Ergonomic evaluations and environmental factors in an agroindustrial company of plant products

Rafael Sobroza Becker*, Airton dos Santos Alonço, Tiago Rodrigo Francetto, Luan Pierre Pott, Juliano Depoi, Tiago Gonçalves Lopes

(Federal University of Santa Maria (UFSM), Post graduation Program in Agricultural Engineering, Laboratory of Research and Development of Agricultural Machinery (LASERG), Av. Roraima, 1000, City of Santa Maria, State of Rio Grande do Sul, Brazil)

Abstract: The search for greater productivity due to the growing demand for food can lead to arduous work, with exhausting and inadequate conditions. Thus, the aim of the study was to carry out a postural evaluation in five different activities in an agroindustrial company, as well as to measure the environmental and organizational conditions of the site. The postural analysis was performed through images of the postures used in the work environment and the required forces, using the RULA method and Ergolandia 6.0 software, associated to a questionnaire evaluating the biomechanical conditions of the work station, applied to the employees. For the environmental factors, the noise analysis (NBR 10152 and NR 17), temperature (NR 17) and illumination (NBR ISSO / CIE 8995-1) were performed. Among the five activities analyzed, two presented a need for immediate postural intervention and modifications in the work environment. Also, when analyzing the biomechanical conditions of the environment, only two workstations presented good condition. Regarding the environmental factors, only one of the workstations was in accordance with the noise standard and all were inadequate for temperature and lightness checks.

Keywords: Ergonomics, postural analysis, RULA.

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1 Introduction

The increasing world population is ever changing their eating habits, searching for a healthier lifestyle. The concern with welfare and quality of life has provided an increase in the consumption of natural foods, boosting the fresh produce sector (SEBRAE, 2019).

Thus, the production and processing of these foods require great attention given the ever more severe demand imposed by the consumer market for product quality. Therefore, according Possebom et al. (2016), the professionals acting in performing these activities must have the necessary conditions for maintaining the yield and quality in the working environment.

Likewise, the search for the increase in work productivity has resulted in the use of technologies in the production mechanisms and adaptation of the workstations to provide safety and welfare to the employees. According to Fiedler et al. (2006), the employees often lift and transport, incorrectly and continuously, loads superior to the tolerable limits, which increases the risk of lesions in the working environment. Thus, we attempt to discuss and analyze

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***Corresponding author: Rafael Sobroza Becker,** Federal University of Santa Maria (UFSM), Post graduation Program in Agricultural Engineering, City of Santa Maria, State of Rio Grande do Sul, Brazil. Email: rafaelsobrozabecker@gmail.com. Tel: (55)999930594.

the factors related to occupational health and safety of the employees.

The science or discipline that guides the studies on work adaptation to men and the human performance in work activities is ergonomics (Guérin et al., 2001). This science aids in the comprehension of health disturbances connected to the performed activities to adopt intervention strategies that prevent the possible occurrence of lesions.

According to Santos and Fialho (1997), the ergonomic analysis at work is divided into three stages: demand analysis, task analysis, and activity analysis. The definition of the problem with the actors in question characterizes the demand analysis. The task analysis considers the technical, environmental, and organizational conditions, and the activity analysis demonstrates and evaluates the work that is effectively executed, as well as the behavior of the employee.

Thus, the aim of the study was to carry out a postural evaluation in five different activities of an agroindustrial company in Santa Maria/RS, as well as to measure the environmental factors of the site.

2 Materials and methods

2.1 Location and characterization of the study

Ergonomic evaluation was carried out in an agroindustrial company of the production and distribution of fruit and vegetable. The company is located in the municipality of Santa Maria, Rio Grande do Sul (RS), Brazil, 294 km from the state capital, Porto Alegre, with a population of 278,445 inhabitants.

The company is specialized in the production of food sprouts of different species, such as flaxseed, clover, bean, radish, lentil, alfalfa, beet, and onion. The company also processes many other products, such as legumes, vegetables, and fruits for subsequent sale and distribution to restaurants and supermarkets of the municipality.

The information was collected during the working day, which includes the morning shift, from 6.5 h to 11.5 h and the afternoon shift from 13.5 h to 16.5h.

2.1.1 Ergonomic work analysis (EWA)

To conduct the ergonomic work analysis (EWA), it was monitored and evaluated the tasks performed by five employees, as described in Table 1.

Table 1 Activity description performed by five employees in the agroindustrial company

Employee	Function performed in the workstation
E1	Packaging and weighting of cherry tomatoes
E2	Washing and preparation of seeds (food sprout production)
E3	Packaging and weighting of alfalfa sprout
E4	Sprout washing
E5	Packaging and weighting of arugula

For the postural evaluation, the execution of the five activities (E1 to E5) during a working day was observed. For analyzes of this magnitude, because they are cyclical activities, a cycle of work must be observed until the final production of the product (Guimarães and Portich, 2002; Striebel, 2003; Silva, 2001). Thus, the observation time was judged representative. The data were composed of photographic and video recordings of the postures used to perform the analyzed activities, for that was used an Apple iPhone, model 5C, with 8-megapixel camera, an image resolution of 3264 × 2448 pixel, and Full HD video recording, with a definition of 30 frames per second.

The postural evaluation was conducted using the RULA method and the Ergolândia software 6.0, 2017. The method employed was proposed by McAtamney and Corlett (1993) with the objective of performing a fast assessment of the potential damage to the superior members in function of the posture adopted. The method allows us to evaluate the posture, dividing the body into two segments: arm, forearm, wrist, and wrist rotation; and neck, trunk, and inferior members relating the segments with the muscle effort and external load to which the body is submitted.

With this method, each factor receives a score according to the posture the employee uses, attributing a final score between 1 and 7 distributed into four levels of action. Results with higher scores present a higher risk level, while those with lower scores present lower risk, as presented in Table 2.

Table 2 Scores and level of intervention presented in RULA method

Level	Score	Level of intervention
1	1 or 2	Acceptable posture provided it not be maintained for long periods
2	3 or 4	Investigate posture; changes might be necessary
3	5 or 6	Investigate posture, induce changes
4	7	Investigate posture, urgently induce changes

Source: McAtmney and Corlett (1993).

2.2 Evaluation of the biomechanical conditions of the workstation

For the simplified evaluation of the biomechanical conditions of the workstation, it was applied to each employee, a questionnaire, second by Couto et al. (2014). According to this author, this evaluation shouldn´t be used to determine if an employee is or isn´t in risk of lesioning the superior members, or to ascertain a relation between a disturbance or lesion and the work performed. This type of conclusion depends on a detailed analysis of occupational exposure.

The method is based on objective questions and answers, using observations whenever necessary, comprised of disqualification items in which, when a positive case is presented, automatically considers the ergonomic condition as bad. Subsequently, was applied a verification checklist attributing the score of zero for the answer ‘no’ and one for the answer ‘yes’. According to the score, was consider an interpretation criterion, as demonstrated in Table 3.

Table 3 Interpretation criterium

Score	Biomechanical condition
11 to 13	Excellent
8 to 10	Good condition
6 to 7	Reasonable
4 to 5	Bad
Less than 4	Very bad

Source: Adapted from Couto (2014).

2.3 Noise level

The measurement of noise level of the workstation, it occurred through the use of a decibel meter (set with the weighting circuit A expressed in dB and slow response (“slow”)) being positioned close to the left and right ear of the employee and second the guidelines recommended by the NBR 10152 (1987). Four repetitions of the measurement were collected, later determined the average among the data and the results compared with NR 17 standart.

2.4 Temperature

The measurement of the temperature was performed using a WIBGET digital thermometer, model RSS-241. The temperature index was measured by placing the thermometer next to the workstation, second second the guidelines recommended by the NR 15 (2011). The result, in degrees Celsius (°C), was obtained from four replications, later determined the average among the data and compared to the values presented by NR 17 stamdart.

2.5 Ilumination

For the measurement of the ilumination conditions, it was used a portable digital lux meter (expressed in lux), by placing the appliance next to the workstation and second the guidelines recommended by the ABNT NBR ISO/CIE 8995-1 norm (2013). Four repetitions of the measurement were collected and later determined the average among the data.

2.6 Strength required

The measurement of the strength required to perform the tasks analyzed was performed using a portable digital dynamometer, with capacity of up to

20 kg (model DD-200). The strength was measured in the exact position where the task is performed, in the required posture and the type of movement to be made, in order to simulate a real situation. Similarly to the other analyzes, four repetitions were obtained and later determined the average among the data. However, theses data was used only as input data in the RULA method to obtain the posture evaluation.Figure 1 shows the equipment used to measure environmental variables.

Figure 1 Equipment for analysis of environmental variables

Note: a – Portable digital dynamometer; b – Digital thermometer; c – Decibel meter; d – Portable digital lux meter.

3 Results

3.1 Postural analysis

Was initially obtained three classification levels that defined the actions to be performed, as demonstrated in Table 4.

The results show the demand on three performance levels among five situations. The less severe, with performance level 2, related to the task of packaging and weighting of cherry tomatoes (E1), implicating a lower need for intervention but requiring investigation and possible changes to the work environment. Despite the lower score of the postural analysis (4), was identified aggravating factors in some of the employees, such as wrist extension and neck flections.

Table 4 Results of the postural analysis (RULA method)

Employee	Function performed at the workstation	Score	Level of performance
E1	Packaging and weighting of cherry tomatoes	4	2
E2	Washing and preparation of seeds (food sprout production)	7	4
E3	Packaging and weighting of alfalfa sprout	7	4
E4	Washing of sprouts	6	3
E5	Packaging and weighting of arugula	6	3

In another two situations analyzed, was demonstrated the performance level of 3, indicating the urgent need for investigating and an effective change in the work environment. Was detected inadequate postures, the occurrence of extensions and deviations of the neutral line of the wrist, neck flection and rotation, and trunk rotations and lateral inclinations for the employees performing washing of sprouts (E4). With an equivalent level of performance, the activity of packaging and weighting arugula (E5) presented greater problems of postural position through flections of the arm, wrist, and neck, as well as the incidence of rotation of the neck.

The higher values for the ergonomic intervention performances were demonstrated by the activities of washing and preparing seeds (E2) and packaging and weighting alfalfa (E3), indicating a performance level of 4, that is, the immediate demand for investigation and changes to the work environment. For E2, we verified relevant wrist, neck, and trunk flections, which also presented lateral inclinations. In E3, the main aggravating postural factors were related to the arm, with the elevation of the shoulders, flection, and deviation of the neutral line of the wrist, flection, and rotation of the neck, and rotation movements of the trunk while performing the tasks.

3.2 Analysis of the environmental variables

3.2.1 Noise

Table 5 shows the situation concerning the level of the employees' exposure to noise when in their workstations when compared to the maximum reference values established by the NR 17.

Table 5 Comparison between the noise collected and the NR 17

Employee	Function performed at the workstation	Noise (dB)		Situation*
		Collected	NR 17	
E1	Packaging and weighting of cherry tomatoes	75.30	65	NA
E2	Washing and preparation of seeds (food sprout production)	72.13	65	NA
E3	Packaging and weighting of alfalfa sprout	65.03	65	NA
E4	Washing of sprouts	71.50	65	NA
E5	Packaging and weighting of arugula	63.63	65	A

Note: *A – Attends; NA – does not attend.

When analyzing the conformity standards of the collected data with the respective norm, was verified that only the workstation related to the packaging and weighting of arugulas (E5) meets the specifications. The workstation for packaging and weighting cherry tomatoes (E1) presented the highest level of sound intensity, given that it was located close to a large horizontal freezer, constantly turned on. The NR 15 (2011) ensures that the performance of activities above the tolerance levels foreseen in the NR 17, but under 85 dB, do not cause disturbances or damage to the health of the employee, also ensuring the perception of an additional incident over the minimum wage of the region, according to the degree of insalubrity (maximum, intermediate or minimum). In this context, the values collected from all the work environments analyzed in this study can be considered acceptable, in conformity with the NR 15 (2011), abiding by the daily exposure to up to 8 hours of continuous work.

3.2.2 Temperature

Table 6 presents the situation of the workstations concerning the effective temperature index recommended to meet the comfort conditions, as stipulated by the NR 17.

Table 6 Comparison between the temperature collected and the NR 17

Employee	Function performed at the workstation	Temperature (ºC)		Situation*
		Collected	NR 17	
E1	Packaging and weighting of cherry tomatoes	12.16	20-23	NA
E2	Washing and preparation of seeds (food sprout production)	12.83	20-23	NA
E3	Packaging and weighting of alfalfa sprout	14.43	20-23	NA
E4	Washing of sprouts	17.03	20-23	NA
E5	Packaging and weighting of arugula	14.66	20-23	NA

Note: *A – Attends; NA – does not attend.

The comparative analysis between the temperature values collected from the work environments and the parameters described by the NR 17, allowed to verify that none of the situations meet the recommendations of the norm. The condition closest to the ideal occurred for the station of washing sprouts (E4), given that it is located between acclimatized environments. According to Possebom et al. (2016), unfavorable temperature conditions, such as extreme heat or cold, can cause tensions and increase the risk for accidentes, and can negatively interfere on the employee performance.

3.2.3 Luminosity

Table 7 shows the relation between the illumination of the work environment and the minimum values established by the ABNT NBR

ISO/CIE 8995-1 (2013) according to the environment, task or activity), for the environments of the food industry.

Table 7 Comparison between the luminosity collected and the ABNT NBR ISO/CIE 8995-1

Employee	Function performed at the workstation	Illumination (lux)		Situation*
		Collected	NBR ISO	
E1	Packaging and weighting of cherry tomatoes	167	300	NA
E2	Washing and preparation of seeds (food sprout production)	122	300	NA
E3	Packaging and weighting of alfalfa sprout	285	300	NA
E4	Washing of sprouts	285	300	NA
E5	Packaging and weighting of arugula	162	300	NA

Note: *A – Attends; NA – does not attend.

According to the NR 17, there must be adequate illumination, natural or artificial, appropriate for the nature of the activity, in all work locations. For the activities performed in food industries, more specifically in triage, packaging, and washing tasks, the minimum illumination requirement cannot be below 300 lux, as demonstrated in Table 7. Therefore, was verified that the values collected in all work environments did not meet the recommendations, even with the presence of translucent windows in some of the rooms. A notable difference between the values of the workstations, such as between E2 (122 lux) and E3 (285 lux), is justified by the differences in the illumination project used in the locations.

3.3 Work conditions analysis

Despite performing distinct functions in each workstation, all employees performed their activities standing. This behavior is characteristic of activities that demand greater reach, application of downward strength (as for packaging), and frequent dislocations from the workstations, as occurs in the activities evidenced in the company studied.

For activities that demand the employee to remain standing, there is a high need for static musculature, causing the position to become highly tiring and subject to any number of health risks. Thus, it is not recommended that the position is maintained for long periods (Iida, 2005). Therefore, we verified the common use of the legs as the main form of body support, considered a fuse to identify the need for changing positions.

It was also verified a unanimity between the employees concerning the incidence of aggravating problems related to the wrist and neck segments. These issues are commonly associated with the demands of the activity, as in the case of precision work, in which there is a need to incline the head forward to obtain a better view.

However, when the workstation does not allow adjustments, incorrect postures are automatically used to perform a specific function. In this sense, when investigating the possible causes for the aggravating factors of the ergonomic analysis of working in the food industry, was identified many negative aspects, susceptible to changes, as described by the RULA method, which can contribute to improving the work conditions.

The main factor to cause neck flections was attributed to the physical arrangement and the layout of the instruments in the workstations, as well as a few characteristics of the furniture present.

In the case of the digital scales used in the workstations destined to food weighing, was verified high proximity to the body of the employees. This occurs due to the display of the scale coupled to the body of the equipment. However, this configuration decreases the effective angle of view reach, leading to the need for flection, inclination or rotation of the neck, or even of the trunk, to visualize the display.

Project aspects of the work tables also potentialize the occurrence of bad posturing, especially regarding the reach of the products to perform specific functions. This difficulty demands to lift the arms and forearms and, consequently, flexing and extending the wrist, such as in movements for laying out products from cargo boxes into lower volume commercial packages.

Unfavorable environmental conditions also cause the environment to become hostile, especially concerning the aspects of insufficient lighting attributed to all workstations evaluated. The incorrect illumination makes hinders the efficient, safe, and comfortable performance of visual tasks, and can result in the adoption of improper postures when seeking better visual conditions to perform the task.

3.4 Complementary analysis

In Table 8, we presented the results of the evaluation, determined by a score based on an interpretation criterion of the biomechanical condition.

Table 8 Biomechanical conditions presented in the workstations

Employee	Score	Biomechanical condition
E1	10	Good condition
E2	-	Bad ergonomic condition
E3	7	Reasonable
E4	6	Reasonable
E5	9	Good condition

According to the evaluation, we observe a good condition for employees E1 and E5, which performed packaging tasks, conditions that required lower effort and movement. For employees E3 and E4, this condition was reasonable, lacking a few of the requisites of the method applied. For employee E2, the ergonomic condition was characterized as bad since the performance of the task presented disqualifying items (weight lifting over 25 kg).

4 Conclusion

Pertinent unconformities concerning the workstation, equipment, and materials present in the internal environment of the agroindustry company through the body posture analysis performed with each employee was identified while performing their duties. The unconformities offer the risk of skeletal muscle disturbances in all activities performed and demanded urgent changes of inappropriate equipment, and adjustments and changes in the furniture layout to allow a configuration compatible with the variations of anthropometric between employees.

The environmental conditions, all workstations were hostile to the occupational health of the employees, demonstrating temperature and illumination that did not attend to the minimum values established in the norms.

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