Ergonomic study of strawberry production in family farming

Ergonomic study in family farming

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Abstract

Agriculture is the main source of food supply in the world and makes up the main axis of the global economy, however due to the lack of mechanization, it poses risks to workers' health. The study of ergonomics in agriculture is still not as widespread, thus, the objective of the study was to evaluate the working conditions of strawberry farmers in family farming, with a focus on strawberry production. This is a series of cases, with a quantitative approach, in which 4 properties distributed in the states of Santa Catarina and Minas Gerais were evaluated. The assessments were performed using the Body Discomfort Scale and the OWAS Method. The main discomforts reported were back pain, followed by pain in the legs and arms/hands. Counselling and ergonomic education is essential for these workers. Labor gymnastics is an intervention that influences the reduction of injuries and bench planting becomes the most appropriate in relation to ergonomics, due to the fact that the worker is in a more upright and correct posture. Finally, the research and their coherence with the sustainable development goals established by the United Nations in the 2030 Agenda were analyzed.

Keywords: Ergonomics, Family farming, Farmer, Strawberry production, Sustainable development goals.

1. Introduction

Ergonomics, according to IEA (2019), seeks to understand the interactions between humans and elements of a system, and the application of theories, principles, data, methods and projects in order to optimize human well-being and global performance of the system (IEA, 2019). It brings together knowledge of subjects such as anatomy and physiology, psychology, engineering and statistics, in order to optimize strengths and minimize the effects of limitations (Capodaglio, 2020; Helali et al., 2008). That is, instead of workers adapting to uncomfortable, stressful or dangerous postures, ergonomics specialists must adapt the work environment to workers (Bligard and Osvalder, 2012; Dzissah et al., 2005; IEA, 2015).

In the world, it is estimated that 1.1 billion people are related to agriculture, which generates about 300 to 500 million salaried workers, where many depend on income from employment in the plantation sector. They often cultivate in the format of family farming, where unpaid family members perform agricultural work to support their families (ILO, 2014).

Agriculture is the main source for global supply and is extremely important for the global economy (Benos et al., 2020). Brazil is one of the largest food producers and most productive agriculture in the world, with more than 5 million farms, with 84.4% of them having family farming, which occupies less than 1/4 of the cultivated area in the country and more than 3/4 of agricultural workers (Abrahão et al., 2015; IBGE, 2012).

Baron and his collaborators, in 2001, already pointed out that the work in agriculture is intense and the workers express that the pain in the back, arms, shoulders and hands are the main discomfort (Baron et al., 2001). A quarter of the injuries that make the workers absent from work are back injuries, which is also one of the most common causes of disability, most often caused by lifting heavy objects. According to Raczkiewicz et al. (2019), Work in agriculture is associated with frequent lifting of heavy objects, exposure to extreme weather conditions (low and high temperature, severe rain and wind) as well as unusual postural positions during work (Raczkiewicz et al., 2019).

However, according to Koehncke (2018), over the years, some types of work in agriculture remained the same (Koehncke, 2018). It is a risky occupation in relation to health and safety, with long hours in postures with inclined trunk, kneeling, carrying weights in difficult positions or with arms above shoulder level with frequent repetitive movements of the hands and wrists. This demonstrates the growing need of more prevention research and strategies to mitigate risks in this area, including ergonomic interventions (Benos et al., 2020).

Abrahão et al. (2015) explain the reasons for the lack of ergonomic studies in agriculture: 1º) the great variability of tasks and jobs; 2º) the product develops itself independently of human work; 3º) the work happens outdoors, with uncontrollable environmental conditions; 4º) the use of various tools, utensils and techniques, making it highly physical, as well as long working hours, excessive commuting, great diversity of activities, lack of training, among others (Abrahão et al., 2015). ILO warns that the inadequacy of personal protective equipment used in agriculture is a relevant factor in precarious working conditions (ILO, 2019).

Barth et al. (2016), in addition to the great physical effort, due to the lack of technology, the small farmer is subjected to several accidents at work, the harmful effects of the sun rays, extreme temperatures and the risk of suffering attacks by venomous animals, ie, have unhealthy and critical ergonomic working conditions. All these conditions still depend on the quantity and type of products that are grown, as the producer needs to dedicate himself fully and, often, even on weekends and hardly take some vacation during the year, causing a physical and psychological overload on the farmer.

Inadequate working conditions in agriculture, where labor is heavily manual, such as horticulture, are well known and documented around the world. Many tasks and tools have been mechanized, improving cultivation methods, but manual work with unwanted postures is still necessary in some cases, which is a risk factor for musculoskeletal disorders, as they cause excessive loads on the back, hips, knees and feet (Pinzke and Lavesson, 2018).

Fethke et al. (2020) reinforce the conclusions of Pinzke and Lavesson when stating that more than half of the agricultural activities, in a sample of farmers, exceeded the mechanical load exposure limits proposed for wrist movements, which suggests excessive risks for musculoskeletal injuries (Fethke et al., 2020).

2. Methods

This study presents a qualitative and descriptive approach and involves 20 workers of four properties with strawberry plantations, linked to family farming, in three cities in Santa Catarina - Brazil, called: Içara, Rancho Queimado and Lages, and one in the state of Minas Gerais - Brazil, in the municipality of Extrema. The localization of the cities can be seen in Figure 1.

Figure 1. *Brazil Map highlighting the states of Minas Gerais and Santa Catarina.*

The methodological framework of the present study is based in the Ergonomic Work Analysis of Guérin et al. (2006) (Figure 2).

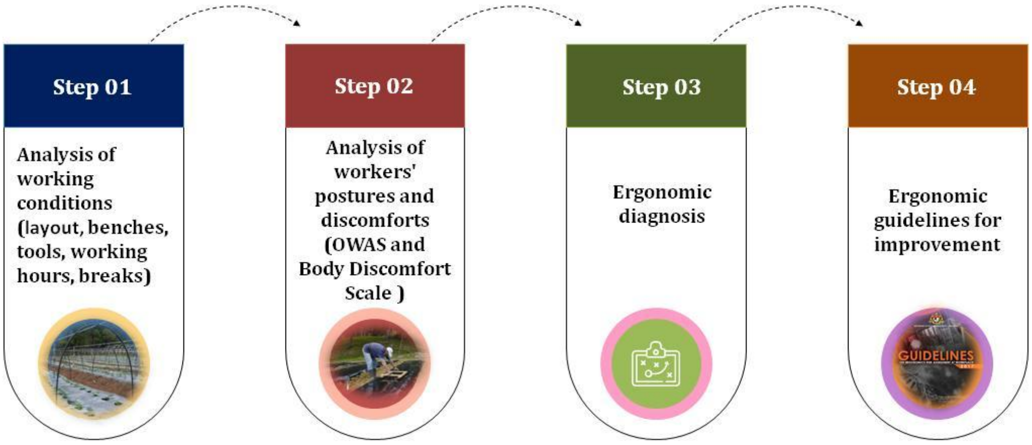

Figure 2*. Methodological framework. Guérin et al. (2006).*

In order to raise the physical requirements of the worker tasks (gestures, postures, displacement and lifting loads), in the strawberries production, two ergonomic methods were used: a) The Body Discomfort Scale, published by Corlett and Bishop (1976); b) The OWAS. The great intention of the two methods is to subsidize the redesign of machines and workstations.

To assess the physical demands (gestures, postures, displacement and lifting loads) of the tasks of the 20 workers in the production of strawberries, two ergonomic methods were used: a) Body Discomfort Scale, published by Corlett and Bishop (1976); and b) The OWAS method.

The Body Discomfort Scale, published by Corlett and Bishop (1976), aims to assess body discomfort and subsidize the redesign of machines and workstations (Corlett and Bishop, 1976). This scale consists of the application of two instruments, one for the general assessment of discomfort and the other for the identification and ordering of discomfort by body region (Corlett and Bishop, 1976). The ordering by body region is classified in 5 levels, “None”, “Some”, “Moderate”, “Enough” or “Extreme” discomfort or pain, numbered from 1 to 5, respectively, for each region of the body described, totaling 29 body segments evaluated.

The Body Discomfort Scale, published by Corlett and Bishop (1976), aims to assess workers' body discomfort, seeking to identify the body segments affected by pain or discomfort, as well as their intensities. The intensities of pain or discomfort are measured using 5 levels - 1 being ‘not uncomfortable’ and 5 ‘extremely uncomfortable’ (Figure 3).

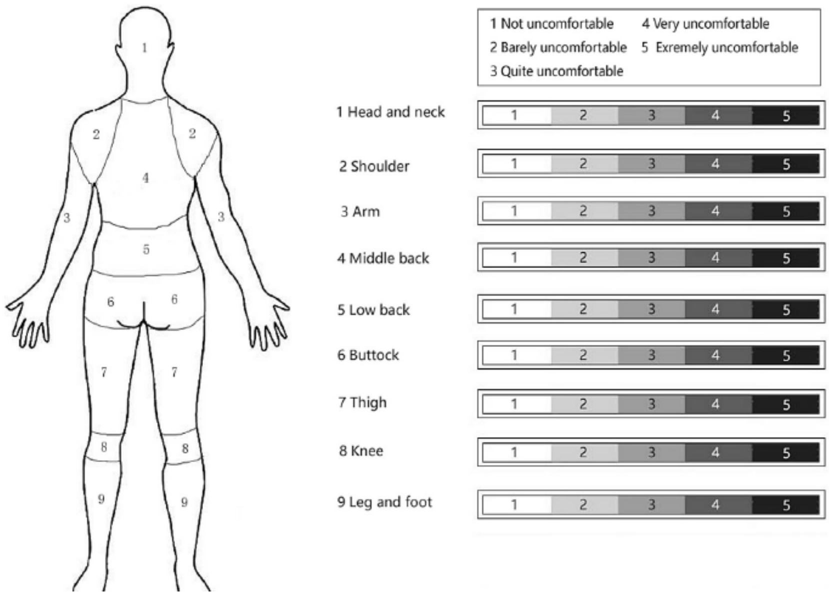

Figure 3*. Body Part Discomfort Scale. Corlett and Bishop (1976); Li et al (2017).*

The OWAS method is an ergonomic tool, which seeks to define the risks of injuries in relation to the postures adopted during work activities, and stipulates ergonomic rules and recommendations that determine the class of correction of postures exercised in activities. Its developers were three Finnish researchers, Karku, Kansi and Kuorinka in 1977. The beginning was through photographic analysis of the main postures, which could be observed in heavy industries, with 72 being found. It results from different combinations of back, arms and legs and also the load that the worker carries during his workday (Cruz et al., 2015). 4 postures were identified for the "back", 3 postures for the "arms", 7 postures for the " legs" and 3 types of load or force exerted. After identifying the postures in each topic, the necessary correction levels are defined, ranging from 1, where corrective measures are not necessary, to 4, where corrective measures are immediately necessary.

To collect information, some visits were made to the properties, aiming at dimensioning the work spaces, benches, tools and equipment and, still, describing the organizational conditions. Document analysis was performed to obtain data such as production volume, number of workers, size of the property. In addition, interviews with producers were used, seeking to analyze and quantify their perception of their working conditions. From the data collected in relation to the working conditions of strawberry production, a diagnosis of the properties studied was made pointing out the deficiencies of the technical, environmental and organizational conditions that could harm health and worker safety. During the visits, the 20 workers were also asked about their discomfort when working on strawberry production, with the support of the Body Discomfort Scale and also their postures were assessed whit OWAS method. Regarding the age of workers, there was a variation between 18 and 65 years, with a greater concentration between 30 and 45 years. There is a turnover of workers in this type of work activity.

3. Results and Discussion

3.1. Results presentation

The Body Discomfort Scale (EDC) was applied, as well as the OWAS method in all properties workers. With EDC it can be seen that in the Rancho Queimado property, which has plantations both on benches (suspended) and on the ground (Figures 4 and 5), 75.9% of the indications are located with “Not” or “Barely" report for pain or discomfort, 17.9% are in "Quite" pain or discomfort and 6.2% indicate pain or discomfort classified as "Very" or " Extreme ", showing the neck and the cervical regions as the main problem of pain or discomfort.

***Figure 4**. Strawberries production on benches (suspended). Source: The authors.*

***Figure 5**. Strawberries production in the soil. Source: The authors.*

At the Içara property, the plantation takes place only on the ground, on the scale it can be seen that 64.1% of the indications are with “Not” or “Barely” report for pain or discomfort, 20% are with pain or "Quite" discomfort. The “Very” or “Extreme” classification presented 15.9% of pain or discomfort. Of these, 87% point to the neck, cervical region and back as the main problem of pain or discomfort.
Based on the scale applied to the Lages property, which has only a plantation in the soil, the results show that 82% of the indications are “Not” or “Barely” reports of pain or discomfort, 7.5% with “Quite” report for pain and discomfort. The classification “Very” or “Extreme” presented 10.5%, with medium and lower related to back and head with pain or discomfort. As for the results of the OWAS method, corrections will be required in all three properties as soon as possible.
At the property in the city of Extremo, in Minas Gerais, producers reported feeling pain in the lower back, however on the body discomfort scale 96.6% reported "Not" discomfort or pain and 3.4% reported "Barely" discomfort or pain. The latter ones, 100% reported the cervical region as the site of "Barely" pain or discomfort. The posture adopted by the workers is straight torso, both arms down, one leg straight and a load above 20 kg, so according to the OWAS method, no corrective measures

are necessary. The results of the Classifications of the Body Discomfort Scale are shown in the Figure 6 below.

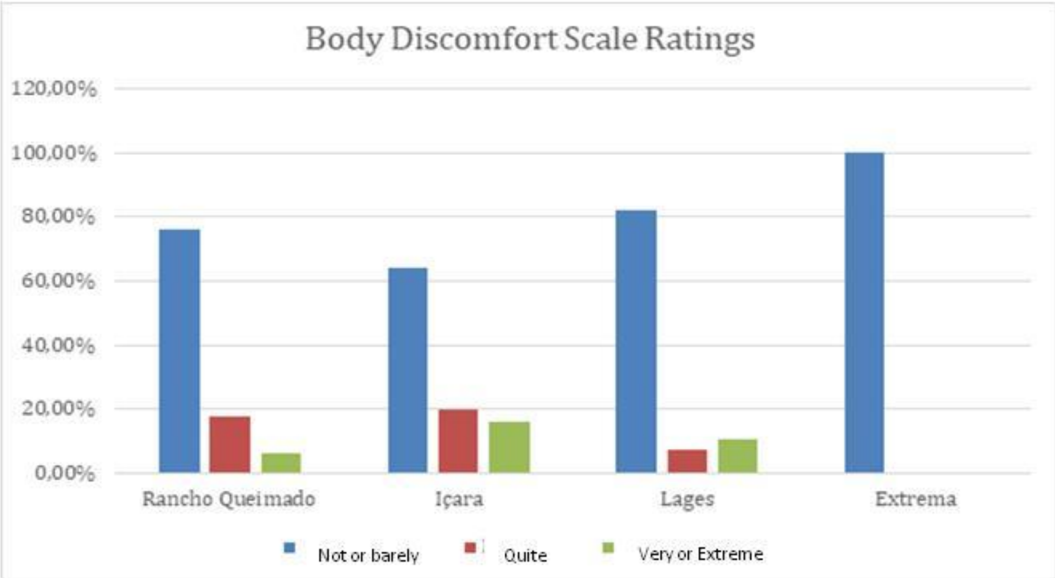

Figure 6. *Classification of discomfort in the four properties. Source: the authors.*

The most physical requirements found with producers, in general, are linked to the following work activities, as shown in Table 1.

Table 1. *The physical requirements found and the work activities.*

Work activities	Physical requirements
Cultivation and harvesting	Predominantly squatting posture, with the trunk facing the soil and the head flexed between 45 ° and 60 ° (production close to the ground). In suspended production, the position is fully upright, requiring the projection of the upper limbs in shoulder flexion between 45 ° and 90 ° and elbow flexion between 60 ° and 100 °. As for the hands, pinching movements are performed between the index fingers and thumbs to select the seedlings and apply pressure from the fingers on the soil to insert the seedlings. For harvesting, pinching movements are performed by the index fingers and thumbs.
Mowing	Predominantly standing posture, with cervical flexion from 45º to 60º. Using hoes, workers perform repetitive movements with their upper limbs to remove weeds from the soil.
Classification	In this stage the worker remains fully in the standing posture, with his head flexed between 45 ° and 60 °. The upper limbs are projected forward, with shoulder flexion between 45 ° and 90 ° and elbow flexion from 60 ° to 100 °. The hands and fingers perform fine handling movements in the selection of strawberries (being pinched by the index fingers and thumbs). Still, movements are often performed with the upper limbs crossing the frontal plane.
Assembly of the packaging	In this stage the worker remains fully in the standing posture, with cervical flexion from 45 ° to 60 °. The

	upper limbs are projected forward, with shoulder flexion from 45 ° to 90 ° and elbow flexion from 60 ° to 100 °. Pinching movements (fine handling) are performed to fold the packaging, as well as applying small pressure so that the cuts in the cardboard fit the templates. In addition, there is a requirement for elevation of the upper limbs from 90º to 120º to accommodate the final packages on the bench.
Labeling	In this stage the worker remains fully in the standing position, with the head flexed between 45 ° and 60 °. The upper limbs are projected forward, with flexion between 45 ° and 90 ° of the shoulders and 60 ° and 100 ° of the elbows. Still in relation to the upper limbs, tweezers are performed (to remove the label from the printed material) and paste it on the plastic packaging.
Regarding the lifting and transportation of loads	There is cargo transportation in some stages of the production process. Preparing the organic compost, it is necessary to handle the bags of fertilizer (40 kg) and transport them to the intended area with the help of a small tractor. During the harvest the strawberries are stored in plastic boxes with a capacity of approximately 40 kg and then transported, with the help of the tractor until the selection area.

Source: the authors.

3.2. Discussion of Results

In properties where there is plantation in the soil, discomfort is more frequent. At the Rancho Queimado property, there is planting on the ground and also on benches, and there is a lower level of discomfort in the items "Very" or "Extreme". In the properties of Içara and Lages, the rates of the items mentioned above are higher, which could be explained by the fact that the producers dedicate themselves entirely to planting in the soil, unlike Rancho Queimado, where workers can alternate the periods between bench and ground.

When planting on the ground, workers are in very inadequate positions, with an inclined trunk, upper limbs down and one or both legs kneeling. Inadequate postures and movements produce mechanical tensions in muscles, ligaments and joints, causing pain in different parts of the musculoskeletal system. Incorrect posture adopted in the long run can cause muscle fatigue and physical constraints such as spinal deformation, tendonitis, among other serious problems (Barth et al., 2016). In the study made by Kahn et al. (2018) it was found that farmers are twice likely to suffer from low back pain if compared to workers in general and they are 8 times more likely to change their work activities due to low back pain (Khan et al., 2019).

At the Extrema property, workers have a low level of discomfort, lower than the other properties, which may be related to planting on benches. Thus, workers remain standing, with the torso erect and with the upper limbs along the body, in less unpleasant positions, which do not cause so much discomfort. Khan et al. (2018), carried out a systematic review about the association between inappropriate postures during work and lumbar dysfunction, where they concluded that there may be an association between these variables, corroborating with the data presented by the property mentioned above (Khan et al., 2019).

Corroborating with the findings in the properties of Rancho Queimado, Içara and Lages, Pinzke and Lavesson (2018), carried out a study, in which one in five strawberry producers (21%) reported physical discomfort due to manual harvesting work among their employees (Pinzke and Lavesson, 2018). Back pain disorders were most frequently reported (85%), followed by lower and upper limb problems and 41% of producers reported having personal experience of physical discomfort with this manual work.

Strawberries planted in benches are preferable from an ergonomic point of view, as excessive bending is eliminated. Today, the cultivation of strawberries in raised beds is more common and individual variations were observed, as well as working positions that influenced physical tension. The most common working posture was kneeling, causing the knees and feet to be flexed in their most extended positions. Kneeling, crouching or leaning on one knee while picking strawberries means a risk of joint discomfort (Pinzke and Lavesson, 2018).

The results of a study that assessed the risk of musculoskeletal disorders in hand-harvested farmers, showed that 77.9% of participants reported pain in at least one part of the body, which proves that musculoskeletal disorders are prevalent among hand-harvested farmers (Jain et al., 2018). Individual factors, including gender (male), age (over 25 years) and education (less than or equal to high school) were noticed in the study by Jain and his collaborators (Jain et al., 2018), in 2018, where it can be concluded that a lower level of education results in a higher prevalence of musculoskeletal disorders, as producers are less aware of appropriate working methods compared to producers with higher education. Factors related to work, such as 5 years of work, are also related to musculoskeletal disorders, emphasizing the need for ergonomic interventions to improve the quality of life and the work environment (Jain et al., 2018).

Pinzke and Lavesson (2018) and Rocha (2014) point out that farmers often come into contact with poisonous animals and plants that can cause allergies, infections, stings, among others (Pinzke et al., 2018; Rocha et al., 2014). They face arduous journeys, with great physical demands, such as muscular strength, permanence in stressful environmental and work conditions, repetitive movements, use of work instruments, with exposure to continuous workloads, which can generate injuries, illnesses and accidents at work. As well as working in cold or hot environments, increasing the risk of accidents and injuries. And when performed, these tasks result in above average pain and injury to the musculoskeletal system.

The stress imposed by long working hours, combined with bad postures and repetitive movements result in occupational diseases. The diagnosis of back pain highlights the concern with the increase in the number of workers that are away from duties due to WMSD (Work-Related Osteomuscular Disorder). To reduce the risk of musculoskeletal injuries, the working hours of employees in these jobs must be reduced. It is up to the farmer to make choices on how to carry out his work and adapt techniques that minimize the workload (Lima and Nogueira, 2018; Pinzke and Lavesson, 2018; Rocha et al., 2014).

The improvement can be done through training and an orientation campaign, so that it is possible to increase productivity, as well as the health and safety of workers (Widyanti, 2018). Occupational gymnastics is seen as a strategy to promote worker health, with the practice of specific physical exercises to compensate the most demanded muscle groups during the workday. In addition, it promotes a healthier work environment, as it encourages the adoption of a more active lifestyle, as well as preventing occupational diseases and reducing stress.

As a result, there is an increase in the company's productivity, which is why organizations invest in quality of life programs, which include actions aimed at physical and mental health, aiming at the well-being of workers (Laux et al., 2016; Lima and Nogueira, 2018). Therefore, we can say that gymnastics at work is effective in preventing RSI/WRMSD, as well as reducing absences, and consequently, increasing productivity. Awareness of the ergonomics approach is essential, as farmers often adopt postures during work, which at the time can be comfortable, but are actually considered risky positions. It is also advisable to work in a specific posture for 20 minutes and walk for 10 minutes to compensate for the unwanted posture (Jain et al., 2018; Pinzke and Lavesson, 2018).

3.3 Ergonomics and Sustainable Development Goals

According to Brunoro et al. (2020) since 1972, the United Nations (UN) documents that it has become the hallmark of corporate action in the sphere of sustainable development and has addressed several direct or indirect issues related to work from different perspectives. Since 2004, federal public health authorities in the United States began developing the evidence base to support comprehensive, integrated models for worksite programs to advance worker health, safety, and well-being (Nobrega et al., 2017).

More recently, the latest United Nations documents proposed the concept of decent work, which involves the Fundamental Principles and Rights at Work. The emergence of this concept resulted, above all, from the need to confront the precarious working conditions, especially in developing countries (Nobrega et al., 2017). The 2030 Agenda, composed of 17 Sustainable Development Goals (SDGs) and established 169 targets to be achieved (Bolis, Morioka, Brunoro, Zambroni-de-Souza, & Sznelwar, 2020). Therefore, understanding the SDGs is essential for estimating improvements in the three pillars of sustainability and directing future developments (Giannetti et al., 2020).

Therefore, it is extremely important to conduct research involving ergonomics and SDGs for the health and quality of workers, both in the city and in agriculture. Among the United Nations' Sustainable Development Goals, number 8 is related to the promotion of inclusive and sustainable economic growth, employment and decent work for all (UNDP, 2015). The consideration of workers' needs is not new and since the middle of the last century, the specific discipline of ergonomics, with the main mission of considering the design and organization of work, has grown (Bolis et al., 2020). According to Bolis et al. (2020), ergonomics and sustainability have different roots but tend to converge in terms of the specific issue of work, as they consider aligned end-goals (in terms of the need for work changes and improvements) and aligned values (in terms of the focus on health and people's well-being) (Bolis et al., 2020). Likewise, considering the ergonomics and health of the worker and their work environment, Figure 7 addresses some of the SDGs, such as 8 and 12.

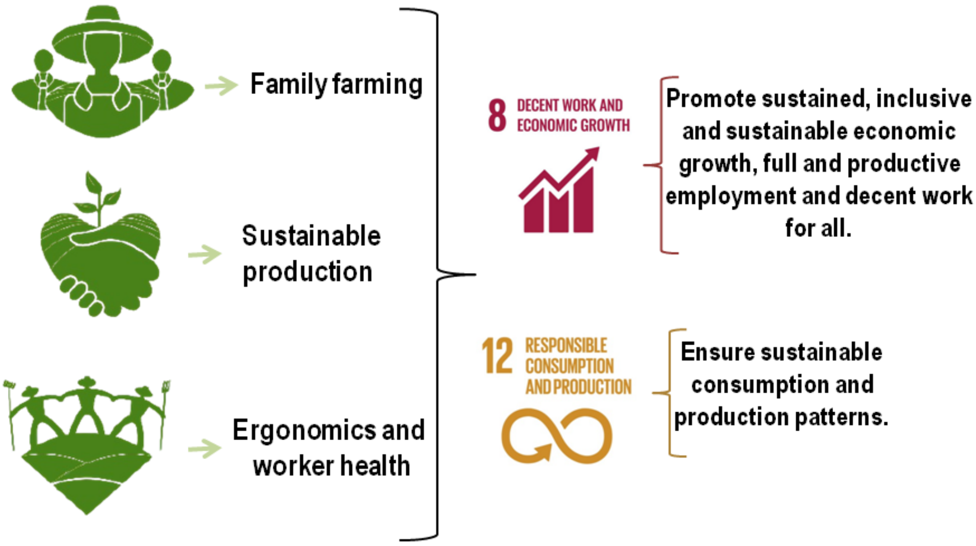

Figure 7. *Ergonomics, family farming and the Sustainable Development Goals. Source: Authors.*

Thus, we highlight goals: a) 8.2 which aims to achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors; b) 8.3 which aims to promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services ; c) 8.4, which aims to improve the efficiency with regard to the consumption and production of global resources and to dissociate economic growth from environmental degradation; and c) 8.8 which aims to protect labor rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment (UNDP, 2015).

SDG 12 (Responsible consumption and production) has several interesting objectives that can be related to family farm workers. Thus, we highlight goals: a) 12.1 which aims to implement the 10 - Year Framework of Programs on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries; b) 12.2 which aims to achieve the sustainable management and efficient use of natural resources; and c) 12.3 which aims to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses (UNDP, 2015).

4. Conclusions

Finally, each ergonomic intervention must be addressed individually, as there may be different anthropometric characteristics in each country, where in one country a given intervention is beneficial, but in another, it is not. In the near future, machines are expected to replace even more manual agricultural operations (Benos et al., 2020). In Brazil, NR 12 already provides guidance on the use of anthropometric and biomechanical data from the Brazilian population for the construction of machinery and equipment, which facilitates the operation by parts of workers, avoiding unnecessary physical efforts.

It is concluded that planting strawberries on benches results in less musculoskeletal disorders, being more recommended from an ergonomic point of view, when compared to planting in soil. However, planting in benches does not have all the substances that the soil itself has, making the strawberry not adapt as well as planted in the soil, perhaps this is a reason why planting in soil is even more common, as it needs a larger investment and an entire adaptation of the plant to move from the soil to the bench.

It was observed that the most frequent complaint of workers was in the cervical region, head and back, which we can associate with the adoption (sustained or repeated) of body posture in cervical and trunk flexion during the harvests, which increases the demand muscle and joint in these body regions. With the research of articles, it was possible to perceive that the gymnastics at work is beneficial and widely used, as well as the education and advice of producers, to make them aware of the correct postures to be adopted during the working day, in order to avoid further complications in the future.

As a limitation we have the subjectivity of the applied scales, and so, it is suggested for future work, to apply the tools presented together with other more specific tools for the assessment of posture, strength performed, in other scenarios within the field of agriculture and in other regions of Brazil, with an interval of years, doing a follow-up with time cut.

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