2 shows this human model; although 8 segments are usually used that are assumed to be non-deformable (Head + neck, trunk, thighs, legs, feet, arms, forearms and hands).

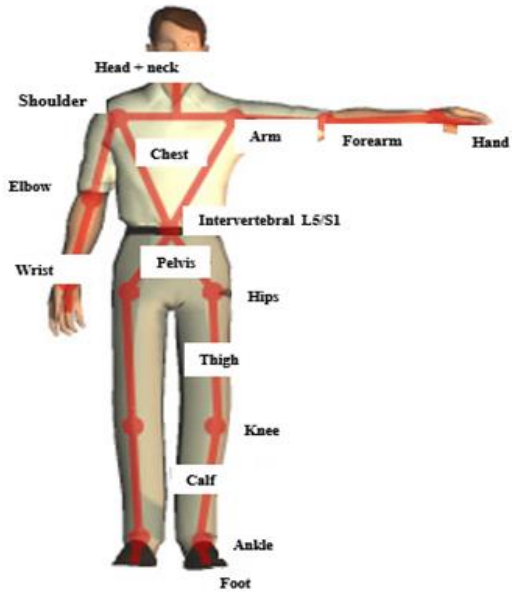


Figure 2: Segments of the human model.

The application of the BioMec model for the evaluation of efforts in the different joints previously collects a series of data on the kneading operation such as: 95% of the craftsmen are women (Larrea, 2018). Therefore, the study was framed in females, with average heights of 1.65 meters, body weight of 75 kg, plus analysis of angles of the body segments in the acquired posture and the weight of the sustained load of 4 kg (Á.Estévez, 2018). It is considered the time of 10 minutes that the effort is made with simultaneous and repetitive movements with an operation frequency of once each productive cycle (S. Chancusi, 2018)

RESULTS

Having determined the human model and the way to obtain the inertial parameters, it is possible to calculate the moments generated by the load and the self-weight of the different body segments (Cuenca, 2017) (Vives, 2016). The current angle analysis is performed in the kneading operation. As shown in Fig. 3, the 161º knee angle is significant, at bottom dead center the angle of the knee to the tibia should be close to 145 degrees and at top dead center it should be greater than 70 degrees. Fig. 4 shows the resulting posture that should be adopted taking into consideration that the sample taken are craftswomen of the elderly and they already have certain postural deformations, so it is not recommended to force the knees.

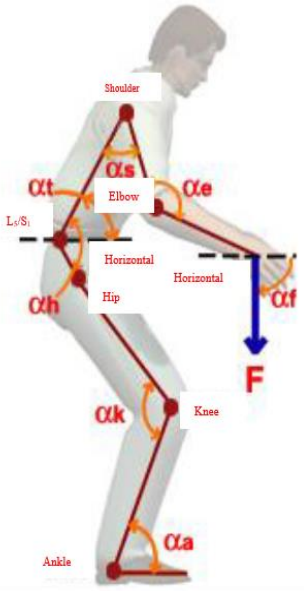
Postural angles	
	α_a = 91° α_k =161° α_h =135° α_t = 65° α_s = 56° α_e =153° α_f = 26° Loads = 4 Kg
The load is held with both hands	

Figure 3: Angular and biomechanical analysis for kneading forced position.

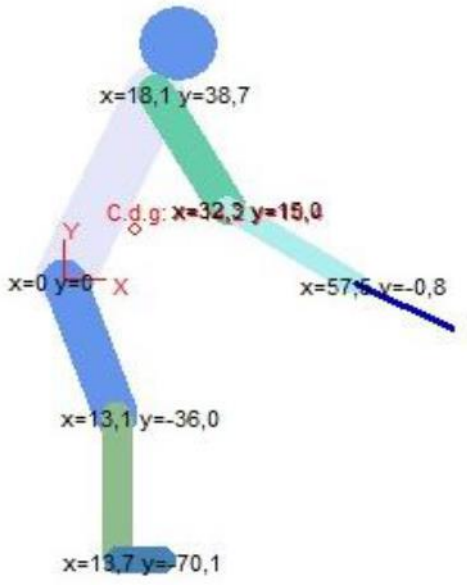


Figure 4: Resulting posture for kneading operation, (centimeter units).

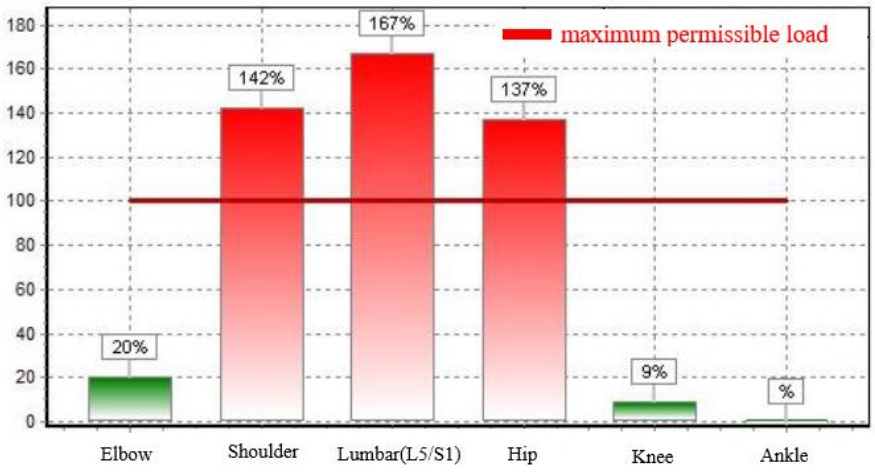


Figure 5: Protected population percentage (%) = 90%.

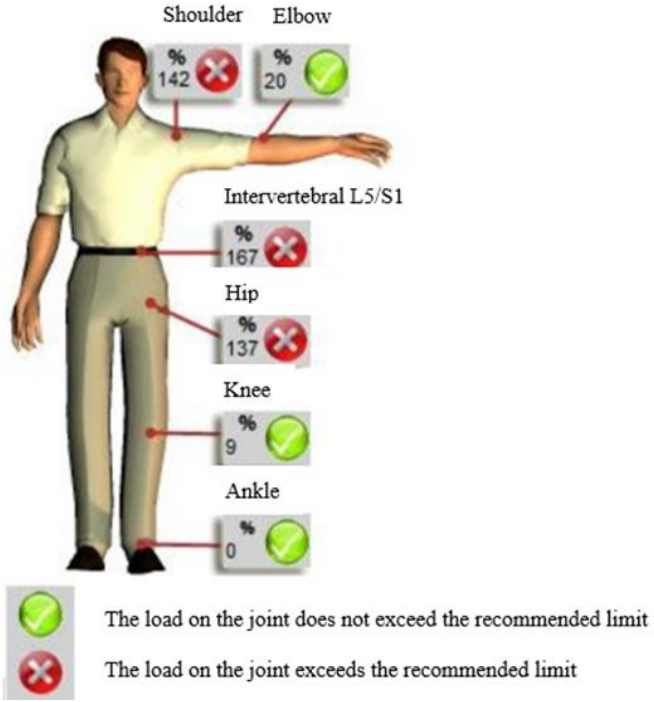


Figure 6: Overloaded areas of the body

Fig. 5 and 6 show the results obtained with the application of the BIOMEC software. The results obtained in shoulder, lumbar and hip show that people evaluated exceed the admissible loads, while elbow, knee and ankle efforts are kept within recommended limits (BUN-CA, 2011)

Table 1: Maximum recommended loads, overloads and risk per joint.

Joint	Maximum load (kg)	Overload (kg)	Risk	% Protected population
Elbow	19,84	-15,84	No	100
Shoulder	2,81	1,19	Yes	99,9
Lumbar	2,4	1,6	Yes	97
Hips	2,92	1,08	Yes	96,5
Knee	43,52	-39,52	No	99,8
Ankle	0	4	Yes	99,9

To maintain and manipulate 4kg load, posture must be corrected since the limiting factor for this case is the ankle, which is the joint that can least bear in these conditions as shown in Table 1. Given the duration and frequency of the efforts of the elderly craftswomen, who spend 10 minutes with a standing posture in the baking of the dough and then develop the kneading operation for 10 minutes more, and considering that, the dough is molded hot, with rotations in the two workplaces, we can protect 90% of the population (Orlando, 2014) (Gama, 2018)

The experiment is based on using the BIOMEC software from these data, the tension and the moments generated in each joint were calculated compared with the maximum permissible posture obtained from the model previously exposed, modified according to effort duration and frequency, and 90% percentage of the population to be protected. From the difference between the acting moment and the permissible moment in each joint, the program determined the existing risk (Mora, 2017) (Celín, 2018)

CONCLUSIONS

BIOMEC Software allowed us to validate musculoskeletal injuries caused to masapan craftsmen. In the physical calculations it is assumed that no part of the body is supported, that is, the operator is supported only by feet on the ground, being a limitation for the results, because in a period of six seconds during the ten minutes that the operation lasts the craftsman leans on the marbled table to turn the dough, however it is considered that this condition will not significantly change the results obtained.

The results obtained from the ergonomic evaluation indicate that the tasks performed by the craftsmen in masapan figures elaboration present a risk to the musculoskeletal system. A correction of the standing posture is needed in the kneading operation and to reduce repetitive movements in each cycle.

ACKNOWLEDGEMENTS

The agreement between the Universidad Tecnológica Indoamérica and the MASARTE Association to carry out the community service internship project: "OWN TECHNOLOGICAL INNOVATION IN THE PRODUCTIVE PROCESSES IN THE MANUFACTURE OF CRAFTS: CASE SECTOR CALDERÓN, QUITO-ECUADOR" was the opening to carry out this research, thank you to all members of MASARTE, to the authorities of such a prestigious university and to the researchers for their support, thank you.

REFERENCES

Á.Estévez. (2018). *UASB-DIGITAL*. Obtenido de https://repositorio.uasb.edu.ec/handle/10644/6174

Abusleme, T. (2018). Trabajo y Personas Mayores en Chile. Santiago: Salesianos Impresores.

Barzola, M. M. (29 de Diciembre de 2017). *Revista Espacios*. Obtenido de https://www.revistaespacios.com/a18v39n23/a18v39n23p32.pdf

BUN-CA, F. R. (2011). Manual Técnico de motores eléctricos. San José: Diseño Editorial S.A.

Celín, R. F. (2018). Intervención ergonómica para reducir la prevalencia de trastornos musculoesqueléticos por movimientos repetitivos de mano-muñeca, en trbajadores de la línea de producción de una fábrica de perfumes. Obtenido de Investigación e Innovación, I conferencia Internacional sobre Seguridad y Saluid en el trabajo, pp. 63-65, .

Cuenca, N. (2017). Simulación Bidimensial del Corte del Acero AISI 1050 .

Diego-Mas, J. A. (2015). Análisis biomecánico estático coplanar. Valencia: Universidad Politécnica de Valencia.

Diego-Mas, J. A. (18 de 10 de 2021). *Análisis biomecánico estático coplanar*. Obtenido de Ergonautas, Universidad Politécnica de Valencia: http://www.ergonautas.upv.es/metodos/biomecanica/biomecanica-ayuda.php

Gama, A. (2018). *Repositorio Institucional Universidad Distrital - RIUD* . Obtenido de https://repository.udistrital.edu.co/bitstream/handle/11349/13598/GuerreroMurciaAngelaJuliana2018.pdf?se

Guillén, M. R. (2015). Factores asociados a lesiones músculo-esqueléticas por carga en trabajadores hospitalarios de la ciudad de Torreón, Coahuila, México. *Ciencia & Trabajo, vol. 17, nº 53*, 144-149.

Larrea, M. (2018). *Repositorio Universidad Católica de Cuenca*. Obtenido de https://dspace.ucacue.edu.ec/bitstream/ucacue/5548/1/MARTA%20YOMARA%20VALLEJO.pdf

Martíneza, J. O. (2017). Envejecimiento músculo-esquelético. *Revista Española de Enfermedades Metabólicas Óseas*, vol. 16, nº 1, p. 1.

Mora, A. (Abril de 2017). *Repositorio Digital Universidad Central del Ecuador*. Obtenido de http://www.dspace.uce.edu.ec/bitstream/25000/10806/1/T-UCE-0009-709.pdf

Orlando, L. A. (Febrero de 2014). *Repositorio Universidad Politécnica Salesiana*. Obtenido de https://dspace.ups.edu.ec/handle/123456789/6311

P. Salazar, L. A. (2019). Evaluación de posturas forzadas en los puestos de trabajo administrativos del Hospital Básico Guamote . Ciencia Digital.

R. Vasconez, V. M. (2020). *Prevalencia de lesiones músculo esqueléticas relacionadas con el puesto de trabajo y variables socio demografícas en una empresa florícola*. Quito - Ecuador: Universidad Internacional Sek.

S. (2020). Projetar o ambiente construído com base em princípios ergonômicos TT - Diseño del entorno construido basado en principios ergons. Ambiente Construído.

S. Chancusi, M. D. (27 de Agosto de 2018). Obtenido de DIALNET: https://dialnet.unirioja.es/servlet/articulo?codigo=7144007

Unidas, O. d. (10 de Diciembre de 1948). *Declaración Universal de Derechos Humanos.* Obtenido de https://www.ohchr.org/EN/UDHR/Documents/UDHR_Translations/spn.pdf

Velázquez, L. (2020). Un enfoque filosófico de la vejez y algunas consideraciones bioéticas. BIOETHICS UPdat.

Vives, G. A. (2016). Envejecimiento y trabajo en Chile: Propuesta para monitoreo de salud laboral. Santiago.