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Musculoskeletal Symptoms and Assessment of Ergonomic Risk Factors on a Coffee Farm

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Abstract: In Honduras, some coffee farms must comply with strict standards of social, economic, and environmental sustainability, due to their organic, gender and fair-trade certifications. The principal research aim is to evaluate the musculoskeletal risks in occupations in a Honduran coffee farm certified in sustainable environments and to know the status of its workers within the farm. Musculoskeletal symptom perception during the last twelve months was consulted, assessing exposure to risk factors for work-related musculoskeletal disorders using the Quick Exposure Check method. Data regarding 48 workers were analyzed to provide the results. Within the body regions where discomfort is concentrated, the back, shoulders, wrists, knees, and feet stand out, and the highest risk exposures are presented for the coffee cutters at the neck level and in the wrist/hand segment, in the coffee pickers at the back, shoulder–arm segment, and wrist/hand segment, and in the processors in the back area and shoulder–arm segment. It is concluded that, in all the coffee fruit harvesting processes, the people who work in these jobs are exposed to ergonomic risks.

Keywords: ergonomics; musculoskeletal disorders; coffee farmers; decent work; QEC method

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1. Introduction

Among the Sustainable Development Goals, SDG 8, related to decent work and economic growth, promotes a safe and secure work environment for all workers, including migrant workers, particularly migrant women, and people with precarious jobs [1]. It is under this trend that coffee farms have obtained Fair Trade and Ecojusto certifications in Honduras, and therefore must comply with strict sustainable criteria: social, economic, and environmental.

1.1. Organic Coffee Consumption and Fair Trade

Organic food production and consumption have a great impact on the environment and human health, demonstrated by the environmental benefits on biodiversity, ecotoxicity impacts and soil quality of the cultivated land, and strongly associated with improvements in food quality and health due to the reduction of pesticide residues and heavy metals compared to conventional foods [2–14]. This has led different food industries to change their production systems, making them more sustainable and seeking to certify their processes regarding their compliance with the standards required for sustainable business behavior [4,9,15]. This is complemented by fair trade relations with suppliers

and decent working conditions for their collaborators, which can be guaranteed through Fair Trade certifications that include compliance with fair purchase prices for producers, input pre-financing, the establishment of long-term trade relations and regulations to ensure socially and economically fair and environmentally responsible production and trade conditions [16–18].

Studies on organic and fair-trade certifications in the coffee industry have provided contradictory results on the improvements expected with certifications [15,19–24]. Some studies show positive results in increased income and poverty reduction [16–19,25,26], while other studies indicate that there are no differences between certified and non-certified producers based on stakeholder benefit objectives [16,27,28].

1.2. Coffee Production in Honduras

Honduras has stood out for its coffee production in several areas, including Marcala (Department of La Paz) located within the Lenca Route tourist zone, one of the coffee tradition municipalities with the greatest popularity in recent years. The coffee varieties that are most produced in this zone are: Catuai, Icatu, Borbón and Obata. This is because most of the farms are located at an altitude of 1000 to 1700 m above sea level, an elevation that favors this crop [29,30].

All the farms in this municipality sell their product to other companies, prior bean certification as Café Marcala Denomination of Origin, a denomination that has been in existence since 2005. In addition, the Marcala city was one of the first in Honduras to declare itself a Fair-Trade City [30,31]. Since 2014, the enterprise research on more environmentally friendly coffee processes was initiated, with good results using the "honey process" and the "natural process", both processes that improve the quality of the coffee [32,33]. The "honey process" avoids water consumption and consists of cherry pulped and then dried with the layer of mucilage still left on the parchment, and the "natural process" consists of drying the coffee with the cherry before being threshed. In addition, to avoid the water consumption, this reduces energy consumption in processing up to a 50% [34].

1.3. Risk Factors and Musculoskeletal Lesions in Agricultural Workers

The European Agency for Safety and Health at Work (EU-OSHA) confirms that musculoskeletal disorders are among the most common occupational diseases in Europe, and indicates that, although these are present in various areas of the body, the most common places are the back and upper extremities [35].

It is estimated that around 1.3 billion people are involved in one way or another in agricultural work [36], and that around 80% of agricultural workers have reported musculoskeletal symptoms [35]. On the other hand, according to data provided by the United States Bureau of Labor Statistics (BLS), 33.8 out of 10,000 agricultural workers reported having symptoms related to musculoskeletal disorders [37,38]. The rate of musculoskeletal disorders of agricultural workers compared to other productive sectors is one of the highest [39,40]. McMillan et al. [41] found a 85.6% prevalence of musculoskeletal pain in at least one part of the body over 12 months in Canadian farmers.

In a study carried out with workers who harvested coffee manually, although it was found that they mainly manifested musculoskeletal discomfort in the lower extremities, when evaluating the intensity of muscle contraction by means of surface electromyography and the measurement of joint angles, it was found that this activity requires considerable physical effort at the level of the upper limbs [42]. A study in Colombian coffee plantations showed that the muscle with the greatest demand was the extensor carpi ulnaris muscle, which is located at the level of the upper extremities; the dynamic activity of this muscle exceeded 20% of the maximum voluntary contraction, making coffee harvesting a threatening activity for the generation of musculoskeletal injuries [43].

Ardiansyah [44] mentions that the work postures that are adopted during the coffee harvesting activity are because the fruit of the trees is at a height that exceeds the height of the worker; however, at the same time, he maintains that it is complex to explain muscu-

loskeletal disorders only from a biomechanical perspective, since the time of exposure to such postures is also involved in their generation. In this regard, there is a broad consensus on the interrelationship between several risk factors, the most documented in this type of activity being physical factors such as repetitive manual work [45], uncomfortable work postures [46,47], loads of heavy physical labor [36,48] and exposure to vibrations [49,50]. However, research on ergonomic evaluations of workers during the coffee harvest is still scarce [51].

The identification of ergonomic risks to which workers are exposed is the first step to improve working conditions, achieving a balance between decent work and economic growth (SDG8). Previous studies in coffee farms show that workers are exposed to biomechanical risk factors and present musculoskeletal discomfort [36,42–48], thus, the need arises to carry out a specific evaluation that considers these risk factors. That is why the objective of this research is to identify musculoskeletal symptoms and evaluate ergonomic risk factors in three occupations of a certified coffee farm in Honduras.

The case study company was founded in 2014 in response to the unemployment crisis in Marcala, aggravated by the Roya disease in coffee plants. This company promotes direct business between producers and buyers, fair trade, the wellbeing of women and children and environmental protection. It has more than 150 producers (40% women) dedicated to producing sustainable high-quality coffee and has a stable and growing relationship with more than 20 buyers in the United States, Canada, Germany, Belgium, Denmark, England, Ireland, Italy, Japan, and South Korea. Their efforts have earned them Fair Trade, UTZ certified, Denomination of Origin Marcala Coffee, Manos de Mujer and Organic certification, as well as international recognition for quality. Among the most recent international recognitions are Excellence Cup Honduras and Coffee Competition with Ecofair process organized by the Honduran Fair-Trade Coordinator.

2. Materials and Methods

2.1. Participants

Every year, the process of harvesting the fruit is carried out in the coffee farms [50]. The study included 48 workers from coffee farms in the Marcala Municipality in the Department of La Paz, Honduras. The participants of this process are called cutters, pickers, and processors. The cutters are responsible for cutting the fruit and then transporting it to its destination, where it is deposited in sacks or boxes. Later, the collectors place them on their shoulders and transport them to vehicles to remove them from the farm and take them to collection centers. On many occasions, it is necessary to carry the coffee on horses or pack animals and carts pulled by oxen, as this transport is popularly known. Finally, the processors manually unload the coffee sacks, deposit the fruit in the storage yards, distribute it with shovels to start the drying process and then deposit it in other sacks. With this, it finishes the drying process for its subsequent distribution to other collection centers and then, to industrial buyers [52].

Table 1 shows that there is a greater male presence in the farm (75% versus 25% female). With respect to the number of workers per job position, 47.9% of the employees work as cutters, 35.4% as pickers and 16.7% as processors. Regarding the number of hours worked per day, 67.7% are between 4 and 8 h, followed by 31.3% between 9 and 12 h. The number of days worked per week was 93.7% between 5 and 6 days, followed by 4.2% between 3 and 4 days and 2.1% every day. Finally, 50.0% of the workers smoke and 64.6% report drinking alcohol.

Table 1. Demographic and laboral data of participants in nominal and categorical variables.

Variables		N	%
Gender	Female	12	25.0
	Male	36	75.0
Job type	Cutter	23	47.9
	Picker	17	35.4
	Processor	8	16.7
Daily working hours	<4	1	2.0
	4 to 8	32	67.7
	9 to 12	15	31.3
	>12	0	0.0
Working days per week	1 to 2	0	0.0
	3 to 4	2	4.2
	5 to 6	45	93.7
	All days	1	2.1
Smoker	Yes	24	50.0
	No	24	50.0
Alcohol drinker	Yes	31	64.6
	No	17	35.4
Job	Gender:	Female	Male
	Cutter	10	13
	Picker	1	16
	Processor	1	7

Table 2 shows the number of participants according to age ranges and statistics regarding age, body weight, height, body mass index and years of experience in the enterprise and in the job. Of these, it stands out that the average age is 44.5 years, with a standard deviation of 10.7 years, which denotes a significant dispersion in terms of this variable. This becomes evident when analyzing the age ranges, where the number of workers between 30 and 39 years old, 40 and 49 years old and 50 and 59 years old is very similar (12, 14 and 13 participants, respectively). Regarding weight and height, with an average of 75.3 kg and 1.66 m, respectively, the data show a low dispersion, which means that these anthropometric characteristics are very similar among the workers. On the other hand, it should be noted that the body mass index of 27.4 kg/m^2 means that the workers are overweight; only 1 worker presented a BMI that classifies him as a normal weight [53]. Finally, workers on average have 13.1 years of experience in the company and 7.5 years in their current job.

Table 2. Demographic and laboral data of participants in numerical variables.

Variables	N		Mean	Standard Deviation	Median	Min	Max
Age (years)	20–29	5	44.5	10.7	44	21	71
	30–39	12					
	40–49	14					
	50–59	13					
	60+	4					
Weight (kg)	48		75.3	2.0	75.2	68.5	80.7
Height (m)	48		1.66	0.02	1.66	1.62	1.70
Body mass index (kg/m^2)	48		27.4	0.8	27.5	24.6	29.3
Years of experience in the enterprise	48		13.1	6.5	12	4	30
Years of experience on the job	48		7.5	3.6	7	0	18

2.2. Instruments

A survey was applied to carry out a demographic and labor characterization, including the following variables: age, gender, years of experience in the enterprise, the job position held, years of experience on the job, daily working hours and working days per week. In addition, a discriminant question was included, based on the Nordic Kuorinka Questionnaire: what is the length of time you have had musculoskeletal symptoms by body region during the last 12 months (in days)? [54].

To assess the biomechanical risk factors, in the present investigation, the Quick Exposure Checklist (QEC) method was applied [55,56]. This is a method to assess the exposure to risk factors for work-related musculoskeletal disorders, which consists of a checklist that has a standard structure and considers the assessment of physical risk factors, including workload, posture, frequency of movement, visual demands, conduction, and vibration, for the four main regions of the body: back, shoulder/arm, wrist/hand, and neck, as well as of psychosocial factors such as work pace and stress. It is based on the use of a questionnaire that contains 15 questions numbered from the letter A to the letter Q. Of these, the first seven questions (up to the letter G) are answered directly by the evaluator through direct observation of the tasks, and the rest (from the letter H to the letter Q) are answered by the worker through an interview [55,56]. Weight and height were measured with a portable device with a weighing scale and built-in stadiometer (ONE-MI brand). Then, body mass index (BMI) was calculated by dividing body weight in kg by height squared in meters, and each worker was categorized.

Table 3 presents the reference criteria of the method to determine the exposure levels, based on a score obtained from the cross-checking of the information collected by applying the checklist.

Table 3. Proposed exposure levels for QEC scores.

Exposure Factor	Exposure Level			
	Low	**Moderate**	**High**	**Very High**
Back (static)	8–14	16–22	24–28	30–40
Back (moving)	10–20	22–30	32–40	42–56
Shoulder/arm	10–20	22–30	32–40	42–56
Wrist/hand	10–20	22–30	32–40	42–56
Neck	4–6	8–10	12–14	16–18
Driving	1	4	9	–
Vibration	1	4	9	–
Work pace	1	4	9	–
Stress	1	4	9	16

David et al. [56], with the participation of 206 workers, tested, modified, and validated the QEC method, demonstrating its usability, intra- and inter-observer reliability and validity in the evaluation of different types of work activities. On the other hand, in the study of Ozcan et al. [57], this instrument demonstrated fair to good reliability. That is why this method has been used in applied research in various productive sectors as a tool for the analysis of risk factors for musculoskeletal disease. Among the studies where this method of ergonomic evaluation has been applied, sorted by number of participants (highest to lowest), is the investigation of Henry et al. [58], carried out in palm plantation workers (n = 84), Karimi et al. [59] in milkers of a dairy plant (n = 48), Ozdemir and Toy [60] in office workers (n = 37), Bell and Steele [61] in cleaning workers (n = 24), Murty [62], carried out in nursing professionals (n = 14), Park et al. [63] in dentists (n = 3) and Rwamamara et al. [64] in construction workers (n = unknown).

2.3. Procedure

To carry out the evaluations in the field, first, a professional was trained telematically in the application of the QEC method. The training was carried out by an ergonomics

specialist, who works in a center specializing in the subject, who provided remote assistance at the time of carrying out the evaluations. The professional who carried out the evaluations in the field had previous experience in coffee farms, knowing very well the type of work that is carried out in this area, since this study is part of a line of research in which he had been working for some time [65]. The coffee farms were visited and the jobs to be evaluated were defined. Subsequently, the general survey was applied to collect information on demographic and labor aspects and the perception of musculoskeletal symptoms. Then, regarding the QEC method, the answers were obtained through direct observation of the tasks and the interview with the worker, according to what was established by the instrument.

2.4. Data Analysis

Once the data were obtained, the exposure levels of each body segment and of the other factors were determined for each worker, according to the reference criteria of the QEC method indicated in Table 3. These data, in addition to the oriented to the investigation of musculoskeletal discomfort, were entered into a spreadsheet, to subsequently perform a descriptive and non-parametric statistical analysis using SPSS software.

3. Results

Regarding Table 4, 100% do not perceive symptoms in the areas of the hips or right thigh, followed by 97.2% in the left thigh and 95.8% in the lower right and left leg. Regarding those skeletal muscle groups where symptoms are perceived more frequently (over 30 days during the last 12 months), the upper back and the right knee are found, with 72.9%, followed by the left knee and both feet, with 70.8%.

Table 4. Frequency (f) and percentage (%) of workers who perceived musculoskeletal symptoms by body region according to number of days during the last 12 months (n = 48).

Body Region	Frequency and Percentage of Workers									
	0 Days		1 to 7 Days		8 to 30 Days		>30 Days		All Days	
	f	%	f	%	f	%	f	%	f	%
Neck	11	22.9	0	0.0	10	20.8	27	56.3	0	0.0
Right shoulder	3	6.3	1	2.1	12	25.0	32	66.7	0	0.0
Left shoulder	3	6.3	1	2.1	12	25.0	32	66.7	0	0.0
Upper back	1	2.1	1	2.1	11	22.9	35	72.9	0	0.0
Right upper arm	29	60.4	1	2.1	4	8.3	14	29.2	0	0.0
Left upper arm	31	64.6	1	2.1	4	8.3	12	25.0	0	0.0
Lower back	4	8.3	1	2.1	10	20.8	33	68.8	0	0.0
Right forearm	44	91.6	0	0.0	2	4.2	2	4.2	0	0.0
Left forearm	45	93.7	0	0.0	2	4.2	1	2.1	0	0.0
Right wrist	8	16.7	0	0.0	9	18.7	31	64.6	0	0.0
Left wrist	9	18.7	0	0.0	9	18.7	30	62.5	0	0.0
Hip/buttocks	48	100	0	0.0	0	0.0	0	0.0	0	0.0
Right thigh	48	100	0	0.0	0	0.0	0	0.0	0	0.0
Left thigh	47	97.9	0	0.0	0	0.0	1	2.1	0	0.0
Right knee	3	6.3	1	2.1	9	18.7	35	72.9	0	0.0
Left knee	4	8.3	1	2.1	9	18.7	34	70.8	0	0.0
Right lower leg	46	95.8	0	0.0	1	2.1	1	2.1	0	0.0
Left lower leg	46	95.8	0	0.0	1	2.1	1	2.1	0	0.0
Right foot	3	6.3	0	0.0	11	22.9	34	70.8	0	0.0
Left foot	3	6.3	0	0.0	11	22.9	34	70.8	0	0.0

It can be seen from Table 4 that the body regions that present more prolonged symptoms are (>30 days): neck, right and left shoulder, upper and lower back, right and left wrist, right and left knee and right and left foot, all with values exceeding 50% of the coffee farmers surveyed.

Table 5 shows, in the three occupational groups, 50% or more of the workers reported discomfort for more than 30 days in the last 12 months at the level of the right and left shoulder, upper and lower back, right and left wrist, right and left knee and right and left foot. Moreover, at the neck level, over 50% of the cutters and pickers reported discomfort for more than 30 days in the last 12 months.

Table 5. Frequency (f) and percentage (%) of workers by job who perceived musculoskeletal symptoms by body region for more than 30 days and all days during the last 12 months.

Body Region	Frequency and Percentage of Workers						
	Cutter (*n* = 23)		Picker (*n* = 17)		Processor (*n* = 8)		Total (*n* = 48)
	f	%	f	%	f	%	
Neck	15	65.2	9	52.9	3	37.5	27
Right shoulder	15	65.2	13	76.5	4	50.0	32
Left shoulder	15	65.2	13	76.5	4	50.0	32
Upper back	16	69.6	13	76.5	6	75.0	35
Lower back	14	60.9	13	76.5	6	75.0	33
Right wrist	16	69.6	9	52.9	6	75.0	31
Left wrist	16	69.6	9	52.9	5	62.5	30
Right knee	16	69.6	13	76.5	6	75.0	35
Left knee	16	69.6	13	76.5	5	62.5	34
Right foot	17	73.9	12	70.6	5	62.5	34
Left foot	17	73.9	12	70.6	5	62.5	34

Table 6 shows the absence of proportional differences, when detailed by smoker, alcohol drinker, gender, height, or weight, in the musculoskeletal symptoms in the different body regions.

Table 6. Frequency (f) of workers by personal characteristics who perceived musculoskeletal symptoms by body region for more than 30 days and all days during the last 12 months.

Body Region	Frequency of Workers										
	Smoker		Alcohol Drinker		Gender		Height (m)		Weight (kg)		Total
	No	Yes	No	Yes	F	M	1.60–1.65	>1.65–1.70	65–75	>75–85	
Neck	14	13	9	18	7	20	13	14	15	12	27
Right shoulder	18	14	11	21	7	25	13	19	17	15	32
Left shoulder	18	14	11	21	7	25	13	19	17	15	32
Upper back	19	16	12	23	8	27	14	21	18	17	35
Lower back	18	15	11	22	7	26	12	21	17	16	33
Right wrist	16	15	12	19	8	23	13	18	18	13	31
Left wrist	16	14	12	18	8	22	13	17	17	13	30
Right knee	20	15	13	22	9	26	14	21	17	18	35
Left knee	20	14	13	21	9	25	13	21	16	18	34
Right foot	19	15	12	22	9	25	14	20	17	17	34
Left foot	19	15	12	22	9	25	14	20	17	17	34
Total	24	24	17	31	12	36	20	28	24	24	

Table 7 shows that the frequency of workers in the range of 20–29 years who report musculoskeletal symptoms is lower than those who belong to the range of 60+.

Table 7. Frequency (f) of workers by age range who perceived musculoskeletal symptoms by body region for more than 30 days and all days during the last 12 months.

Body Region	20–29	30–39	40–49	50–59	60+	Total
Neck	1	7	7	8	4	27
Right shoulder	1	8	9	10	4	32
Left shoulder	1	8	9	10	4	32
Upper back	1	8	12	10	4	35
Lower back	0	8	11	10	4	33
Right wrist	1	8	10	8	4	31
Left wrist	1	8	9	8	4	30
Right knee	1	8	12	10	4	35
Left knee	1	7	12	10	4	34
Right foot	1	8	11	10	4	34
Left foot	1	8	11	10	4	34
Mean	1	8	10	9	4	32
Total, workers	5	12	14	13	4	48

Table 8 shows the relationship between the musculoskeletal symptoms for each body region; statistically significant differences were found by job type, smoker, alcohol drinker, gender, BMI level and age level. Statistically significant differences were observed between type of work with symptoms in the neck, right wrist, and left wrist, between alcohol consumption with symptoms in the right wrist and left wrist, between BMI level with symptoms in the right shoulder, left shoulder, right foot, and left foot, and between age level with right shoulder, left shoulder, low back, right foot and left foot.

Table 8. Pearson chi-square test musculoskeletal symptoms by variable.

Body Region	Job Type	Smoker	Alcohol Drinker	Gender	BMI level	Age Level
Neck	9.975 (0.041) *	0.128 (0.938)	1.300 (0.522)	2.697 (0.260)	3.435 (0.179)	12.497 (0.130)
Right shoulder	8.744 (0.188)	2.167 (0.539)	0.774 (0.856)	1.056 (0.788)	15.319 (0.002) *	21.420 (0.045) *
Left shoulder	8.744 (0.188)	2.167 (0.539)	0.774 (0.856)	1.056 (0.788)	15.319 (0.002) *	21.420 (0.045) *
Upper back	3.302 (0.770)	3.075 (0.380)	2.396 (0.494)	3.449 (0.327)	0.379 (0.944)	18.287 (0.107)
Lower back	6.731 (0.346)	1.673 (0.643)	1.075 (0.783)	2.053 (0.562)	0.464 (0.927)	21.005 (0.050) *
Right wrist	13.966 (0.007) *	0.643 (0.725)	6.130 (0.047) *	4.492 (0.106)	0.560 (0.756)	11.655 (0.167)
Left wrist	12.814 (0.012) *	1.244 (0.537)	6.807 (0.033)	4.859 (0.088)	4.426 (0.109)	11.841 (0.158)
Right knee	5.354 (0.499)	4.825 (0.185)	2.560 (0.465)	1.676 (0.642)	0.379 (0.944)	14.545 (0.267)
Left knee	4.379 (0.625)	6.170 (0.104)	3.181 (0.365)	2.039 (0.564)	0.421 (0.936)	15.448 (0.218)
Right foot	3.196 (0.526)	1.622 (0.444)	0.010 (0.995)	1.070 (0.586)	15.319 (0.000) *	15.759 (0.046) *
Left foot	3.196 (0.526)	1.622 (0.444)	0.010 (0.995)	1.070 (0.586)	15.319 (0.000) *	15.759 (0.046) *

( ): Asymptotic significance (2-sided). * Significant relationship between variables (p-value ≤ 0.050).

Figure 1 shows that the frequency of manifestation of musculoskeletal symptoms in the neck (A) and right (B and D) and left (C and E) wrists of the cutters is significantly higher than that of the pickers and processors. In respect to both the right and left wrist, 100% of the cutters presented discomfort in the last 12 months, either between 8 and 30 days or more than 30 days. Significant statistical differences were also found between right and left wrist discomfort and alcohol consumption, where alcohol consumption was associated with a lower frequency of symptoms in this segment. In relation to BMI, overweight is

associated with a higher frequency of manifestation of musculoskeletal symptoms at the level of the shoulders (F and G) and right (H) and left (I) foot. On the other hand, it should be noted that, with increasing age, the frequency of manifestation of symptoms at the level of the right (J) and left (K) shoulders, lower back (L) and right (M) and left (N) feet tends to increase, it being evident that, over 60 years of age, 100% of the workers manifested discomfort over 30 days during the last 12 months.

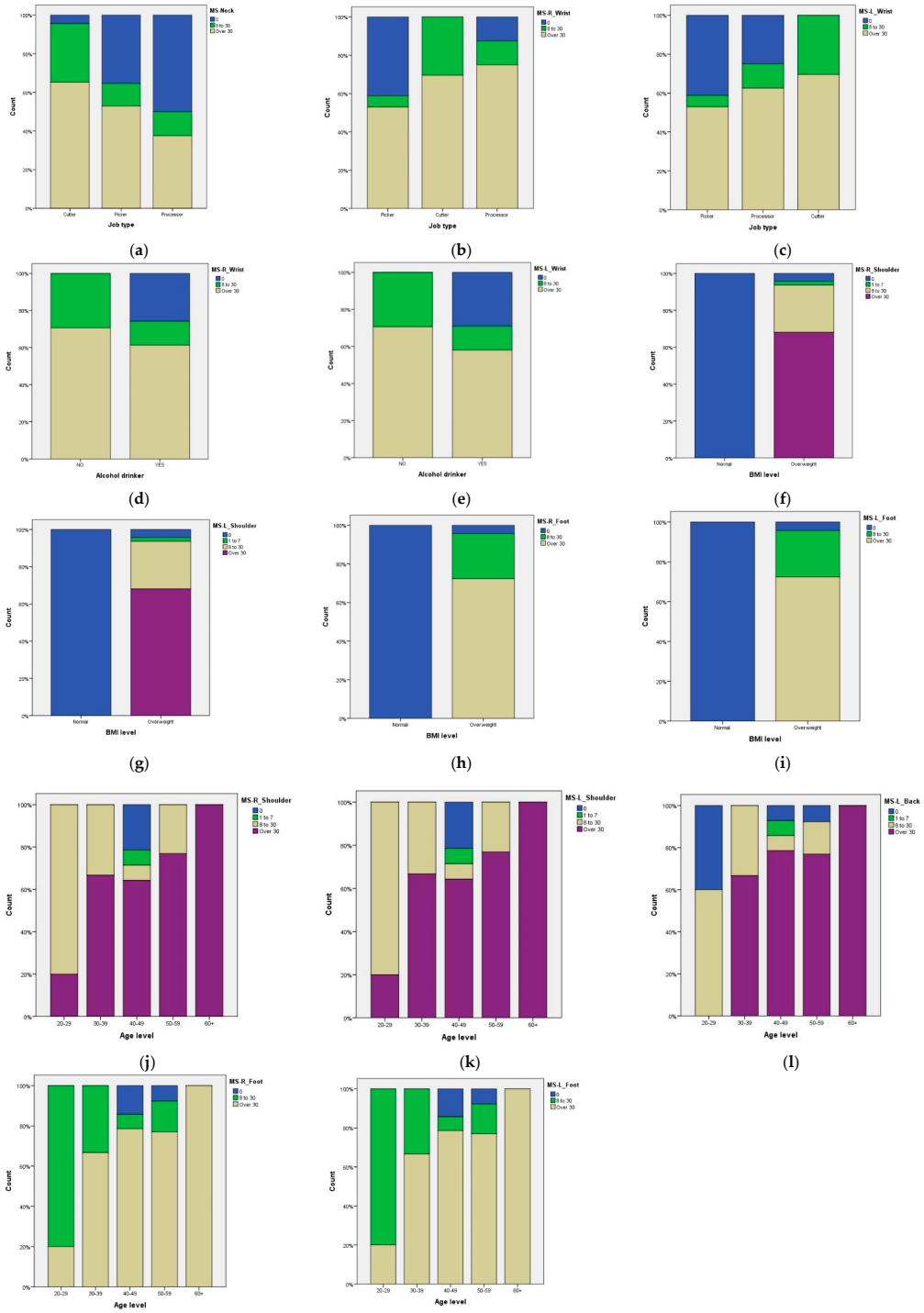

Figure 1. Relation between musculoskeletal symptoms by variables such as job type: (**a**) neck, (**b**) right wrist, (**c**) left wrist; alcohol drinker: (**d**) right wrist, (**e**) left wrist; BMI level: (**f**) right shoulder, (**g**) left shoulder, (**h**) right foot, (**i**) left foot; age level: (**j**) right shoulder, (**k**) left shoulder, (**l**) lower back, (**m**) right foot, (**n**) left foot.

Table 9 shows those body regions with a higher exposure to risk, which would be at a very high value in the neck (56.3%) followed by the back (54.2%) and the shoulder/arm 52%. A high value of exposure to risk was reported especially for the wrist/hand (66,7%), and moderate values of exposure were reported predominantly for stress (72.9% of workers) and work pace (58.3% of workers). Finally, a lower value is found regarding vibration, with 93.8%, 72.9% in driving and 72.9% in the back.

Table 9. Frequency (f) and percentage (%) of workers for each factor according to the level of exposure based on the scores proposed by the QEC method (n = 48).

Exposure Factor	Exposure Level							
	Low		Moderate		High		Very High	
	f	%	f	%	f	%	f	%
Back	0	0.0	6	12.5	16	33.3	26	54.2
Shoulder/arm	0	0.0	2	4.2	21	43.8	25	52.1
Wrist/hand	1	2.1	14	29.2	32	66.7	1	2.1
Neck	0	0.0	8	16.7	13	27.1	27	56.3
Driving	35	72.9	10	20.8	3	6.3	0	0.0
Vibration	45	93.6	2	4.2	1	2.1	0	0.0
Work pace	19	39.6	28	58.3	1	2.1	0	0.0
Stress	4	8.3	35	72.9	5	10.4	4	8.3

Table 10 shows that 82.61% of the cutters have a very high exposure level for the neck and a high exposure level for the wrist and hand.

Table 10. Frequency (f) and percentage (%) of cutters for each factor according to the level of exposure based on the scores proposed by the QEC method (n = 23).

Exposure Factor	Exposure Level							
	Low		Moderate		High		Very High	
	f	%	f	%	f	%	f	%
Back	0	0.0	6	26.1	14	60.9	3	13.0
Shoulder/arm	0	0.0	1	4.4	13	56.5	9	39.1
Wrist/hand	0	0.0	4	17.4	19	82.6	0	0.0
Neck	0	0.0	0	0.0	4	17.4	19	82.6
Driving	23	100	0	0.0	0	0.0	0	0.0
Vibration	23	100	0	0.0	0	0.0	0	0.0
Work pace	12	52.2	11	47.8	0	0.0	0	0.0
Stress	3	13.0	15	65.2	1	4.4	4	17.4

Table 11 shows a very high exposure level in 94.12% of the workers in the back area, 76.47% in the shoulder/arm area and 58.82% at a high exposure level in the wrist–hand segment.

Table 12 shows that 87.5% of the workers have a very high exposure level in the back area. Of the workers, 50% have a high exposure level and 37.5% a very high exposure level in the shoulder/brachial region. It should be noted that the processors and pickers handle loads of 40 kg and the cutters of 12 kg, manually.

Table 13 shows the relationships between QEC exposure levels and the frequency of musculoskeletal symptoms by body segment. Statistically significant associations were observed between the exposure level of the wrist/hand segment, with symptoms in the neck, right shoulder, left shoulder, right wrist, and left wrist, and between the exposure level of the neck segment, with symptoms in the right wrist, left wrist, right foot, and left foot.

Table 11. Frequency (f) and percentage (%) of pickers for each factor according to the level of exposure based on the scores proposed by the QEC method (n = 17).

Exposure Factor	Exposure Level							
	Low		Moderate		High		Very High	
	f	%	f	%	f	%	f	%
Back	0	0.0	0	0.0	1	5.9	16	94.1
Shoulder/arm	0	0.0	0	0.0	4	23.5	13	76.5
Wrist/hand	0	0.0	6	35.3	10	58.8	1	5.9
Neck	0	0.0	5	29.4	6	35.3	6	35.3
Driving	6	35.3	8	47.1	3	17.7	0	0.0
Vibration	15	88.2	1	5.9	1	5.9	0	0.0
Work pace	3	17.7	13	76.5	1	5.9	0	0.0
Stress	0	0.0	15	88.2	2	11.8	0	0.0

Table 12. Frequency (f) and percentage (%) of processors for each factor according to the level of exposure based on the scores proposed by the QEC method (n = 8).

Exposure Factor	Exposure Level							
	Low		Moderate		High		Very High	
	f	%	f	%	f	%	f	%
Back	0	0.0	0	0.0	1	12.5	7	87.5
Shoulder/arm	0	0.0	1	12.5	4	50.0	3	37.5
Wrist/hand	1	12.5	4	50.0	3	37.5	0	0.0
Neck	0	0.0	3	37.5	3	37.5	2	25.0
Driving	6	75.0	2	25.0	0	0.0	0	0.0
Vibration	7	87.5	1	12.5	0	0.0	0	0.0
Work pace	4	50.0	4	50.0	0	0.0	0	0.0
Stress	1	12.5	5	62.5	2	25.0	0	0.0

Figure 2 shows that the level of exposure of the wrist/hand segment is statistically significantly associated with musculoskeletal discomfort at the neck (A), right (B) and left (C) shoulder and right (D) and left (E) wrist. In this regard, it should be noted that, in the case of the relationship between the level of exposure of the wrist/hand segment and discomfort at the neck and right and left shoulders, at high and very high-risk exposure levels, the frequency of manifestation of musculoskeletal symptoms is higher, i.e., as the level of exposure increases, from low to very high, the frequency of manifestation of musculoskeletal symptoms tends to increase. Now, regarding the relationship between the level of exposure of the wrist/hand segment and discomfort in the right and left wrist, at the low-risk exposure level, the frequency of symptoms in 100% of the workers was greater than 30 days, and at the very high-risk exposure level, the frequency of symptoms in 100% of the workers was between 8 and 30 days during the last 12 months. On the other hand, the level of exposure of the neck segment is statistically significantly associated with musculoskeletal discomfort at the level of the right (F) and left (G) wrist segment and right (H) and left (I) foot. In this regard, it is observed that, as the level of exposure to the risk increases, the frequency of presentation of musculoskeletal symptoms in workers tends to increase, with 100% of workers showing musculoskeletal symptoms for the very high level of exposure, with a frequency between 8 and 30 days or more than 30 days during the last 12 months.

Table 13. Pearson chi-square test musculoskeletal symptoms by QEC method exposure level.

Body Region	Exposure Factor							
Musculoskeletal Symptoms	**Back**	**Shoulder/Arm**	**Wrist/Hand**	**Neck**	**Driving**	**Vibration**	**Work Pace**	**Stress**
Neck	4.841 (0.304)	1.387 (0.846)	12.954 (0.044) *	10.609 (0.101)	4.794 (0.309)	1.903 (0.754)	2.084 (0.720)	5.925 (0.432)
Right shoulder	3.499 (0.751)	6.470 (0.373)	21.741 (0.010) *	11.549 (0.240)	2.229 (0.898)	1.272 (0.973)	7.098 (0.312)	5.550 (0.784)
Left shoulder	3.449 (0.751)	6.470 (0.373)	21.741 (0.010) *	11.549 (0.240)	2.229 (0.898)	1.272 (0.973)	7.098 (0.312)	5.550 (0.784)
Upper back	1.972 (0.922)	3.659 (0.723)	7.162 (0.620)	9.425 (0.399)	1.973 (0.922)	1.258 (0.974)	2.662 (0.850)	2.513 (0.981)
Lower back	2.459 (0.873)	4.673 (0.586)	7.026 (0.634)	10.757 (0.293)	3.372 (0.761)	1.618 (0.951)	2.586 (0.859)	4.074 (0.906)
Right wrist	4.748 (0.314)	2.313 (0.678)	16.225 (0.013) *	19.045 (0.004) *	3.603 (0.462)	2.045 (0.727)	1.065 (0.900)	4.365 (0.627)
Left wrist	5.794 (0.215)	3.375 (0.497)	18.733 (0.005) *	19.809 (0.003) *	5.554 (0.235)	2.127 (0.712)	1.752 (0.781)	4.472 (0.613)
Right knee	9.267 (0.159)	6.455 (0.374)	8.682 (0.467)	13.542 (0.140)	3.096 (0.797)	1.764 (0.940)	2.148 (0.906)	3.583 (0.937)
Left knee	6.612 (0.358)	4.171 (0.654)	9.252 (0.414)	15.278 (0.084)	3.529 (0.740)	1.828 (0.935)	2.575 (0.860)	8.580 (0.477)
Right foot	3.639 (0.457)	1.463 (0.833)	6.243 (0.397)	12.513 (0.051) *	1.863 (0.761)	1.322 (0.858)	1.388 (0.846)	3.178 (0.786)
Left foot	3.639 (0.457)	1.463 (0.833)	6.243 (0.397)	12.513 (0.051) *	1.863 (0.761)	1.322 (0.858)	1.388 (0.846)	3.178 (0.786)

( ): Asymptotic significance (2-sided). * Significant relationship between variables (p-value ≤ 0.05).

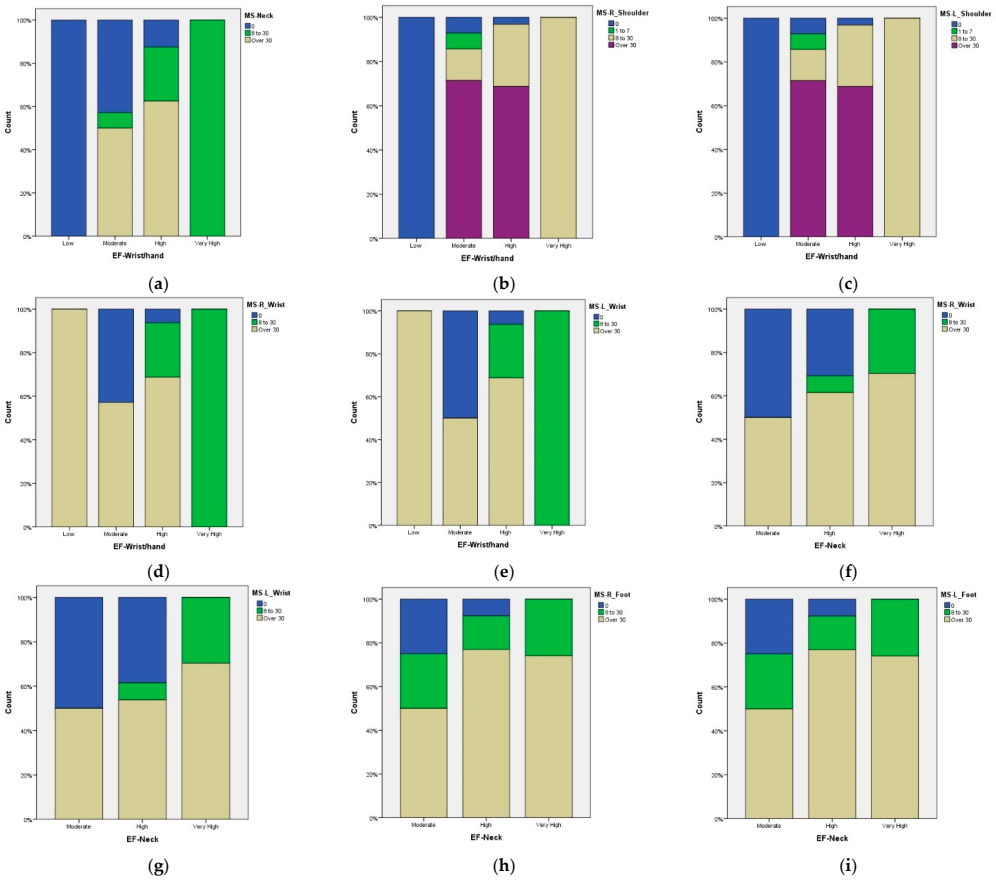

Figure 2. Crossover between musculoskeletal symptoms by QEC method exposure level. Exposure factor—wrist/hand: (**a**) neck, (**b**) right shoulder, (**c**) left shoulder, (**d**) right wrist, (**e**) left wrist, and Exposure factor—neck: (**f**) right wrist, (**g**) left wrist, (**h**) right foot, (**i**) left foot.

4. Discussion

In general terms, the musculoskeletal complaints reported by people working on the farm correspond to the typical symptoms of this type of work [66–69]. Prolonged standing work is associated with musculoskeletal disorders at the level of the load-bearing joints, such as the lumbar spine [70–72], and the adoption of awkward postures is associated with discomfort at the level of the shoulders, arms, wrists, hands, fingers, and neck [73], body areas that the QEC method considers in the estimation of risk.

In the case of cutters, the risk level is presented in a higher percentage in the neck regions and in the wrist–hand segment, given the working position that workers adopt to perform their work and given the location of both the ground and the branches of the trees, i.e., having to extend the neck to reach the fruit. The wrist–hand offers greater risk because the cutting is manual. In addition, in the case of pickers, they present a higher level of risk at the back, shoulder–arm and wrist–hand levels. This is to be expected, since their tasks are associated with loading, transporting, and unloading bags of coffee, requiring significant strength, and forced postures. Finally, the processors present a higher level of risk in the back and shoulder–arm area. This is because, during the process, they must move heavy loads and then arrange them in the storage and distribution areas of the coffee farm.

In the case of cutters, the level of risk occurs in a higher percentage in the neck regions and in the wrist–hand segment, in the first case, due to the posture in maintained extension that the neck must adopt, given the location of the branches of the trees, and in the second case, due to the repetitive nature of the task, associated with force requirements, since the cut is performed manually. In this regard, international standards, such as the ISO 11226:2000 standard, support that sustained neck extension constitutes a musculoskeletal risk factor for that body region [74,75] and, on the other hand, regarding repetitive movements, international standards such as ISO 11228-3:2007 establish a direct association between this risk factor, associated with strength requirements and musculoskeletal disorders of the hand–wrist segment [76,77].

In the case of pickers and processors, it is expected that they present a higher level of risk at the level of the back and shoulder–arm segment and, particularly in the case of pickers, also at the level of the wrist–hand segment, since their tasks are associated, in the pickers, with the loading, transport and unloading of bags of coffee and, in the processors, with the transport of heavy loads to later dispose them in the coffee storage and distribution areas. These tasks involve manual load handling, with significant strength requirements associated with awkward postures. Manual load handling is associated with significant biomechanical stress at the level of the lumbar spine [78] and the strength requirements associated with forced postures, with musculoskeletal disorders at the level of the upper extremities [79].

5. Conclusions

In all the processes involved in the coffee fruit harvest, the people who work in these jobs are exposed to ergonomic risks, especially because of the physical demands imposed by the nature of the tasks they perform.

Workers are on their feet most of the day and are exposed to physical demands derived from manual handling of loads and the adoption of uncomfortable postures at the level of the spine and upper limbs.

It is concluded that the body segments with the highest level of exposure to risk, in the cutters, are the neck and the wrist/hand segment, in the pickers, are the back, the shoulder/arm segment and the wrist/hand segment, and in the processors, are the back and shoulder/arm segment. These risk factors are frequent in this class of process, which was covered in the discussion [80–82]. On the other hand, the cutters showed a greater frequency of presentation of musculoskeletal symptoms at the level of the neck and right and left wrists, and variables such as overweight and age are associated with a greater frequency of discomfort at the level of the shoulders and feet, and in the case of age, in addition to symptoms at the level of the lower back. As for alcohol consumption, it was

found to be associated with a lower frequency of musculoskeletal symptoms at the level of the wrists.

According to the QEC method, it is concluded that the higher the level of wrist–hand segment exposure, the higher the frequency of musculoskeletal discomfort in the neck and shoulders, and when correlating the level of wrist–hand segment exposure with musculoskeletal discomfort in the wrists, the low level of exposure is related to a higher frequency of discomfort, followed by a very high level of exposure. In addition, as the level of exposure of the neck to risk increases, the frequency of presenting musculoskeletal symptoms at the wrists and feet increases [58].

As a line of future research, it could be interesting to include the evaluation of other risk factors, such as environmental, organizational, and psychosocial, and to address aspects associated with safety in the workplace and social protection for families, since workers are usually low-income and, in most cases, do not have free social security, much less private health insurance, topics scarcely addressed in the available research. Moreover, it is proposed to study in greater detail the body composition of the workers by determining their percentage of fat and estimating the energy requirements of the activities they carry out and the contributions through the evaluation of the diet. In addition, it would be interesting to evaluate, with other methods, specifically, the biomechanical risk factors of those body regions that presented higher levels of exposure, to apply the full version of the Nordic questionnaire and investigate more about the aspects associated with risk factors derived from driving, exposure to vibration, work rhythm and stress, which were identified in the article. On the other hand, it would be interesting to study the incorporation of exoskeleton systems as a viable alternative to help operators and harvesters in agricultural tasks, such as in the coffee industry, since these portable devices help reduce physical demands, avoiding related musculoskeletal injuries with work [83].

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