Design, Development, Prototyping, and Pilot-Testing of An Ergonomic Farmer's Chair

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Abstract

Farmers have a huge role in providing food security for any country. However, in some regions in the Philippines where farming activities are still done manually, farmers experience muscle and bone stress and strain, leading to work-related musculoskeletal disorders. The initial ergonomic assessment for farmers that do manual farming indicated that the farmers have a "high" risk of injury due to long hours of squatting and sitting with a twisted upper body and neck. Hence, this study involved designing and developing an ergonomic chair that would help farmers do their work more efficiently while reducing the risk of musculoskeletal disorders. A prototype of the ergonomic chair was constructed and pilot-tested with some farmers. REBA was used to assess the risk level of farmers before and after using the prototype. Paired t-test was used to determine significant changes in REBA score before and after intervention. Using the prototyped ergonomic farmer's chair, the risk level for musculoskeletal disorders was significantly reduced from "high" to "medium." Aside from this, the farmers observed an improvement in the overall well-being of their bodies.

Keywords
ergonomic chair, farming, musculoskeletal disorders, REBA, postural analysis

1. Introduction
The dilemma between work production requirements and health and safety in different industries are getting more serious day by day. With this, the agriculture sector cannot be ignored because it is a huge part of society and has a big role in the economy. According to Nankongnab et al. (2019), agriculture is often regarded as one of the world's most important industries, not just in terms of food production but also in terms of employment. Agriculture plays a

crucial role in human life because eating is a basic human requirement, necessitating the utilization of crop products. It's also one of the most dangerous jobs on the earth in today's world.

The Philippines is predominantly an agriculture-dependent country, with agricultural lands accounting for around one-third of the country's total land area of 30 million hectares (ha). Furthermore, the country's population is largely rural, accounting for roughly 70% of the total, with two-thirds of the people relying on farming for a living; in fact, 1:2 of the labor force are farmers (AgriFarming.in 2021). The primary crops in the Philippines are rice, corn, coconut, sugarcane, bananas, pineapple, coffee, mangoes, and tobacco, where rice is usually the country's main staple food. Peanuts, cassava, garlic, onion, cabbage, eggplant, rubber, and cotton are the secondary crops in the country (AgriFarming.in 2021).

In both developing and developed countries, ILO regarded agriculture as one of the three most unsafe sectors, along with construction and mining. In the Philippines, there has been a poor adoption rate for mechanical transplanters, four-wheel tractors, and combine harvesters which means that planting and harvesting will continue to be performed manually (Arcalas 2021). Thereby, many of the farming and agricultural activities are done manually. Farming is considered to be a physically hazardous occupation that places farm workers at potential risk of musculoskeletal disorders and imposes a greater impact on their health. Each activity in agriculture brings about certain stress and strain on bones and muscles leading to work-related musculoskeletal disorders which can lead to several permanent diseases and disabilities (Vyas 2012).

A study by Chandra et al. (2016) showed that the prevalence of MSDs was very high among vegetable cultivators and the most affected area were the back, knees, shoulder, neck, hand, wrist, thighs, legs, and foot. Low back pain was more frequent in those with over 30 years of farming experience. The musculoskeletal disorder has a significant association with pain, history of a prior injury, and workload. The frequency of farmer MSDs are in the lower back (63.8%), leg/foot (43.3%), shoulder (42.9%), wrist/hand/finger (26.6%), arm/elbow (25.3%), and neck (21.8%). Likewise, Manothum (2018) also reported that maize farmers experience pain in the lower back (44.1%) and their hands (39.1%).

According to the latest available data from the Philippines Statistics Authority, the total population of farmers in the Philippines was 9,998,000 in 2018. Statistics show that women seem to be the minority in agriculture-24.9 percent of the workforce, compared to men comprising 75.08 percent (Bueno 2018). Furthermore, in a 2020 study by the University of the Philippines (UP) Los Baños, as cited by Angara (2022), it was revealed that the average age of a farmer has jumped to 53 years old in 2020, from 46 years old in 1966. This means that farmers in the Philippines are an aging population. A factor that may contribute to this is that farming is not an attractive source of livelihood to the young generations anymore, because of the low income and poor working conditions (Ordinario 2017). Hence there is an even more urgent need to address MSD risk among our farmers because health deteriorates with age faster in manual occupations than in non-manual occupations (Gorman, 2003). It is essential to provide farmers with effective work accommodations and interventions that may not only improve their vitality and working life but also extend their participation in the labor market (Vanajan et al. 2020).

The majority of the farmers in the provinces of Ilocos Sur, La Union, Pangasinan, and Tarlac commonly work 5 hours or more daily on the farm. They manually plant and harvest their crops at least once a year. A few of them do not even use a small chair (bangkito) or any other seating aids to support their posture while working. As a result, farmers frequently suffer from back, hip, hand, and leg discomfort, among other ailments. Based on observation and interviews, traditional farming techniques do not promote safe farming strategies a hundred percent. There is a lack of awareness in terms of ergonomic interventions in farming, thus farmers perceive that body pain and related risks in farming activities are normal. Therefore, in this study, the research team aimed to promote improved working conditions in manual farming through the use of ergonomic principles. Specifically, by designing an ergonomic farming chair that will allow farmers to work comfortably, reducing the chances of suffering body pain and other types of ailments. An ergonomically designed farmer's chair was recommended because of the long hours spent by farmers in sitting positions while doing their planting and harvesting activities. Moreover, the design will ensure a correct sitting posture that is ergonomically fit for an average Filipino farmer, considering safety and well-being.

Posture is simply the position of the body during an activity including resting, and an awkward posture is associated with an increased risk of injury (Brintrup et al. 2008). The more a joint deviates from the neutral position, the greater the risk of having an injury (Grandjean et al. 1983). Therefore, to improve the situation experienced by the farmers, it is supposed that the designed ergonomic farming chair could reduce the probability of Work-related Musculoskeletal Disorders. The crops chosen as a work sample in this study to analyze farmer posture are onion, corn, peanut, and sweet potato, since the method of planting or harvesting these crops involves sitting posture, as per our survey.

Traditional farming is still prevalent in developing countries. It cannot be easily transformed into full automation, especially when factors like finance, culture, and beliefs are put into consideration. Therefore, the risk of having musculoskeletal disorders is indeed a threat to farmers' health and safety. WRMSDs develop over time, to the point where the injured or damaged structures lose their ability to adapt and repair, resulting in continuous pain and further limiting the affected individual's everyday activities or work responsibilities. (Lim et al. 2021). This study aimed to design, develop, build a prototype, and test the proposed ergonomic farmer's chair while analyzing the farmer's condition in planting and harvesting crops on the farm.

1.1 Objectives

It is the objective of this study to help the farmers carry out their job with ease by designing a farming implement that would increase their efficiency and minimize the risk of musculoskeletal disorders. The following statements summarize the objectives of the study:

1. To identify problems or issues in terms of awkward body postures when planting and harvesting manually, through REBA pre-analysis,
2. To design, develop, and build a prototype for the proposed ergonomic farming chair,
3. To test the effectiveness of the prototyped ergonomic chair in reducing the risk of WRMSDs, through REBA post-analysis.

2. Literature Review

2.1 Scope of Musculoskeletal Disorders in Farmers

Farmers, according to studies, are significantly more prone than the average worker to suffer from musculoskeletal diseases (Prairie 2018). Farm work is difficult, and farm laborers suffer as a result. Backaches and pains in the shoulders, arms, and hands affect farm laborers more than any other health concern. Sprains and strains account for a third of the injuries that keep them from working, while back injuries account for a quarter. (Barron et al., 2001). They experience these problems due to repetitive tasks, frequently working with a flexed back area, prolonged stooping/sitting, and lifting and carrying heavy loads. Pain in the upper extremity, in particular, is becoming increasingly common among Asian agricultural workers (Sombatsawat et al. 2019).

According to the study conducted by Basher et al. (2015), a large number of people in Bangladesh are directly involved in farming and have a distinct exposure, unlike other industries. The study involved 200 farmers in one location, and it was determined that musculoskeletal disorders were prevalent among the farmers, particularly those aged 41 to 60 who worked more than 20 years (82.6%) and an average of 6 hours per day in a traditional way. Musculoskeletal pain was shown to be more common among farmers when they worked in a crouching position (52%), especially when weeding plants (31 %). Gadhavi and Shukla (2019) also stated in their study that agriculture is a physically demanding profession. This puts farmworkers in jeopardy. Osteoarthritis (OA) of the hips and knees, low back pain (LBP), neck and upper limb symptoms, and hand-arm vibration syndrome are all at risk (HAVS). Pain, musculoskeletal damage, poor health, bad quality of life, and decreased productivity are all possible consequences. They are the leading cause of severe chronic pain and disability in the world, affecting hundreds of millions of people. It frequently occurs when a person's labor load exceeds the locomotor apparatus' capacity.

2.2 Postural Risk Associated with Harvesting and Planting

Harvesting is the act of gathering crops from the fields and transferring them to designated storage, processing, and consumption areas. Minimal mechanization occurs in small farms (particularly in poor countries), greenhouses, and numerous horticultural crops, such as vegetables. Workers had shown a troubling risk of being exposed due to repetitive upper-limb activities, according to Cecchini et al. (2010) and Merino et al. (2019) Risk factors related to lateral and forward trunk flexion, flexion and abduction of the shoulders, cervical protrusion, awkward wrist postures, and repetitive movements were reported, as well as pains in the spine and hips.

Furthermore, Meucci et al. (2015) and Udom et al. (2016) investigated low back pain among Brazilian tobacco farmers and Thai rubber farmers, respectively. The findings of the study showed that as people get older, they are exposed to more labor-intensive occupations, adopt uncomfortable postures, and develop green tobacco disease. Houshyar and Kim (2018) attempted to find remedies for musculoskeletal diseases among apple harvesters by using break times and ergonomic approaches. Inattentive workers may exceed appropriate pressure limits, according to the study, although rest periods combined with ergonomic settings can help workers. More ergonomic tools and rest periods were recommended in the poll. Pain in the low back, shoulders, neck, hands, wrists, and fingers were the top risk factors for MSDs during manual harvesting in an Indian area, as per Jain et al. (2018), with aging being the primary source of all body pains except neck and shoulders. Gender also had a role, with male employees displaying more uneasiness than female employees.

Ergonomic strategies for reducing physical burden during harvesting were also investigated. Silverstein et al. (2012) used an ergonomically designed bag instead of a tethered basket around the waist during coffee harvesting in a research study. The pain was reported by a somewhat higher percentage of basket users than bag users. Pranav and Patel (2016) created an ergonomic gadget for manual orange harvesting in mountainous areas and compared its performance to two other devices. The findings revealed a significant reduction in damage quantity and physical discomfort, as well as increased work output. Furthermore, Pinzke & Lavesson (2018) investigated whether transporting a box with a conveyor belt reduced hazardous stooping. Surprisingly, strawberries grown in pots were observed with a straight neck and back and lowered arms, whereas strawberries grown on raised beds were observed kneeling or leaning forward with straight legs, which can cause detrimental lumbar compression.

Planting necessitates constant and repetitive bending and strong bodily movements, resulting in a high prevalence of Musculoskeletal Disorders (MSDs), particularly in the lower limbs and trunks of farmers in Southeast Asian countries. The muddy terrain, according to Juntaracena et al. (2018), has a significant impact on lower extremity pain and muscular activation. The data revealed that on this type of surface, there is a significant amount of muscle activation and pain in the ankle and knee. As a result, ergonomic protection equipment should reduce the musculoskeletal dangers that farmers are said to face.

2.3 Ergonomics for Farmers

Ergonomics can be defined in a single line: It is the science of matching workers to their jobs as precisely as possible. In a nutshell, ergonomics is the science of matching workers as closely as possible to their occupations. This entails evaluating workplace biomechanics and redesigning it to fit within the body's natural limitations (BHS 2017).

NIOSH believes that farm work sprains and strains can be reduced with better work practices and tools. Since the chair has a direct impact on body alignment (posture), farmers who experience musculoskeletal injuries as a result of long periods of sitting should use an ergonomically designed chair. The goal is to keep the farmers safe, uninjured, comfortable, as well as productive (Barron et al. 2001). When selecting a chair, consider the adjustability of the seat height and seat pan depth in proportion to the user's anthropometrics. A mismatch in chair dimensions hinders the postural muscles' capacity to support the body, as well as causes abnormal neuromuscular system stress and pain. As a result, seats that can reduce these effects can be beneficial in preventing back pain. Thus, it is predicted that a chair that fulfills ergonomic standards will reduce the prevalence of musculoskeletal issues (Niekerk, et al. 2012).

3. Methods

The one-group-pretest-posttest experimental research method was used to test the study's fundamental objective: to develop an ergonomic chair that may help alleviate musculoskeletal disorders among farmers. There were two levels of treatments- first is the traditional method of planting or harvesting without the use of any chair, and second is with the use of the ergonomic farmer's chair when planting or harvesting. The REBA score was used as the dependent variable. The same farmers were involved in the pretest and posttest activities, to control the variable of individual differences in the study. Twelve farmers from Ilocos Sur, La Union, Pangasinan, and Tarlac were asked to participate as test subjects to determine the effectiveness of the ergonomic chair. Quantitative analysis was used to analyze and interpret the data obtained from the tests. The following steps were used as a guide in answering the research objectives:

An initial questionnaire was administered to 258 farmer respondents from Tagudin, Ilocos Sur; Aringay, La Union; Manaoag, Pangasinan, and Moncada, Tarlac to determine if they experience body pains as a result of their manual farming activities. The respondents were selected randomly during the first two weeks of data gathering.

A total of 12 farmers (3 per area) were observed during their manual planting and harvesting activities. These farmer respondents were asked to sign a letter of informed consent to participate in the study. REBA analysis was used for their 2 common postures to determine the level of risk associated with WRMSDs. Photos were taken for each posture to determine the angles and relative postures needed in the REBA worksheet. REBA worksheet analysis was done per farmer, and their overall REBA scores were averaged to get the mean REBA score of the sample under study. This served as the pretest or baseline information for the sample.

Using the results of the pretest, coupled with the results of the initial questionnaire, an ergonomic farming chair was designed and developed to address the awkward postures of the farmers, and eventually, reduce their postural risk. Ergonomic principles were applied in the design of the chair, as well as recommended measurements were tested to ensure that the chair and its parts fit the farmers with their height and body build. After several revisions in the design, a prototype was constructed through a local fabrication shop.

To determine the effectiveness of the prototyped ergonomic farmer's chair, the same farmers who were measured in the pretest were asked to use the chair in their planting or harvesting activities for one hour. The farmers were also trained by the research team on the proper use of the chair. After the first hour, a REBA analysis was again conducted to determine the level of risk associated with WRMSDs. Again, photos were taken for each posture to determine the angles and relative postures needed in the REBA worksheet.

To determine the statistical significance of the difference in the pre-and post-REBA scores, a paired t-test was computed. Informal interviews were also done with the farmer participants to solicit their opinion on the design of the chair, its usability, and its effectiveness in reducing awkward postures.

3.1 Sampling Method

The research team conducted the study in four provinces, specifically Ilocos Sur, La Union, Pangasinan, and Tarlac. These provinces were chosen because of the availability and proximity of the research team when conducting the study, and these provinces are well-known producers of the study's crop targets (onion, rice, corn, peanut, sweet potato, and vegetables). Moreover, in these provinces, many farmers still plant, cultivate and harvest manually, especially those engaged in small to medium-scale farming. Before the REBA pretest, an initial survey was conducted of 258 farmers in the form of a questionnaire. The research team used this formula for computing the sample size for the farmers' initial survey (Calmorin 2016), with a 0.99 reliability level, and 0.01 Se:

Formula:

$$S_s = \frac{NV + [Se^2(1-p)]}{NSe + [V^2p(1-p)]} = \frac{1{,}123{,}000(2.58) + [0.01^2(1-0.5)]}{1{,}123{,}000(0.01) + [2.58^2(0.5)(1-0.5)]} = 258$$

Where:
Ss = Sample Size
N = population, number of farmers in Region 1 and Region 3, Philippines
V = standard value of 1 % level of probability with 99 percent reliability (2.58)
Se = Sampling error (1% or 0.01)
p = the largest possible proportion (0.50)

After analysis of the initial survey, twelve (12) farmers were chosen for the REBA postural analysis (pretest and posttest) and participated in the performance and practical tests. Area sampling was conducted, and three subjects for each of the four selected provinces were selected through purposive sampling. These tests helped determine the prototype's usability and ergonomic features if it helps in fixing and easing the postural problems experienced by farmers when planting and harvesting crops.

4. Data Collection

4.1 Instruments

To determine the problems and issues experienced by the farmers concerning posture while doing their activities, an initial survey was conducted of 258 farmers through a questionnaire. The survey helped the research team identify areas in need of additional research and relationships between variables that require future study.

Rapid Entire Body Assessment (REBA) Worksheet (Pre-test and Post-test) was used to evaluate the Musculoskeletal Disorders (MSDs) risk of the 12 selected farmers' working postures in planting and harvesting of target crops (onion, rice, corn, peanuts & camote). REBA worksheet analysis was used to identify postural disorders of the whole body concerning the muscular action and the external loads applied to the body before and after the ergonomic intervention. This tool contains a numerical table that obtains body measurements to analyze the respondent's body part(s). Table 1 shows the scale of interpretation used for the REBA scores computed before and after the intervention.

Table 1. Score, actions and risk levels for REBA:

REBA Score	Action Level	Risk Level	Action
1	0	Negligible	No action required
2-3	1	Low	Change may be needed
4-7	2	Medium	Further investigation, change soon
8-10	3	High	Investigate and implement change
11-15	4	Very High	Implement change

Note: From "REBA Employee Assessment Worksheet" by Hignett, McAtamney, 2000, *Applied Ergonomics, 201-205* (https://dllhclcl9i8fl.cloudfront.net/resources-materials/REBA.pdf). Neese Consulting, Inc.

4.2 Treatment of Data

The posture of farmers before using the ergonomic chair (pretest) and while using the ergonomic chair in planting or harvesting (posttest) was captured through photos. After this, markings were done on the images to accurately measure the angles needed for the REBA worksheet. The procedure for calculating the REBA score was followed, as indicated in the worksheet. The interpretation was also done through the guide given in the REBA worksheet. To determine the effectiveness of the designed and prototyped ergonomic chair in reducing postural risk levels, REBA scores before and after using the ergonomic farmer's chair were tabulated and compared using the paired t-test. Excel Analysis Tool Pack was used for this purpose.

5. Results and Discussion

5.1 Problems and Issues Encountered by Farmers When Planting and Harvesting Crops

Based on the results of the survey of 258 respondents, 256 or 99.2% experience body pain from farming, while 2 or 0.8% of them do not. Table 2 presents the specific parts where farmers feel pain when planting and harvesting crops.

Table 2. Farmers' pain points when planting and harvesting crops

Body Part	The number who feel pain/discomfort	Percent of those who feel pain/discomfort	Remarks
Back	211	81.8	The back is bent and/or twisted for 5 hours or more.
Hip	141	54.7	
Shoulder	94	36.4	
Hand/Wrist	87	33.7	
Legs	82	31.8	Legs are bent for 5 hours or more.
Knees	80	31	Knees are bent for 5 hours or more.
Thighs	70	27.1	
Neck	41	15.9	The neck is bent and/or twisted for 5 hours or more.

Elbow	20	7.8	
Arm, waist, feet, head	4	1.6	An arm is bent for 5 hours or more.

As seen in Table 2, back pain was the most common source of pain for farmers during planting and harvesting crops followed by hip pain due to long working hours in awkward positions. These findings are parallel to the study of Rosecrance et al. (2006), where Kansas Farmers reported the most-related pain in their lower back. To further discuss, based on actual observation, planting and harvesting crops involves awkward postures that cause discomfort. Some of the participants in this study can be seen in Table 3 with the following body postures.

Table 3. Summary of REBA Analysis Before Intervention

Subject no.	Location/ Area	Name of Task	Short description of posture	REBA Score		Interpretation
2	La Union	Harvesting Onions 	The back and legs are bent, and the upper body is twisted.	10		*High-risk level.* The final score indicates the need for an intervention and a change in a short period.
7	Pangasinan	Harvesting Chili 	The back and legs are bent, and the neck is twisted.	9		*High-risk level.* The final score indicates the need for an intervention and a change in a short period.
MEAN SCORE of 12 subjects				9.7		*High-risk level.* Need for intervention and change in a short period.

The mean score for both the first posture and second posture were computed to determine the general effectivity of the ergonomic chair. It is evident from Table 3 that the participants have a high-risk level of body posture, with a mean REBA score of 9.7, indicating the need for an intervention and a change in a short period to minimize the risk of injury. In a brief interview with Mr. Pedro Lacuata (Test Subject 2) who is harvesting onions in the field confirmed that he frequently suffers from back and hip pain, which he manages by getting massages or resting. Likewise, Mr. Romeo Sarabia (Test Subject 7) said he experiences discomfort in his hand/finger/wrist, back, hip, legs, knees, neck, shoulder, elbow, and thighs, which he only tolerates till the pain is gone. They may experience more severe musculoskeletal injuries from their current posture if ignored, especially since most of them claimed to stay for 5 hours or more in a sitting position when doing farm work.

5.2 Proposed Improvements

Ergonomic Chair Design That Could Help the Farmers Improve Their Awkward Posture

The target users of the designed ergonomic farmers' chair are farmers who do manual planting and harvesting of vegetable crops. Farmers who do small to medium-scale farming cannot afford modern farming technologies such as planting and harvesting machines, elevated farming beds, greenhouses, and the like due to the high cost. Hence the farmers' chair is a welcome idea to these farmers because they see it as a helpful implement that they could at least afford. With the results of the initial survey coupled with the pretest REBA analysis, the research team specifically designed a farming chair that will address the farmers' pain points and improve their awkward posture. For this purpose, the design and development of the product were based on the following parameters:

General design. The design of the farmers' chair was based on a couple of gardening stool products from Korea which is easy to wear using a waist buckle attached to the hip, making it easier to move around while wearing the stool. The goal of the design is to prevent the farmer or user from squatting when planting or harvesting crops and avoid body pain and risks of injury.

Back Seat Angle. From a study involving college students, the preferred seat back angle for comfort is 15 degrees. This is in keeping with other studies by Grandjean, et.al. (1983) where VDT operators have preferred a 13-15-degree backward incline. At this angle the pressure on the intervertebral discs is minimal (Cornell University Ergonomics Web, n.d.).

Seat Height. Optimum seat height is controversial and should be adjusted to support a knee angle of 90 degrees to prevent leg swelling. However, 75% of leg swelling may be due to low leg muscle activity rather than a chair (Cornell University Ergonomics Web, n.d.). For this prototype, the seat height was lowered since the crops being planted and harvested are close to the ground.

Materials. The anticipated materials for the product's development are limited in the local market, and finding manufacturers for the model is challenging. In addition, the idea of using aluminum alloy for the chair's frame was modified into stainless steel instead due to the unavailability of manufacturers in Baguio City who could fabricate the model using aluminum alloy. Table 4 summarizes the improvements made in the chair for each design phase.

Table 4. Prototyping stages and design features

Prototype	Key Materials	Key Features
1	Frame: S4S Wood Belt- nylon webbing, seat-foam	-Foldable backrest -Adjustable seat height -Swivel Wheels -Seatbelt for mobility
2	Frame: stainless steel tube Belt- nylon webbing, seat-foam	-Foldable backrest -Adjustable Backrest height (3 levels) -Seatbelt for mobility
3	Frame: stainless steel tube Belt- nylon webbing, seat-foam	-Foldable backrest -Adjustable Backrest height (3 levels) -Seatbelt for mobility -Improved structural integrity -More comfortable backrest and seat.

Furthermore, considering the target users of the ergonomic farmers' chair, the materials used to construct the product are cheaper while ensuring that the product will still deliver its intended usability and performance. This constraint was used to make production feasible and easier while minimizing the production cost. The prototyping stage underwent three versions, and the product design was also modified following the prototype revisions. The prototypes were tested by the research team before each revision was done. Revisions in the prototype and design were done to improve the materials, measurements, usability, comfort, and stability.

The third revision was considered as the final prototype, and the final design is presented in Figure 1. The final prototype with specifications presented in Figure 1, was used in the post-test REBA analysis. The swivel wheels were removed in the final prototype because it is not useful in the rough terrain of the soil. The farmers' feedback on the chair was taken through informal interviews to serve as a basis for future improvements. Figure 1 shows the orthographic projections and dimensions of final prototype.

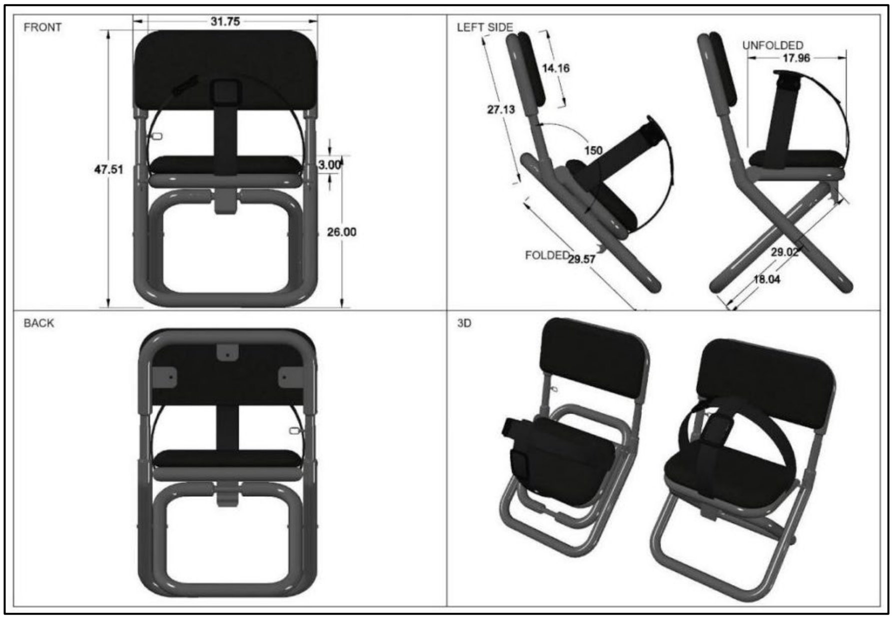

Figure 1. Orthographic projections and dimensions of final prototype (in centimeters)

5.3 Validation

In this study, a post-test was conducted to determine the effectiveness of the ergonomic farming chair. A REBA ergonomic posture analysis was used to compute the REBA score and determine the risk level associated with the observed postures. The mean score for both the first posture and second posture were computed to determine the generalized effectivity of the ergonomic chair. Some photos during the post-test are shown in Table 5.

Table 5**.** Summary of REBA analysis after intervention

Subject no.	Location/ Area	Name of Task	REBA Score	Interpretation
2	La Union	Harvesting Onions 	6	*Medium risk level.* Need for further measures and analysis.
7	Pangasinan	Harvesting Chili 	6	*Medium risk level.* Need for further measures and analysis.
MEAN SCORE of 12 farmers			6.4	*Medium risk level.* Need for further measures and analysis.

In the post-test analysis of the first and second postures from all twelve (12) participants, a mean score of 6.4 was computed, which indicates a medium risk level posture. This means that there was an improvement of 3.3 units from the traditional farming REBA score of 9.7. However, this also indicates the need for further analysis and chair design improvement. During the one hour that the farmers used the chair, they were able to practice putting on the seatbelt and moving around with the chair without needing to hold it. Table 6 summarizes the comparison of pre-and post-REBA results before and after the ergonomic intervention.

Table 6. Summary of REBA results (pre-test and post-test)

Subject No.	Pre-Test REBA Score	Post-Test REBA Score	Remarks
1	9	7	Risk level reduced from high to medium
2	10	6	Risk level reduced from high to medium
3	12	7	Risk level reduced from very high to medium
4	9	6	Risk level reduced from high to medium
5	11	8	Risk level reduced from very high to medium
6	6	6	Risk level is maintained at medium
7	9	6	Risk level reduced from high to medium
8	10	5	Risk level reduced from high to medium
9	11	5	Risk level reduced from very high to medium
10	9	6	Risk level reduced from high to medium
11	10	7	Risk level reduced from high to medium
12	10	6	Risk level reduced from high to medium
Overall Mean	9.7	6.4	Risk level reduced from very high to medium
Paired t-test	t-critical=2.26	t-computed=6.71	p-value=8.77×10^{-5} (Significant at 0.05 and 0.01)

Results of the paired t-test from Table 6 indicate a significant reduction in the postural risk level of farmers when using the ergonomic chair. The research team believes that this improvement can make a huge difference that can still be improved further through chair design enhancement. According to the Ergonomic Solutions for Farm Workers by Barron, et.al. (2001), prolonged kneeling and squatting to harvest, transplant, or weed puts farmers at one of the highest risk groups for occupational injuries, but harvesting from a seated position eliminates knee strain and is less tiring for the back, hamstrings, and torso. The designed ergonomic chair promotes a better sitting posture, so injuries can be prevented, while fatigue and discomfort can be lessened. Through informal interviews, the research team was able to get feedback from the farmers regarding the chair. Some of their feedback are- the chair is comfortable, they do not get tired easily when using the chair, the seatbelt is very helpful in their mobility and the adjustable backrest and seat height are very useful features for them.

6. Conclusion

Farmers in Regions 1 and 3 suffer from body pain, particularly in their hip, shoulder, hand/wrist, legs, knees, thighs, neck, elbow, arm, waist, feet, head, and back when manually planting and harvesting crops. Furthermore, their Rapid Entire Body Assessment (REBA) scores fall into the high-risk level of injuries when doing their manual farming activities without the use of any chair. This indicates the need for an intervention and a change in a short period.

The farmer's ergonomic chair design was based on the body measurements and movements of the farmers, specifically the seat height, backrest height adjustments, and overall chair dimensions. The chair's features were also based on the needs and environment of the farmers. The research team made three prototypes specifically designed for farmers. Prototype 3 is the final chair design and is the farming instrument that could help the farmers improve their awkward posture and reduce body pain when planting and harvesting crops.

The use of ergonomic farming instruments like the designed ergonomic farmers' chair relatively reduced the risk of acquiring Work-related Musculoskeletal Disorders (WRMSDs). The intervention allowed a REBA score improvement from 9.7, which is at a high-risk level, down to 6.4, at a medium-risk level, indicating a lesser burden of 3.3 units. However, a medium risk level still needs further measurement and analysis. Thus, utilizing an ergonomic farming instrument can be an effective farming technique to reduce the risk of WRMSDs.

A further improvement in the design could involve using the originally intended frame material of aluminum alloy to decrease the weight of the chair and increase the length of the seatbelt until shoulder level for more stability. Furthermore, correct sitting posture is just as important as correct posture while standing. Hence, farmers must consider ergonomics when performing farm work such as when planting or harvesting, whether they are seated or standing. With that, the research team concludes that the ergonomic farming chair is an effective farming implement in reducing the risk of acquiring Work-related Musculoskeletal Disorders.

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