African Journal of Biological Sciences

Research Paper Open Access

Analysis of Physical Load in Coffee Pickers

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Article Info

Volume 6, Issue 8, April 2024
Received: 12 Feb 2024
Accepted: 03 April 2024
Published: 11 May 2024

Abstract

In Colombia, the cultivation of coffee has been one of the most recognized agricultural activities in the country, for this reason, the national federation of coffee growers estimates that a little more than a third of the Colombian rural population lives on coffee. This reflects the importance of addressing the dangers and risks associated with agricultural work, especially biomechanical risks, since they are closely related to the appearance of musculoskeletal disorders in the agricultural sector. This descriptive cross-sectional study evaluated the physical load in the task of harvesting Coffee, through the international standard ISO 11226 of 2000, the ergonomic evaluation method, ERGO/EPM and the REBA (Rapid Entire Body Assessment) method. 60 collectors participated. of Coffee of both sexes distributed in five farms, with inclusion criteria such as taking two years or more in the collection task. Among the main results, it is evident that there is physical overload mainly in the upper limbs, due to forced postures, repetitive movements and inappropriate postures present during the execution of the task, increasing fatigue, pain, tiredness, and increasing the possibility that possible pathologies of musculoskeletal origin can be generated in the medium term.
research.

Key words: Agriculture, Coffee Growers, Ergonomic Risks, Physical Load, Musculoskeletal Disorders

Introduction

The International Labour Organization estimates that the agricultural sector employs 1.3 billion people globally, constituting 27.4% of global employment. In this sense, the agricultural sector in Colombia is important for the country's economy because it enables employability, which is why coffee growing is a prominent agricultural activity in the country. According to the National Federation of Coffee Growers, it is estimated that about 2.7 million people in the country depend

exclusively on this crop. However, the largest proportion of these workers live in informal working conditions, which does not guarantee the coverage of their labor rights. (ILO, 2020)

Coffee farming constantly demands labor since its activity is present throughout the year in activities such as weeding, pruning, planting, harvesting, pulping, washing, fermenting, storage, sale and the harvesting process, being among the most important, although its periodicity does not exceed 5 weeks (Fathallah, 2010; Jaramillo, 2018; Peláez & Quintana, 2020; Orozco, 2022).

Farmers face working conditions that often compromise their physical well-being, specifically the musculoskeletal system resulting from handling heavy loads, transporting materials, and prolonged or repetitive hunching of the body, these activities intrinsic to agricultural work predispose these workers to develop musculoskeletal disorders. (Walker & Palmer 2002; Fathallah, 2010; Kang et al., 2016; Patil, 2018; Benos et al, 2020; Momenni et al, 2020; Barneo et al.2021; Kee, 2022; Akbar et al. 2023)

Musculoskeletal disorders (MSDs) constitute a significant occupational risk in the agricultural sector, where the prevalence of such disorders is high due to the nature of the work, as agricultural activities involve repetitive tasks, prolonged postures and improper postures, which can lead to a variety of musculoskeletal conditions, which compromises the health of workers in this sector. (Walker & Palmer 2002; Patil, 2018; Dianat; 2020; Benos et al, 2020; Peláez & Quintana, 2020). In particular, harvesting and post-harvest activities represent situations where workers often experience musculoskeletal symptoms, due to the constant mobilization and handling of loads. (EU-OSHA, 2020; Estrada, 2022 Orozco, 2022; Akbar et al. 2023).

Low back pain is one of the most common symptoms in the agricultural context, in line with the global landscape of musculoskeletal disorders, where this type of pain has a prevalence of 568 million people in the world. (ILO, 2021). During the development of agricultural activities, workers are exposed to physical load due to repetitive movements for a long time that forces the joint action of muscles, joints and bones, causing overloads, fatigue, pain and ultimately musculoskeletal symptoms and disorders. (Walker & Palmer, 2002; Jain et al; 2018; Benos et al 2020; Peláe., & Rodríguez, 2021; Hassani et al, 2022).

From the point of view of occupational safety and health, agriculture presents a series of conditions that make the risk assessment process particularly complex. First of all, it should be noted that the standardization of tasks and activities is extremely difficult to achieve, as they vary considerably depending on daily and seasonal labor needs, as well as the specific cultural phases of each crop. In addition, heterogeneity in the gender, age, anthropometric characteristics, and level of education of farmworkers adds another layer of complexity to the picture. In addition, the presence of atypical forms of employment and the variability of work shifts, which often depend on weather conditions, make risk assessment even more challenging. (EU-OSHA, 2020; ILO, 2020)

Finally, the scarcity of economic resources to adopt preventive measures and update obsolete machinery, especially among small farmers, intensifies the difficulties in managing safety and health in agricultural work. Therefore, the ability of assessors to apply risk assessment methods effectively becomes a crucial element for the prevention and effective management of these disorders derived from agricultural activity. (Kearney et al; 2016; Dianat et al. 2020; ILO, 2020; Estrada et al, 2022; Varghese, & Panicker 2022)

According to the literature, it is pertinent to adopt preventive measures; but to do so, it is necessary to carry out risk assessments focused on MSDs and the development of protocols that minimise ergonomically unfavourable postures and the repetitiveness of tasks. (EU-OSHA, 2020). In this sense, the present work sought to analyze the task of coffee bean harvesting to determine if there is physical overload in the development of this that may be influencing the manifestation of MSDs in this population.

Materials and Methods

The study is cross-sectional descriptive in which we wanted to evaluate the aspects related to postures and body movements in the development of the coffee harvesting task, and thus determine if there is physical overload in the workers, because within the dangers and risks previously observed in the different stages of planting and harvesting, the presence of high biomechanical risk was detected in the latter.

The evaluated population was made up of 60 coffee picking workers who carry out work activities on five different farms located in the department of Cundinamarca; The workers range in age from eighteen to fifty-eight, with experience between two and twenty years. The following inclusion criteria were taken into account for their selection.

Table 1: *Inclusion criteria . In original language: Spanish*

VARIABLES DE IDENTIFICACIÓN	VARIABLES BIOMECANICAS
Sexo	Edad
Edad: Categorización de edad desde 18 hasta 58 años.	Realización de movimientos repetitivos
Centro de trabajos: Producción	Adopción de posturas forzadas y mantenidas.
Categoría ocupacional. Operarias Todas las personas del estudio tienen la misma categoría.	Aplicación de fuerza.

Figure 1 Workers of the exhibition carrying out the task of collection.

Evaluation of postures and movements

For the evaluation of these aspects, the international standard ISO 11226 of 2000 (Ergonomics - Evaluation of static working postures) was first used, since this international standard evaluates static working postures and recommends specific limits for postures that do not require or minimally require the application of force. At the same time, it also considers time and body angles through a procedure (quick assessment) that determines whether the evaluated posture is acceptable or not, analyzing joints and body segments in two steps. (CENEA, 2015; Institute of Occupational Safety and Health, 2015).

Second, the ERGO/EPM method was used, which is used to establish the recommended limits for static and dynamic work postures, taking into account the angles of the body during the execution of the task. (CENEA, 2015), This method is developed in three different stages; The first is the initial evaluation, where information is collected about the process and objectives are established to analyze the tasks in detail; then there is the detailed evaluation, where the analysis of repetitive movements, evaluation of physical load, postural evaluation and the last one consists of the design

of solutions that seek the prevention of the risks encountered. (Asensio et al, 2012; CENEA, 2015; Institute of Occupational Safety and Health, 2015).

Finally, the REBA (Rapid Entire Body Assessment) method was used, a method that evaluates the ergonomic risks associated with postures and body movements at work. This method focuses on rapid visual assessment of the task at hand, providing a risk score that determines whether intervention actions are required to reduce the risk of illness and injury at work. To do this, it was necessary to observe the task, where the posture of the head, neck and trunk, position of arms and hands, position of legs and feet, strength and effort, frequency and duration of work activity were evaluated. (Asensio et al, 2012; CENEA, 2015; Institute of Occupational Safety and Health, 2015).

Results and Discussion

According to the working population, the sociodemographic variables collected are presented*.*

Table 2. Right-handed (96.4%) Left-handed (3.6%)*. In original language: Spanish*

Variable	Frecuencia en %	Variable	Frecuencia en %
Sex	Female (45%) Male (55%)	Civil status	Single: (40%) Common-law union: (35%) Married (10%) Separated: (15%)
AGE	20-28 years (15.1%) 29-35 years (15%) 36-55 years (65%) 56-68 years (5%)	BMI	Underweight: (15%) Normal: (10%) Overweight: (75%)
Schooling	Civil status BMI Income	Income	1 SMLV :(100%)
ANTIQUITY ON THE ESTATE	Less than 5 years (65%) 2-5 years (15%) 5-10 years (20%)	Seniority in position (Collector)	Less than 5 years (15%) 2-5 years (35%) 5-10 years (50%)
WORK AREA	Collection area	Use of free time	Housework :(55%) Other:(45%)
LATERALITY	Right-handed (96.4%) Left-handed (3.6%)		

According to the previous table of the sociodemographic profile of coffee pickers, there is a predominance of male individuals (55%) with ages concentrated in the range of 36-55 years (65%). Aspect related to agricultural activities, in which the male sex predominates. At the same time, with regard to schooling, a large majority have completed only primary education (75.4%), which may have implications in terms of access to better working and health conditions, further deepening the problem of informality in the agricultural sector in the country. It should be noted that 100% of workers receive an income equivalent to 1 SMLV (Minimum Legal Wage in Force), which could be an indicator of economic vulnerability to which this population would be exposed.

It is also observed that the Body Mass Index (BMI), which represents the majority of the population, shows that 75% of the collectors are overweight; This may be associated with the high intake of carbohydrates in their daily diet, due to the fact that they do not have enough income to access the necessary foods of a balanced diet. Finally, it should be noted that most of the employees have been on the farm for 5 years (65%), but in the work they occupy, the trend is reversed, with 50% showing a permanence of 5 to 10 years. This might suggest a high turnover in the agricultural sector due to informality, but once they settle into the work, the permanence is longer.

Regarding the application of the methods, which sought to determine if there is physical overload in coffee pickers, it begins by presenting the evaluation based on the ISO 11226 Standard of 2000, the harvesting activity represents sufficient physical and mental variation for the workers, evidencing that the worker at the time of the execution of the task can displace one or more body segments from his state of comfort. This can lead to positions that induce hyperextensions, hyperflexions, and/or hyperrotations in the joints when harvesting the coffee beans, affecting the normal positions of the trunk, upper and lower extremities. In accordance with this, an unacceptable risk related to physical load was evidenced by the type of postures that coffee growers perform during the execution of their work activity, therefore the application of the ERGO EPM method continued.

ERGO EPM:

When carrying out the evaluation of the coffee harvesting task with this method, it was possible to show that the dynamic load on farm No. 1, trunk movement is acceptable, trunk torsion, neck torsion, arm abduction and static neck postures the risk is NOT acceptable. For the same load on farm No. 2, trunk movement, trunk twisting, neck twisting, arm abduction risk is also NOT acceptable; in farm No. 3, also trunk movement is acceptable, trunk torsion, neck torsion, arm abduction and static neck postures the risk is NOT acceptable, the same is observed in farm No. 4: where trunk movement, trunk torsion, neck torsion, arm abduction and static neck postures the risk is not acceptable and in farm No. 5, the same pattern is found as the previous ones and therefore the risk assessment is NOT acceptable.

Table 3 Acceptable. *In original language: Spanish*

Dynamics	***Posture or movement***	***Finca 1***	***Finca 2***	***Finca 3***	***Finca 4***	***Finca 5***
Trunk	Trunk Flexion/Extension	Aceptable	No Aceptable	Aceptable	No Aceptable	Variable
	Variable	Frequency in %	Sex	Female (45%) Male (55%)	Marital status	Single: (40%) Common-law union: (35%) Married (10%) Separated: (15%)
	20-28 years (15.1%) 29-35 years (15%) 36-55 years (65%) 56-68 years (5%)	BMI	Underweight: (15%) Normal :(10%) Overweight: (75%)	Schooling	Primary (75.4%) Baccalaureate (24.6%)	Revenue
1 SMLV :(100%)	Seniority in the FInca	Less than 5 years (65%) 2-5 years (15%) 5-10 years (20%)	Seniority in office (Collector)	Less than 5 years (15%) 2-5 years (35%) 5-10 years (50%)	WORK AREA	Collection area
	Housework :(55%) Other:(45%)	Laterality	Right-handed (96.4%) Left-handed (3.6%)	No Aceptable	No Aceptable	No Aceptable
Brazos	Flexión/Extensión del brazo	Aceptable	No Aceptable	Aceptable	No Aceptable	Dynamics
	Farm 1	Finca 2	Finca 3	Finca 4	Farm 5	Trunk
Trunk Flexion/Extension	**Acceptable**	**Not Acceptable**	**Acceptable**	**Not Acceptable**	**Acceptable**	**Valoración**
Lateral Trunk Flexion	Not Acceptable	Acceptable	Acceptable	Not Acceptable	Not Acceptable	Aceptable

1. Tronco

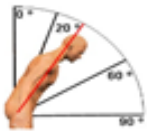
Señalar con una X cuál de estas dos exigencias está presente:

x	La postura del tronco permanece de manera sostenida la mayor parte del tiempo
x	La postura del tronco permanece poco tiempo de manera sostenida

Flexión/extensión del tronco

Número de veces por minuto que se realiza el movimiento de flexión/extensión:	30
Ángulo máximo de la postura adoptada:	60

Nota: En caso que el movimiento sea de extensión, escribir el ángulo en negativo.



Flexión lateral del tronco

Número de veces por minuto que se realiza el movimiento de flexión lateral:	x
Ángulo máximo de la postura adoptada:	25

Torsión del tronco

Número de veces por minuto que se realiza el movimiento de torsión:	55
Ángulo máximo de la postura adoptada:	10

2. Brazos

Señalar con una X cuál de estas dos exigencias está presente:

Izq.	Der.	
	x	La postura del brazo permanece de manera sostenida la mayor parte del tiempo
x		La postura del brazo permanece poco tiempo de manera sostenida

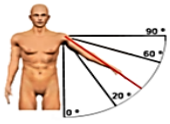
Flexión/extensión del brazo

	Izq.	Der.
Número de veces por minuto que realiza el movimiento de flexión/extensión:	56	
Ángulo máximo de la postura adoptada:	90	90

Nota: En caso que el movimiento sea de extensión, escribir el ángulo en negativo.

Abducción del brazo

	Izq.	Der.
Número de veces por minuto que realiza el movimiento de abducción:	45	
Ángulo máximo de la postura adoptada:	60	60



3. Cabeza y cuello

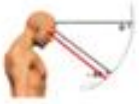
Señalar con una X cuál de estas dos exigencias está presente:

x	La postura de la cabeza y cuello permanece de manera sostenida la mayor parte del tiempo
	La postura de la cabeza y cuello permanece poco tiempo de manera sostenida

Línea de visión de cabeza y cuello

Ángulo máximo de la postura adoptada:	40

Nota: En caso que el movimiento sea de flexión, escribir el ángulo en negativo.



Flexión lateral de la cabeza

Ángulo máximo de la postura adoptada:	10

Torsión del cuello

Ángulo máximo de la postura adoptada:	35

Table 4 Acceptable

Trunk Torsion	***Not Acceptable***	***Not Acceptable***
Not Acceptable	Not Acceptable	Not Acceptable
	Head and neck line of sight	Acceptable
	Not Acceptable	Acceptable
Not Acceptable	Head and neck line of sight	Neck torsion
	Not Acceptable	Not Acceptable
Not Acceptable	Not Acceptable	Arms
	Acceptable	Not Acceptable
Acceptable	**Not Acceptable**	**Acceptable**
Head & Neck	Arm Abduction	Not Acceptable

Based on the application of the Ergo/Epm method, it was evidenced that the physical demands of the work for the collection task involve the synchronization of biomechanical movements in global dynamic posture that involve the segments of the Trunk: Not Acceptable, Head and Neck Not Acceptable, and Arm Not Acceptable, where the Global rating of the group of segments is in accordance with the Biomechanical gestures that are performed during the execution of the the task, indicating that this assessment is consistent with the movements made by the worker during the grain harvest. Likewise, for the qualification of static postures, as opposed to the line-of-sight position of the head and neck, the overall consolidated is acceptable with posture rectification options, which means that the position of this segment of the worker is adequate and is not representing a significant risk.

The previous evaluations of the ERGO/EPM method indicate that the work postures evaluated during the Coffee harvesting task present significant ergonomic risks, these "unacceptable" results suggest that there is the presence of postural physical load and this means that the conditions of the task can cause discomfort, fatigue or even injury in workers due to uncomfortable or inadequate postures, This finding reinforces the need to modify the working conditions for this population in order to reduce exposure to biomechanical irrigation, improving the health and well-being of the workers on the five farms. Below are the evaluations obtained.

Finally, the task was evaluated with the REBA method, which allowed the analysis of a set of postures with emphasis on the upper limbs such as the forearm, wrist, neck and lower limbs, specifically on the leg, these data are evidenced below describing the score obtained in each farm.

Table 5.

Not Acceptable Reba	***Not Acceptable***	***Not Acceptable***	***Not Acceptable***	***Static***	***Posture or movement***
Assessment					
Assessment	Assessment	Assessment	Assessment	Head & Neck	Head and neck line of sight
Not Acceptable	Acceptable	Not Acceptable	Acceptable	Acceptable	4
Puntuación Tronco	5	4	4	4	4
Puntuación carga/Fuerza	Dynamics	Posture or movement	Assessment	Trunk	Trunk Flexion/Extension
Not acceptable					
Puntuación Antebrazos	Lateral trunk flexion	Acceptable	2	Trunk Torsion	Acceptable

Head & Neck	Head and neck line of sight	Not acceptable	2	Neck torsion	Acceptable
Arms	Flexion/Extension of the Arm	Not acceptable	4	Arm Abduction	Not acceptable
Static	Posture or movement	Assessment	Head & Neck	Head and neck line of sight	Acceptable
Risk and Action Levels					
REBA Final Score	12	11	12	11	12
Action Level	4	Reba	Farm 1	Finca 2	Finca 3
Finca 4	Farm 5	Group A Data	Neck Score	3	3

Within the results of the REBA evaluation applied in each of the farms, it was found that within the execution of the task there is a physical overload in the segments of the upper and lower body, this leads to the fact that each person who is harvesting the coffee bean, has a high probability of developing a presumed injury at the musculoskeletal level due to the type of overexertion that must be made for the The level of action for most of the farms had a score of 4, which indicates a Very High level of risk, so it is necessary to intervene immediately by carrying out controls at the source, medium and/or worker level in order to improve the inadequate postures observed and prevent the appearance of musculoskeletal disorders related to inadequate postures and physical overload.

Conclusion

According to the three methods applied, there is physical overload in the segments of the upper body and lower body, which generates a high probability of developing an injury at the musculoskeletal level due to the type of overexertion that must be made for the task, so it is necessary to intervene in the hierarchical order of the criticality of the risks. To this end, source condition controls must be implemented, such as improvements in tools, mechanical aids for the handling of loads, biomechanical risk intervention program, monitoring of activities that intervene in the condition of the work areas and the health conditions of each employee as established by Colombian regulations applied to the economic sector.

Likewise, there is evidence of a high demand for repetitive efforts, postural movements, uncomfortable postures, forced movements, lifting of physical loads that cause body stress, the need to generate an adequate intervention is determined, so it is recommended to establish the rotation of jobs to reduce the overload on the joints, muscles and bones of the upper extremities mainly.

It is pertinent to continue carrying out studies that evaluate the exposure to biomechanical risks of workers engaged in the tasks of coffee cultivation, since there are few studies in developing countries that investigate the occupational risks of this population and that could be related to the high figures associated with MSDs as a result of work activities in the agricultural sector.

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