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An Analysis of Occupational Hazards Based on the Physical Ergonomics Dimension to Improve the Occupational Health of Agricultural Workers: The Case in Mayo Valley, Mexico

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Abstract: The occupational health and safety of agricultural workers is a topic that has a direct impact on the agricultural sector worldwide. For this reason, investigations into ergonomic factors are relevant to the health and safety of agricultural workers. In this study, nine variables of the physical–ergonomic dimension were analyzed to determine which factors represent occupational risks for agricultural workers in Mayo Valley, Mexico. A sample of 200 people was considered. The sample was separated by gender and divided into groups according to age. A closed-ended survey was developed and validated to assess physical ergonomics variables using a five-level Likert scale. Using Principal Component Analysis, it was found that there are physical ergonomic variables that affect male agricultural workers more than female workers (the risk of carrying heavy objects, PE3, and the risk of performing repetitive movements, PE4). It was also found that certain physical ergonomic variables are not perceived as hazardous by agricultural workers (the risk of using inappropriate materials, PE9). In addition, various research findings are discussed to determine the implications and recommendations for improving the occupational health and safety of agricultural workers in Mayo Valley, Mexico.

Keywords: risk factors; physical ergonomics; agricultural workers; principal component analysis; occupational health

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1. Introduction

Ergonomics is a field of engineering that plays an important role in the study of the occupational health of workers involved in the development of any operation (i.e., blue-collar workers, but also white-collar and pink-collar workers) in industries belonging to the different production and service sectors, such as primary (the extraction of raw materials), secondary (manufacturing), and tertiary (service industries that facilitate the transport, distribution, and sale of goods produced in the secondary sector). This field is one of the scientific disciplines responsible for studying the interrelationships between people and their work environments in order to improve the occupational health of workers and optimize the efficiency of production systems [1]. In general, the term 'environment' refers not only to the improvement of systems, but also to the use of materials, tools, the physical environment, and work methods, both in groups and by individuals [2]. Consequently, ergonomics not only has a significant impact on occupational health, but also supports other areas such as job satisfaction, performance, and commitment, among others. In addition, it not only plays an important role in the prevention of occupational accidents, but also assists in reducing production costs and increasing productivity [3]. At present, the acceptance of this discipline around the world has been considered to be of great importance. This is because it has contributed to reducing the workload, discomfort, fatigue, chronic diseases, and injuries that the working population can suffer [4].

According to the International Ergonomics Association, ergonomics is divided into three dimensions of cognitive, organizational, and physical ergonomics. These dimensions play fundamental roles in the prevention of occupational risks, mainly problems related to musculoskeletal symptoms in workers' health [5,6]. In particular, cognitive ergonomics is interested in human mental processes (e.g., perception, reasoning, memory, etc.) because these processes affect the interactions between humans and the other elements of a working system. Organizational ergonomics is concerned with the optimization of socio-technical systems (e.g., organizational structures, policies, and processes). Finally, physical ergonomics is concerned with human physiological, anthropometric, and biomechanical aspects related to physical movement. In light of what is mentioned above, this research will focus specifically on the physical ergonomics dimension, because this construct is more related to the physical activities of the human body concerning blue-collar workers, e.g., agriculture workers. This dimension is responsible for studying the characteristics of physical loads, such as anatomical, anthropometric, physiological, and biomechanical aspects of the human being [7]. It is, therefore, the psychophysical demands (the relationship between stimuli and sensation) that a person undertakes in their work environment, involving the use of the musculoskeletal and cardiovascular systems. Thus, these variables can be represented as repetitive movements such as strength, loads, fatigue, and postures, as well as the manipulation of objects and the workplace layout. It is important to remark that these factors only represent a risk when the response capacity of the individual is exceeded. Hence, occupational health and safety should focus on the worker [8,9].

In the same context, occupational health is a multidisciplinary field that has been considered as an important factor in all areas of engineering, for example, in those involved in the development of different products within an organization. Consequently, this field has been of great interest in the development of research on occupational health and work-related illnesses in order to exhaustively understand the risks that affect these issues in terms of the safety of workers in the workplace and to maintain and achieve the well-being of workers [10,11]. Therefore, occupational risks need to be carefully considered, whether formally or informally. Formally, there are occupational health and safety standards and regulations that have been properly established, e.g., ISO 45001 Occupational Health and Safety Management System Requirements, and in the past, OHSAS 18001, Occupational Health and Safety Assessment Serie, and the recommendations of the International Labour Organization, which have been withdrawn and replaced by ISO 45001 [12–14]. Even with the above, in some regions of the world and in companies with a bad organizational culture, it has become a topic of economic, political, and social debate [15]. In particular, occupational health is an underdeveloped topic in Mexico, mainly in some economic sectors [16]. The most recent advance was in 2018, with the establishment of the official Mexican standard NOM-035-STPS-2018, psychosocial risk factors at work- identification, analysis, and prevention [17,18].

Considering the aforementioned, ergonomic studies have been developed in different production and service sectors. For example, the role of ergonomics in the manufacturing sector has been analyzed concerning the sustainability and innovation capacity of employees [19,20]. Digital twins have also been developed to help employees to improve their ergonomics. Additionally, many of the advances in ergonomics in companies are within the framework of Industry 4.0 [21–23]. Also, it is important to remark that it is estimated that there are 1.3 billion agricultural workers around the world. In addition, at least 170,000 agricultural workers die each year. There is no doubt that this number could be much higher if we take into account accidents that go unreported for a variety of reasons [24]. Hence, it is important to research the occupational health of workers involved in agricultural activities, such as picking or harvesting crops. These people mostly live in rural areas, are generally not highly educated, and consider their income too low. In particular, agricultural activity is largely dependent on manual labor (blue-collar work), which requires great physical efforts. In addition, agricultural workers are exposed to unsafe or unfavorable conditions in their workplace (i.e., the field). As a result, the working day can exceed 10 h per day, depending on the type of activity being carried out. In addition, as many countries base their economies on agriculture, research into the health of agricultural workers is of paramount importance.

For this reason, the objective of this research is to analyze those factors that represent ergonomic occupational risks, considering the physical dimension of workers dedicated to agricultural activities in a particular region of the state of Sinaloa, Mexico. In particular, this region includes the Mayo Valley, which is very important for Mexico's food security both in terms of agricultural (representing 26% of the total national agricultural production) and livestock products (see Figure 1) [25,26]. The last is based on the perception of agricultural workers regarding the relevant variables of their occupational health. At the end of the study, recommendations will be proposed to improve their working conditions.

Figure 1. Agricultural workers of Mayo Valley.

2. Literature Review

Various research projects have been developed around the world that relate, either directly or indirectly, some dimension of ergonomics to the quality of life and risk reduction of agricultural workers. For example, ergonomic factors have been studied concerning the discomfort experienced by agricultural machinery operators because of the modernization of their tools and processes [27–29]. Furthermore, some studies have looked at the design and redesign of machines and workplaces, as well as the use of Artificial Intelligence (AI) in the Rapid Entire Body Assessment (REBA) method [30,31]. In the same way, there is a variety of research on occupational health in different countries, such as India, southern Iran, southeastern US coastal states, Indonesia, Thailand, and others [32–37]. In general, the analysis of occupational risks for women in agriculture has been addressed. These analyses have been carried out through a literature review and considering statistical relationships with public health data. Important findings have also been generated in terms of describing the current state of occupational health and safety in the agricultural sector worldwide, the barriers to improving occupational health and safety, and the enablers of occupational health and safety. In addition, cross-sectional studies have also been conducted to identify the occupational and non-occupational factors that influence the levels of stress, depression, and anxiety among farmers in the northern part of Thailand, including the possible psychological effects of pesticide use [38]. Agricultural business models have been developed based on the occupational health of their workers. In these models, healthy farmers, healthy products, and a healthy society were the consequences of using appropriate strategies for agricultural occupational health behavior [39]. In the national context, in Mexico, the design and implementation of an industrial process for agricultural companies based on some ergonomic aspects has been reported. The above aimed to increase productivity and the quality indicators of agricultural products [40]. Furthermore, research has also been carried out on work-related Musculoskeletal Disorders (MSDs) in agricultural workers. In general, the conclusions are that ergonomic interventions are needed to eliminate the risk factors for MSDs in the agricultural sector [41,42]. After reviewing the literature and analyzing the investigations that have addressed the problem stated in this article, it was found that no research has directly addressed the occupational health of agricultural workers, taking into account an adequate number of physical ergonomic variables. Although several studies have addressed the issue, they have been limited to surveys with open and closed questions, few variables, and no clear and explicit relation with the ergonomics dimensions. In addition, no studies were found that used an extraction method using Principal Component Analysis that took into account the gender of agricultural workers and nine physical ergonomic risk factors, as this research did, which will be described in the next sections.

3. Methodology

3.1. Sample Determination

For the present study, the development of the research was quantitative, non-experimental, and cross-sectional; therefore, the object of study was focused on workers dedicated to the agricultural crops (mainly potato and pumpkin) located in the Mayo Valley in the state of Sinaloa, Mexico. According to the 2022 Agricultural Census of the State of Sinaloa, the population employed in agricultural activities in the state of Sinaloa is approximately 500,000 people [43]. Considering the aforementioned, given a confidence level of 93% (i.e., the degree of certainty that the data are representative of the whole population) and a margin of error of 7% (i.e., the percentage of error that may be present in the sample), the theoretical sample size should be 168 agricultural workers, using the Simple Random Sample method (SRS) in MatLab© 2023 program. In our case, the sample was 200 people, which means it is representative and adequate for the population.

3.2. Instrument Development and Validation

A closed survey instrument was applied to the sample. In particular, the instrument considered nine variables related to physical ergonomics (see Figure 2), based on its definition mentioned earlier in the Introduction section. In addition, the set of variables shown was based on the analysis of several studies [1,6,8,20,27,29]. The instrument used a Likert-type scale with five levels of responses with a descending–ascending scale: extremely high impact (1), high impact (2), moderate impact (3), low impact (4), and no impact (5), using nominal and ordinal scales. These scales made it possible to measure the agricultural workers' perceptions of the impact of the nine variables on their health and safety at work. The individual questions and statements that made up the instrument are not presented in this article, because they were directly related in quantity to the physical ergonomics variables shown in Figure 2 and Table 3. This means that each physical ergonomics variable represents one question or statement in the instrument. Concerning the validation of the instrument, experts helped to validate the instrument, and a pilot test (45 agricultural workers) was carried out. As a result of the validation process, the instrument was improved in terms of the clarity of the wording according to the comments of the people interviewed in the pilot test (agricultural workers). After validation, the instrument was directly applied in the workplaces of agricultural workers.

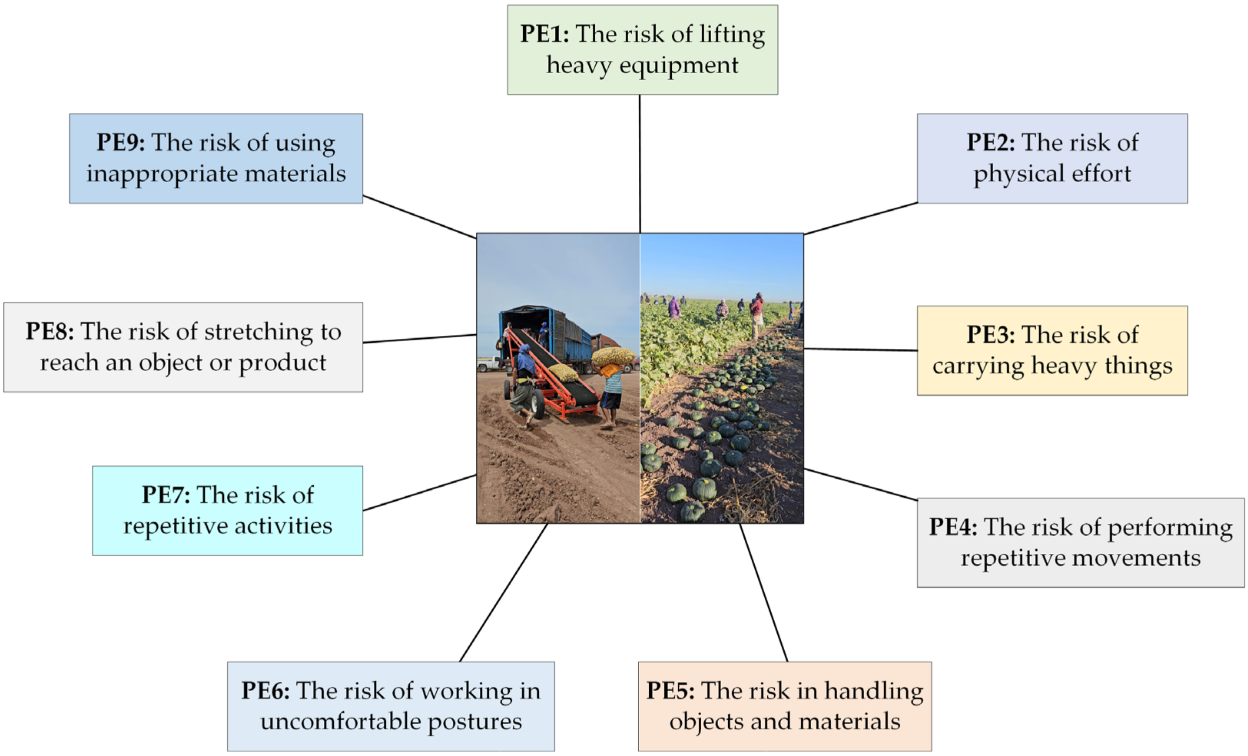

Figure 2. Variables related to physical ergonomics.

3.3. Statistical Method

The Principal Component Analysis (PCA) method is a powerful tool for studying a multivariate data set, used for the extraction of and reduction in variables within a construct, whose purpose is to eliminate the non-significant factors of a given dimension, and which allows for easy visualization of all the information contained in a data set. Although there are other statistical methods (e.g., Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA)), PCA has certain important and relevant attributes for this study. For example, PCA is useful for reducing the number of variables while retaining the maximum amount of information in the data analyzed, whereas EFA is useful for measuring latent variables. Furthermore, when variables have nothing in common, EFA will not find a well-defined underlying factor, whereas PCA will find a well-defined principal component that explains the maximum amount of variance in the data, among other important differences [44]. In addition, this tool helps to find the differences between one sample and another, managing to obtain only the information that is considered to be important [45]. In this way, it is possible to analyze the structure of the observable variables and transform them into a smaller number of underlying uncorrelated and orthogonal variables that are related to each other [46,47]. Consequently, this multivariate analysis helps to strengthen the relationships between different groups or variables related to the object of study [48]. This is because it attempts to discover the true dimensionality of the data without losing the relevant information [49]. Therefore, it is an effective technique to generate reliable information [50].

Figure 3 shows a flowchart of the different steps of the analysis. In general, the flowchart consists of the processes and sub-processes of the whole investigation, linked to sections, subsections, tables, and figures.

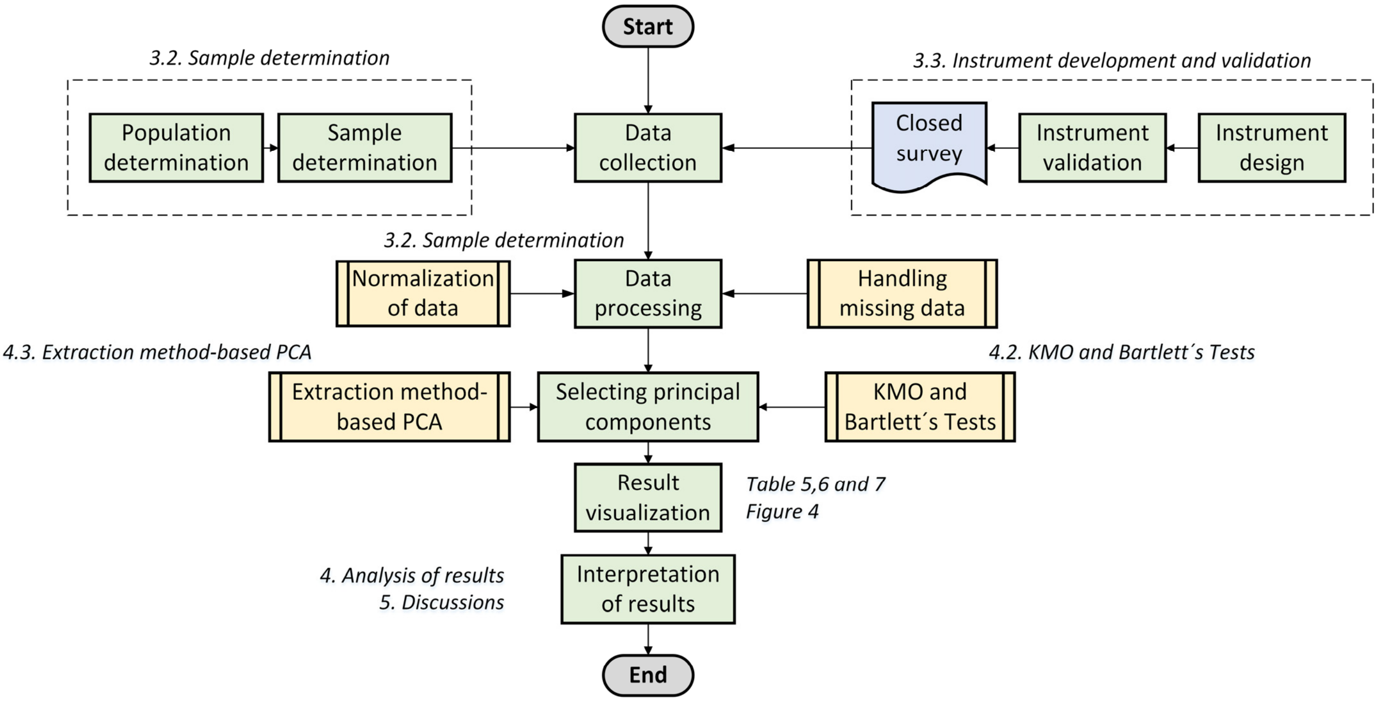

Figure 3. Flowchart of different steps of the analysis.

4. Analysis of Results

4.1. Statistical and Cronbach's Alpha Gender Analysis

In general, the sample was analyzed as a whole. Then, the sample was also analyzed by gender and divided into groups according to age, so that three groups of men and two groups of women were presented. This was conducted to obtain results (also research findings) relating to these groups. Looking at the data provided by the surveys, out of the 200 workers (sample), there were 48 female workers (24%) and 152 male workers (76%) in this research (see Table 1). This is closely related to the result of the 2022 agricultural census of the state of Sinaloa, which states that 75.7% of agricultural workers are men and 24.3% are women. The sample is, therefore, adequately representative in terms of gender.

Table 1. Gender analysis of the sample.

Gender	Frequency	%	Total
Women	48	24	24%
Men	152	76	100%
Total	200	100	

A descriptive statistical analysis was carried out in order to obtain a summary of the information relating to the sample data. It can be seen in Table 2 that the average age at which these people worked was 29.36 years, and the most common age in the sample was 25 years. Complementing the percentiles information, 25% of the sample were under 25 years of age, 50% were under or equal to 28 years of age, and finally, 75% represents those who were under 34 years of age. Considering the above, it is possible to conclude that most of the workers were young people engaged in agricultural activities, and only 25% of these workers were over 35 years old and engaged in this sector.

Table 2. Descriptive statistical analysis based on the age of agricultural workers.

Parameters	Age Data
Mean:	29.36
Median:	28.00
Mode:	25
Standard Deviation:	6.734
Range:	34
Minimum:	18
Maximum:	52
Percentiles:	
25%	25
50%	28
75%	34

Table 3 shows the nine variables that make up the physical ergonomics dimension, whose factors are related to daily activities in the agricultural field and were also considered in the instrument for the development of the survey. As a next step, a Cronbach's Alpha analysis was developed in the study to verify the reliability of the data. Hence, the analysis was categorized according to gender. The results showed that men had a magnitude of 0.850 and women 0.814, so both represented a high reliability in the study and the following analysis was carried out.

Table 3. Physical ergonomics variables and Cronbach's Alpha analysis.

Physical Ergonomics Variables		Cronbach's Alpha by Gender
PE1	The risk of lifting heavy equipment	Men: 0.850 Women: 0.814
PE2	The risk of physical effort	
PE3	The risk of carrying heavy things	
PE4	The risk of performing repetitive movements	
PE5	The risk in handling objects and materials	
PE6	The risk of working in uncomfortable postures	
PE7	The risk of repetitive activities	
PE8	The risk of stretching to reach an object or product	
PE9	The risk of using inappropriate materials	

After developing the Cronbach's analysis, the sample was categorized according to gender and age, with three categories for men and two for women. Table 4 shows that the first category of men was made up considering a range from 18 to 29 years old. This classification represented 54.61% of those who worked in agricultural activities, the second category of the same gender showed 36.18% of workers who were between 30 and 39 years old, and finally, the third category had only 9.21% who were adult workers between 40 and 52 years old.

Similarly, in the same table, there are only two categories of women. In the first category, 58.33% of the women were aged between 18 and 29, while in the second category, 41.67% were aged between 30 and 39.

Table 4. Category by gender: men and women.

Category (Men)	Age Range	Number	%	Total
1	18–29	83	54.61	54.61%
2	30–39	55	36.18	90.79%
3	40–52	14	9.21	100%
Total:		**152**		
Category (Women)	**Age Range**	**Number**	**%**	**Total**
1	18–29	28	58.33	58.33%
2	30–39	20	41.67	100%
Total:		**48**		

4.2. KMO and Bartlett's Tests

After analyzing the results in the descriptive analysis and explaining the nature of the survey, the PCA method was used to reduce the number of observable variables that had no relationship with the physical ergonomics dimension and to obtain only those factors that help to significantly predict the impact on the occupational health of workers in the agricultural sector. To develop this technique, the KMO and Bartlett's tests were applied in all categories. The KMO and Bartlett's tests allow us to compare the magnitudes of the correlation coefficients observed between the variables. It is important to emphasize that these tests are measures of the adequacy of the data in the sample. Therefore, it would help us to know, in detail, what type of variables would be useful for the analysis of this study and which of them would not be feasible. This will allow us to eliminate those factors that do not contribute to the research and make changes in the sample in a positive way. For the KMO test to be accepted, the factor coefficients must be close to 1.0 (on a scale between 0 and 1). Therefore, according to some authors, a KMO coefficient greater than 0.5 should be taken into account appropriately [51]. Otherwise, if the values of these variables are less than 0.5, they are not adequate and, consequently, they should be eliminated in the construct structure. It can be seen in Table 5 that the three categories of the gender of men had factorial coefficients of 0.795, 0.865, and 0.811, indicating that the relationship of the variables was high and the sampling was adequate for the research; therefore, this can act efficiently in the prediction of the data concerning the dimension of physical ergonomics. Regarding Bartlett's test, the p-value (Sig.) was equal to $0.001 < 0.05$, so the test was significant, there were relationships between the observable variables, and it is applicable in the factor analysis.

Table 5. KMO and Bartlett's tests in the age group of males and females.

KMO and Bartlett's Test					
Age Category (Men)		**Kaiser-Meyer-Olkin Measure of Sampling Adequacy**	**Bartlett's Test of Sphericity**		
			Approx. Chi-Square	**gl**	**Sig. (p-Value)**
1	18–29	0.795	144.308	6	0.001
2	30–39	0.865	288.225	21	0.001
3	40–52	0.811	58.643	15	0.001
Age Category (Women)		**Kaiser-Meyer-Olkin Measure of Sampling Adequacy**	**Bartlett's Test of Sphericity**		
			Approx. Chi-Square	**gl**	**Sig. (p-Value)**
1	18–29	0.735	55.133	10	0.001
2	30–39	0.808	43.879	10	0.001

On the other hand, in the same table, the two gender categories of women had factorial coefficients above 0.735 and 0.808, indicating that the relationship between the variables was acceptable and, therefore, the sampling was adequate for the study, since it could act efficiently in predicting the data concerning the physical ergonomics dimension. Regarding the p-value, it was equal to $0.001 < 0.05$, so it was significant, there were relationships between the observable variables, and it is applicable in the factor analysis.

4.3. Extraction Method-Based PCA

In the next step, the communalities were analyzed in three categories concerning the male gender. The communalities measure the part of the variance related to the common components or factors, so the items with a factor loading greater than 0.5 are taken [48]. Thus, the results related to the category of men are presented in Table 6.

Table 6. Extraction method: Principal Component Analysis (Men).

Principal Component Analysis			
Physical Ergonomics Risk Factors (Men)	**(Category) Component**		
	18–29	**30–39**	**40–52**
PE1	0.897	0.952	---
PE2	---	0.718	---
PE3	0.854	0.870	0.832
PE4	0.812	0.827	0.871
PE5	0.762	0.808	0.922
PE6	---	0.831	0.733
PE7	---	0.757	0.878
PE8	---	---	0.877
PE9	---	---	---
Total Variable Explained:	**69.35%**	**68.29%**	**73%**

In the first category, men between 18 and 29 years of age, a final extraction of four variables obtained a factorial loading above 0.762, from which it can be concluded that, for those workers who belonged to this category 1, the factors that significantly affect occupational health are the risks of lifting heavy equipment (PE1), carrying heavy things (PE3), performing repetitive movements (PE4), and handling objects and materials (PE5), with factor loadings of 0.897, 0.854, 0.812, and 0.762, respectively. Thus, this new construct explains most of the variance, with almost 70% concerning category 1.

In the second category, men between 30 and 39 years of age, an extraction of seven variables was obtained which had factor loading greater than 0.718. So, for those who belonged to category two, the factors that have a significant impact on occupational health are the risks of lifting heavy equipment (PE1), physical effort (PE2), carrying heavy things (PE3), performing repetitive movements (PE4), handling objects and materials (PE5), working in uncomfortable positions (PE6), and performing repetitive activities (PE7), with factor loadings of 0.952, 0.718, 0.870, 0.827, 0.808, 0.831, and 0.757, respectively. Thus, 68.29% of the variance is explained in this category.

Finally, among men aged 40–52 years old, six variables are considered to be occupational health risks. These are carrying heavy objects (PE3), performing repetitive movements (PE4), handling objects and materials (PE5), working in uncomfortable positions (PE6), repetitive activities (PE7), and stretching to reach an object or product (PE8), with factor loadings of 0.832, 0.871, 0.922, 0.733, 0.878, and 0.877, respectively. Hence, 73% of the variance is explained in this category.

An analysis with a different approach concerning the male gender is presented. It can be seen that the variables most frequently presented as occupational risks in the three categories are: carrying heavy objects (PE3), performing repetitive movements (PE4), and handling objects and materials (PE5). Therefore, these are factors of concern to workers, since these activities in the field mainly involve the use of the human body and accidents might occur in the future that could cause illness or injury to the musculoskeletal and cardiovascular systems. On the other hand, in the same categories, the variables that had the least impact on workers' occupational health were physical effort (PE2) and stretching to reach an object or product (PE8). Finally, the variable that was not relevant in any of the three categories was the use of inadequate materials (PE9).

On the other hand, Table 7 shows the factor loadings of the two categories of the female gender. In the first category, the variables that represent occupational risks concerning female workers aged between 18 and 29 are the risks of lifting heavy equipment (PE1), performing repetitive movements (PE4), handling objects and materials (PE5), performing repetitive activities (PE7), and stretching to reach an object or product (PE8), all with factor loadings of 0.897, 0.808, 0.711, 0.702, and 0.711, respectively. They explain 59.21% of the variance of this dimension.

Table 7. Extraction method: Principal Component Analysis (Women).

Physical Ergonomics Risk Factors (Women)	**(Category) Component**	
	18–29	**30–39**
PE1	0.897	0.811
PE2	---	---
PE3	---	---
PE4	0.808	---
PE5	0.711	0.828
PE6	---	0.845
PE7	0.702	0.913
PE8	0.711	0.854
PE9	---	---
Total Variable Explained:	**59.21%**	**73%**

Meanwhile, in category two, the factors most related to occupational risks are: lifting heavy equipment (PE1), handling objects and materials (PE5), working in awkward postures (PE6), performing repetitive activities (PE7), and stretching to reach an object or product (PE8) with factor loadings of 0.811, 0.828, 0.845, 0.913, and 0.854, respectively. They explain 73% of the variance of this dimension.

As in the male category, the use of inadequate materials (PE9) is not considered a risk factor in the female category, as it is not considered relevant to the daily tasks in the field. Consequently, the variables that are more frequent in both categories are the risks of lifting heavy equipment (PE1), handling objects and materials (PE5), performing repetitive activities (PE7), and stretching to reach an object or product (PE8).

Figure 4 presents the results of Tables 6 and 7 visually. To clarify the relation level, the physical ergonomics risk factors (PEs) were coded with colors (white, green, orange, and red) representing zero, low, medium, and high relation levels, respectively

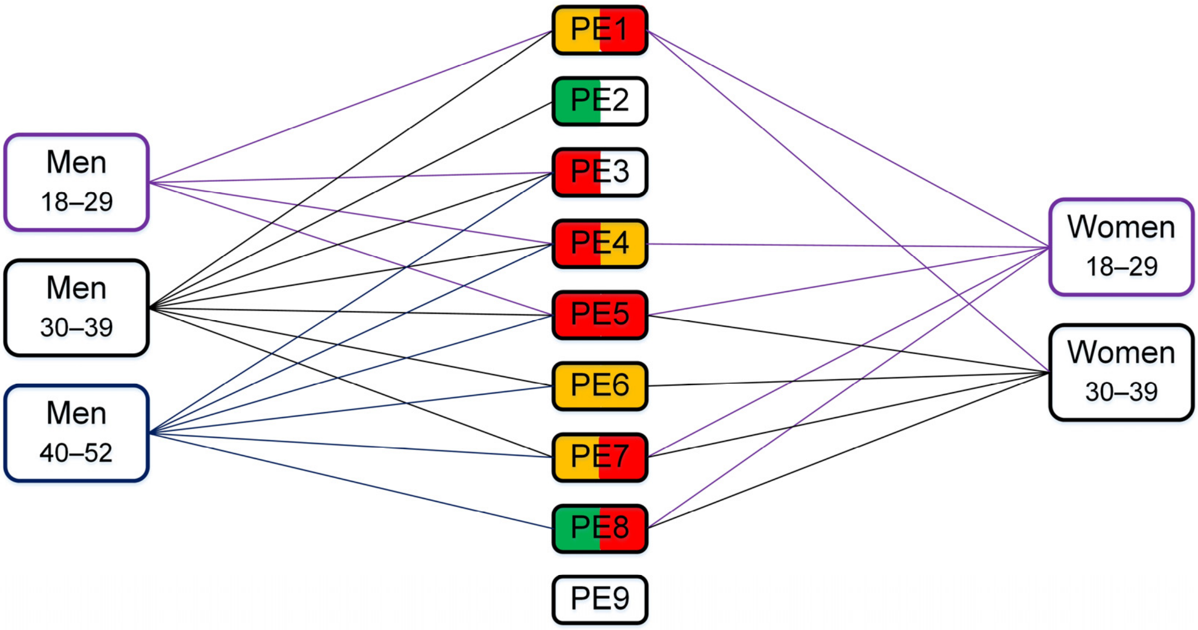

Figure 4. Graphic representation of the results of Tables 6 and 7.

5. Discussions

Looking at the analysis of the results presented in the previous section, it is undoubtedly possible to identify a significant number of findings. However, to clarify the potential contributions of this research to the real world of agricultural work, only the clearest findings are presented. These are presented below. In addition, a discussion of these findings is presented, taking into account the literature review.

Finding 1: The risk of handling objects and materials (PE5) was the only physical ergonomics variable present for agricultural workers of both genders based on the PCA. This finding is strongly related to several studies on musculoskeletal disorders and pain in agricultural male workers and postmenopausal agricultural female workers [52–54]. In addition, this physical ergonomics variable has a more significant impact in low- and middle-income countries [53].

Finding 2: The risk of using inappropriate materials (PE9) was the only physical ergonomics variable that was not present (not as important) for agricultural workers of both genders based on the PCA. This is because the factorial coefficient was less than 0.5. In this case, the results showed that the use of fertilizers, pesticides, herbicides, irrigation systems, seedlings, seeds, and farm machinery did not represent a significant risk to agricultural workers. The above can be related to the care taken by companies concerning the general uses of materials and machinery in the Mayo Valley region [27,55,56].

Finding 3: Concerning the physical ergonomics variable related to the risk of carrying heavy things (PE3), this variable was significant for male agricultural workers, while it was not significant for female agricultural workers. This does not mean that the variable PE3 is not present in the opinion of the agricultural workers, but that there are other more important variables. In fact, there is evidence that a significant percentage of women working in agriculture suffer from back pain, joint pain, and leg pain [32,57]. In this way, this finding must be contextualized to the Mayo Valley and not generalized worldwide. Perhaps the working conditions of agricultural women in this region have certain characteristics that result in a factorial component value of less than 0.5 for the physical ergonomics variable studied.

Finding 4: It should be noted that, in terms of the relationship between the explained variable and the factorial loading, Table 6 shows the variability of the male agricultural workers concerning the factorial loading, with a mean value of μ_M = 70.21% and a standard deviation of σ_M = 2.47%. This implies a coefficient of variation (CV = σ/μ) of 3.51%, whereas, for female agricultural workers (according to Table 7), the mean is μ_F = 66.12% and the standard deviation is σ_F = 9.72%. This gives a coefficient of variation of 14.7%. In this way, it can be seen that the CV of female agricultural workers was significantly higher than that of male workers. The above could be interpreted as a significant difference in the perception of physical ergonomics risk factors by women.

6. Conclusions

Once all the categories were developed and analyzed using Principal Component Analysis, it could be concluded that most of the variables in this dimension (i.e., physical ergonomics) were significantly important for both genders related to the occupational risks that affect the occupational health of workers. Concerning the nine variables presented in this research, the factor that was presented most frequently as an occupational risk was the variable related to the handling of objects and materials (PE5), because the constant handling of a certain object or material during a certain period of medium- or long-term work would lead to increased physical fatigue, with the following consequences: injuries to muscles and limbs, blows, excessive strain on joints, and damage to the spine, among others. On the other hand, the occupational risks with less impact were lifting heavy equipment (PE1), performing repetitive movements (PE4), and repetitive activities (PE7). Similarly, the factor that did not have a relevant impact on occupational risks for workers was physical effort (PE2), which was only considered in the category of men aged between 30 and 39 years. In addition, the variable that was not considered to be a risk in any of the groups was the use of inappropriate materials (PE9).

6.1. Implications and Recommendations

The importance of this study lies in that these people are the main actors in the primary activities of the supply chain concerning the flow of basic food products (e.g., vegetables and fruit), since, without the participation of these people in the field, a good supply would not be achieved in different commercial locations. Considering the above, there is a relevant need to create policies or safety standards that allow for the well-being and potential development of workers, not only to obtain benefits for agricultural workers and the prevention of illnesses and/or occupational accidents, but also for organizations themselves. The aforementioned is related to increased productivity, the elimination of absenteeism, increased net profits, and the application of continuous improvements within the production chains in the agricultural and primary sectors. In particular, related to Finding 1, there are key benefits of material handling equipment in the agro-industry, e.g., an improved efficiency for harvesting and processing and increased productivity contribute to labor savings, highlight employee safety, and spotlight quality assurance.

6.2. Limitations

The agricultural sector has many variables that could affect the results of this research. For example, each type of crop presents different challenges in terms of physical ergonomics, i.e., some crops are lighter than others. In our case, only the occupational risks of agricultural workers, mainly in potato and pumpkin cultivation, were analyzed. This means that the type of crop may have influenced the perception of occupational hazards by the workers. It is also likely that there was some sort of bias in the responses, as the survey was conducted at a particular time of the workers' working day (when workers were traveling in company buses), when many factors could have influenced the responses of the agricultural workers, such as fatigue, lack of sleep, hunger, etc. Accordingly, the results of this research should not be seen as general findings that describe the reality of all agricultural workers, but rather the results presented should be contextualized and seen as a starting point for increasing the regional competitiveness of the Mayo Valley. Another limitation could be the sample size. Although it was mentioned earlier that the sample size is representative with a confidence level of 93% and a margin of error of 7%, it is possible to improve the accuracy of the results by increasing the confidence level and decreasing the margin of error, e.g., with a confidence level of 95% and a margin of error of 5%, the future sample size should be 384 agricultural workers.

6.3. Future Research

Based on these results, it is important to emphasize that there is a great need for new research on the working conditions of workers in the agricultural sector, since there are few studies on the subject of the study and no importance has been given to analyzing, in detail, the working conditions of this type of sector. For this reason, it is recommended to analyze other multivariate statistical methods to know, in detail, which variables can have a significant impact on the occupational health of workers dedicated to the agricultural sector, and it is also relevant to include new ergonomic dimensions in future studies, such as organizational and cognitive, as well as other constructs such as commitment and job satisfaction.

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