# Ergonomic Risk Assessment of Distal Upper Extremities in Agriculture Workers of Uttar Pradesh

**Sushma Gangwar[1], Seema Kwatra[2]**

[1]Assistant Professor, Department of Family Resource Management, College of Home Science, G. B. P. U. A. & T. Pantnagar, Uttarakhand, India-263145
Corresponding author Email address: *sushmagangwar6[at]gmail.com*

[2]Professor, Department of Family Resource Management, College of Home Science, G. B. P. U. A. & T. Pantnagar, Uttarakhand, India-263145

**Corresponding Address**: Head of the Department, Department of Home Science, Rajshree Institute of Management and Technology, Bareilly

**Abstract:** *Musculoskeletal disorders (MSDs) are the most common work-related problems among farm workers involved in sugarcane cultivation. Distal upper extremities musculoskeletal disorders (DUEMSDs) is considered as the main cause of working lost time, increased labour costs, and human injuries. This study was conducted to assess the risk factors of DUEMSDs in sugarcane workers. This descriptive study was conducted on 75 sugarcane workers of Bareilly district in Uttar Pradesh. The postural Discomfort analysis was used to find out the discomforts of different body parts during harvesting and planting of sugarcane. All risk factors that caused DUEMSDs were determined and risk assessment of DUEMSDs was done by the Job Strain Index (JSI) and RULA method. For the study planting and harvesting activities were selected from the sugarcane cultivation. Agricultural workers suffered from pain especially in the low back, knees, hands shoulder and neck. The average RULA score observed was 7. Strain score of right hand was 18 which is hazardous.*

**Keywords:** Sugarcane Cultivation, Musculoskeletal Disorders, Posture Analysis, Ergonomics, Rapid upper limb Assessment, Visual Analogue Scale

## 1. Introduction

In India, large number of human resource is mainly associated with agricultural work in rural areas due to poor socioeconomic status and poverty. Agricultural workers, especially rural people suffer from musculoskeletal disorders (MSDs) in different parts of the body, especially lower and upper back pain, during different activities in sugarcane production. Farm workers have to perform a fair amount of manual, continuous rigorous tasks in the agricultural field. There are some activities in sugarcane production which are regarded as heavy and requires great physical exertion i. e planting and harvesting of sugarcane. Farmers usually use a variety of different awkward postures while performing various manual tasks for an extended period of time. Because of awkward and stressful postures for prolonged period of time Indian agricultural workers are suffering with high work related musculoskeletal disorders. Low back problems are common among farmers, and appear to be associated with the frequency of using postures requiring back flexion carrying and lifting of heavy loads and exposure to whole body vibration (J. Penttinen 1987). Unlike many occupational diseases, which result from exposure to several specific risk factors, musculoskeletal (MSDs) are considered as a multifactorial injury, which is created and developed depending on risk factors, such as repetitive actions, high force exertions, awkward working postures, contact stress or pressures, vibration, and physical fatigue (David GC.2005, Marras W. S, Karwowski W.2006). Occupational exposure to these risk factors at occupational workplaces could cause various diseases, such as Tenosynovitis, Lower Back Pain (LBP) and Carpal tunnel syndrome (CTS), in which the neck, shoulders, back and upper extremities are affected (Marras W. S, Karwowski W.2006). Cumulative trauma disorders (CTD) are chronic work-related musculoskeletal disorders (WMSDs), which mostly influence the upper limb extremities (ULEs)

## 2. Review of Literature

**Borah and Kalita (2002)** reported that combination of standing and bending postures were generally used by most of the farm workers for performing cutting (89%), threshing (37%) storage (45%), and sun drying of grains (56%) respectively. Squatting and bending postures were adopted for soaking and preparing the seed for sowing (57%) and preparing threshing yard for threshing (74%). Only bending postures were used for uprooting of seedlings (95%) and transplanting (96%). Sitting posture was used for winnowing (92%), sieving (95%) and cleaning (96%) by majority of the farm women for performing the farm activities. Out of 160 farm workers 126 were suffering from postural discomforts, musculoskeletal disorders and fatigue due to awkward posture during activities. It was concluded that there is a great need to generate awareness about ergonomic aspects and to provide guidance about right postures during different positions.

**Gangopadhyay et al. (2005)** stated that preadolescent agricultural workers are continuously exposed to bending posture in different environments, and as a result, they suffer from acute pain and discomfort in different parts of the body.

**Gupta and Tarique (2013)** conducted a study of prevalence of Musculoskeletal Disorders among a sample of 300 farmers of Kanpur rural area. It was found that 60 percent

were suffering from low back pain, 39 percent from knee pain, 22 percent from shoulder pain and 10 percent from neck pain and a higher percentage of respondents indicated chronic affection persisting nearly a year as compared to those who were afflicted for around a week. It was concluded that low back pain is the most prevalent type of MSDs affecting the farmers. Knee, shoulder and neck pain are other important MSDs affecting farmers in the study area. Observations made during the present study suggest that poor postures and lack of ergonomic awareness in the farming community are the two principal causative factors contributing to the development of MSDs.

## 3. Materials and Methods

**Selection of subjects**
For the study, 75 agricultural workers (40 for harvesting and 35 for planting of sugarcane) aged 20-50 years, were selected by simple random sampling method from the four village in Bareilly District of Uttar Pradesh.

**Visual Analogue Scale**
The Visual Analog or Analogue Scale (R. Thomee, G. Grimby, B. D. Wright and J. M. Linacre 1995) is designed to present to the respondent a rating scale with minimum constraints. Respondents mark the location on the 10-cm line corresponding to the amount of pain they experienced. This gives them the greatest freedom to choose their pain's exact intensity. It also gives the maximum opportunity for each respondent to express a personal response style. The VAS frame measures exactly 10 cm. The distances from zero to the markings in cm are result indicators to be processed as continuous variables for statistical analysis.

**Postural analysis**
RULA is a survey method developed for use in ergonomic investigations for work related upper limb disorders (**McAtamney and Corlett, 1993**). RULA is a screening tool that assesses biomechanical and postural loading on the whole body with particular attention to the neck, trunk and upper limbs. A RULA assessment requires little time to complete and the scoring generates an action list which indicates the level of intervention required to reduce the risk of injury due to physical loading on the operator (**McAtamney and Corlett, 1993**). RULA is intended to be used as part of a broader ergonomic study. A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator.

**RULA Method**
- Postures were evaluated by numbers – greater the number, worse the posture.
- Group A measures the effect on upper arm, lower arm, wrist and wrist twist.
- Group B measures the effect on neck, trunk and leg.
- Average values of group A and group B were calculated and external force and frequency adjustments were done to get an overall score.
- On the basis of an overall score action level was determined.

**Strain Index (SI)**
The strain index (SI) or repetitive strain index method was developed by **Moore and Garg in 1995.** It is a method for estimating the risks of injury to the wrists and by analyzing the qualitative scores for the variable viz., intensity of exertion, duration of excretion, efforts per minute, hand/wrist posture, speed of work and duration of task per day. It gives a quick and systematic assessment of the hand/wrist postural risk to a worker.

Calculation of the SI score involves four steps viz., data collection, and assignment of rating values, determination of the multiplier and calculation of the SI score. Six variables are needed to collect the data. Each variable was assigned a rating and a multiplier.
a) **Intensity of exertion** is a qualitative measure of the force required to perform task one time.
b) **Duration of efforts** is the duration of the exertion and the measure of the physiological and biomechanical stress related to how long an exertion is maintained.
c) **Efforts per minutes** are the frequency of exertions per minute.
d) **Hand/wrist posture** relates the anatomical position of the hand.
e) **Speed of work** is the perceived pace of the task associated with dynamic work.
f) **Duration of task** is a measure of how many hours of the workday is allocated to perform the task.
The SI score is the product of the six variables. Four action levels for the SI scores have been proposed for assessing the ergonomic risk of a job categories viz-SI<3: safe; SI between 3 and 5: some risk; SI>7: hazardous.

## 4. Result and Discussion

**Table 1:** Physical characteristics of farm workers

| Physical characteristics | Mean ± SD |
|---|---|
| AGE (year) | 36.08 ± 7.86 |
| HEIGHT (cm) | 168.5 ± 5.10 |
| WEIGHT (kg) | 58.06 ± 8.45 |
| BMI | 20.43 ± 2.64 |

**Physical characteristics**
The physical characteristics of the farm workers selected for ergonomic experiments to carry out the identified drudgery prone activities of sugarcane production activities with mean has been presented in the Table 1. The mean age and SD values of the farm workers was 36.08 ± 7.86 years and height 168.5 ± 0.05 cms. The mean body weight was 58.06 ± 8.45 kgs. The computation of Body Mass Index (BMI) revealed that the average BMI was 20.43 ± 2.64 percent and almost all the farm workers fell in the normal range.

**Table 2:** Postural discomfort among the farm workers engaged in planting of sugarcane (VAS Scale)

| Body parts | Traditional method (n=20) (Mean±SD) | Planter method (n=15) (Mean±SD) |
|---|---|---|
| Neck | 7.11±0.92 | 5.92±1.03 |
| Shoulder | 6.66±0.84 | 5.92±1.11 |
| Upper back | 5±1.53 | 5±0.81 |
| Upper arm | 6.6±0.68 | 6.37±0.91 |
| Mid back | 5.25±0.5 | - |
| Lower arms | 5.37±1.58 | 4.75±0.70 |
| Low back | 6.75±3.02 | 5.58±0.79 |

| | | |
|---|---|---|
| Buttocks | - | - |
| Thighs | 6.75±1.01 | 5.56±0.98 |
| Legs | 7.0±0.85 | 7.53±0.51 |

The Postural discomfort analysis was used to find out the discomforts of different body parts during harvesting and planting of sugarcane. The questionnaire was given to each subject and was asked to put the mark on the line, which was then being analyzed. The descriptive (mean and SD values) were determined for VAS (Visual Analogue Scale) validated by **Corlett and Bishop (1976) and Huskisson (1983).** Similar work was reported by **Newel (2003).** The results depict (table 2) that the mean value was highest during planting by traditional method in the neck i. e.7.11 followed by legs (7.0), thighs (6.75), lower back (6.75), shoulder (6.66), upper arm (6.60), lower arms (5.37), mid back (5.25) and upper back (5). The pain and discomfort in neck was highest due to lifting and forceful action. They work in standing and bending position for 8 hours per day with a rest in between for 1 hour. This is the reason for pain in legs, thighs, lower back and other body parts. Whereas in planter method of planting the mean value was highest in the legs i. e.7.53 followed by upper arm (6.37), neck, shoulder (5.92), lower back (5.58), thighs 5.56), upper back (5), lower arms (4.75). The discomfort in lower and upper back were due to bending postures adopted by them at work.

**Table 3:** Postural discomfort among the farm workers engaged in harvesting of sugarcane (VAS Scale)

| Body parts | (Mean±SD) |
|---|---|
| Neck | 5.1±1.18 |
| Shoulder | 5.81±1.10 |
| Upper back | 5.16±0.61 |
| Upper arm | 6.74±1.01 |
| Mid back | 5.45±0.82 |
| Lower arms | 6±0.90 |
| Low back | 6.63±1.07 |
| Buttocks | - |
| Thighs | 6.01±1.10 |
| Legs | 6.37±0.86 |

Table.3 depicts that the mean value was highest during harvesting in the upper arm i. e.6.74 followed by low back (6.63), leg (6.37), thighs (6.01), lower arm (6.0), shoulder (5.81), mid back (5.45), upper back (5.16), and neck (5.1). In harvesting activity pain and discomfort was highest in upper arm and low back because hands are most active organs while working thus overwork by these lead to pain and low back pain may be due to the frequent standing and bending while doing harvesting for 8 hours a day. Lower part of the back bears the weight of the upper body plus any weight that is carried and it also twists and bends more than the upper back causes low back pain.

**Application of RULA for the postural analysis**
The results of the RULA assessment were based on the calculation of a grand score that was used to determine an action level.

**Table 4:** Distribution of farm workers according to RULA assessment in planting of sugarcane

| Scores | Action levels | Traditional method n=20 | | | Planter method n=15 | |
|---|---|---|---|---|---|---|
| | | Making furrows | Placing setts in rows | Covering it with soil | Placing setts in rows | Covering it with soil |
| 1 or 2 | Indicates that posture is acceptable if it is not maintained or repeated for long periods. | - | - | - | - | - |
| 3 or 4 | Indicates that further investigation is needed and changes may be required. | - | 5 (25) | -- | - | - |
| 5 or 6 | Indicates investigation and changes are required soon. | - | - | - | - | - |
| 7 or 8 | Indicates investigation and changes are required immediately. | 20 (100) | 15 (75) | 20 (100) | 15 (100) | 15 (100) |

Percentage is given in parentheses

**Table 4** indicates that grand score calculation of all the working postures of all the farm workers revealed that all farm workers who were involved in traditional method of planting of sugarcane activity i. e making furrows were scored as 7 score which indicates that the farm workers working in a bad posture with an immediate risk of injury from their work therefore there was a need to investigate and implement change immediately.

In placing setts in rows activity 75 percent farm workers were scored as 7 score. Whereas in the covering with soil activity, all farm workers scored 7 which indicate that the farm workers working in a bad posture with an immediate risk of injury from their work therefore there was a need to investigate and implement change immediately. Above table indicates that in planter method of planting i. e In placing setts in rows activity and in covering setts with soil all the farm workers scored 7 as score which indicates that the farm workers working in a bad posture with an immediate risk of

injury from their work therefore there was a need to investigate and implement change immediately.

**Table 5:** Distribution of farm workers according to RULA assessment in harvesting of sugarcane, n=40

| Scores | Action levels | Cutting of sugarcane | cleaning | bundling |
|---|---|---|---|---|
| 1 or 2 | Indicates that posture is acceptable if it is not maintained or repeated for long periods. | - | - | - |
| 3 or 4 | Indicates that further investigation is needed and changes may be required. | - | 12 (30) | - |
| 5 or 6 | Indicates investigation and changes are required soon. | 25 (62.5) | 28 (70) | - |
| 7 or 8 | Indicates investigation and changes are required immediately. | 15 (37.5) | - | 40 (100) |

Percentage is given in parentheses

Table 5. indicates that grand score calculation of all the working postures of all the farm workers revealed that 62.5 percent farm workers who were involved in cutting of sugarcane activity were scored as 6 score which indicates that the farm workers working in a bad posture with an immediate risk of injury from their work therefore there was a need to investigate and implement change soon, whereas 37.5 percent scored 7 which means farm workers fall under the category of red zone which indicate that all the farm workers were working in difficult posture, so there was a need to investigate and implement changes immediately.

In the cleaning activity, 70 percent farm workers scored 6 which indicates that the farm workers working in a bad posture with an immediate risk of injury from their work therefore there was a need to investigate and implement change soon, All the farm workers who were involved in bundling activity were scored as 7 score which fall under red zone category, which indicate that all the farm workers were working in difficult posture with an immediate risk of injury

from their work therefore there was a need to investigate and implement change immediately.

**Ergonomic interventions-**
- Repetition of work in planting and harvesting activity, which causes musculoskeletal disorders, should be avoided.
- Short rest break should add to work schedule of farm workers.

- **Suggestion of new posture during planting**
Planting of sugarcane is a very physical demanding work. Standing, bending and twisting posture were adopted during planting. In planting with planter method there were two steps first to place sett in row and second cover it with soil. In second step farm workers bend and cover the setts with soil with the help of hands. Here we suggested them to make standing posture and use their feet to cover the setts with soil.

**Table 6:** Distribution of farm workers according to RULA assessment in planting of sugarcane

| Scores | Action levels | Planter method n=15 | | | |
|---|---|---|---|---|---|
| | | Line Diagram | Covering setts with soil (n=15) Posture adopted | Line diagram | Covering setts with soil (n=12) Improved posture |
| 1 or 2 | Indicates that posture is acceptable if it is not maintained or repeated for long periods. | | - | | - |
| 3 or 4 | Indicates that further investigation is needed and changes may be required. | | - |  | 12 (100) |
| 5 or 6 | Indicates investigation and changes are required soon. | | - | | - |
| 7 or 8 | Indicates investigation and changes are required immediately. |  | 15 (100) | | |

It is concluded from Tables 6 that in the improved posture the RULA score is reduced and this activity falls in low risk category now from the High risk.

## 5. Conclusion

1) This study mainly indicates that farm workers involved in sugarcane planting and harvesting activities are mainly suffering from work related musculoskeletal disorders (especially in the neck, legs, thighs, lower back, upper back, shoulder, upper arm, lower arm and mid back) due to prolonged awkward (squatting, bending and twisting) postures with a high amount of repetitiveness.
2) RULA posture analysis indicated that in different phases of planting and harvesting activities implementation of immediate corrective measures are needed.
3) Manual planting and harvesting is physically demanding activity because of prolonged work activity, high repetitiveness, and remaining constantly in an awkward posture for a prolonged period of time which leads to work related musculoskeletal disorders among farm workers.

4) The present study recommends that there is a need of implementation of ergonomics interventions with proper awareness among farm workers involved in sugarcane cultivation.

## References

[1] **Borah. R.; Kalita M.2002.** Extent of Participation and Postures adopted in Performance of Farm Activity by Women in Assam Rural India. *Journal of Ergonomics*, **65** (1): 7-10
[2] **David GC**. Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occup Med (Lond).*2005; **55** (3): 190–9. doi: 10.1093/occmed/kqi082. [PubMed: 15857898].
[3] **Gupta, G. and Tarique.2013**. Prevalence of Musculoskeletal Disorders in Farmers of Kanpur-Rural, India. J Community Med Health Educ 3: 249. doi: 10.4172/2161-0711.1000249
[4] **J. Kishtwaria, A. Rana and S. Sood J. Penttinen**, "Back pain and Sciatica in Finnish Farmers, " Helsinki: Publication of the Social Insurance Institution, 1987.

[5] **Marras WS, Karwowski** W. *Fundamentals and assessment tools for occupational ergonomics*. CRC Press; 2006. Moore JS, Garg A. The Strain Index: a proposed method to analyze jobs for risk of distal upper extremity disorders. *Am Ind Hyg Assoc J*.1995; **56** (5): 443–58. doi: 10.1080/15428119591016863. [PubMed: 7754975]

[6] **Marras WS, Karwowski W**. *Interventions, Controls, and Applications in Occupational Ergonomics*. Crc Press; 2006.

[7] **McAtamney, L. and E Nigel Corlett, 1993.** RULA: a survey method for the investigation of world-related upper limb disorders. Applied Ergonomics, 24 (2): 91-99. | [2]

[8] **Moore, J. S. And Garg, A.1995**. The Strain Index: A Proposed Method To Analyse Jobs For Risk Of Distal Upper Extremities Disorders. American Industrial Hygiene Association Journal.56 (5): 443-458.

[9] **Newell T.2003.** Comparison of instantaneous and cumulative loads of the low back and neck in orthodontists. MSc Programmes in Engineering Industrial Ergonomics. Lulea University of Technology. Accessed<http: //epubl. ltu. se/ 14021617/2003/053/index-en. html

[10] **R. Thomee, G. Grimby, B. D. Wright and J. M. Linacre,** "Rasch analysis of Visual Analog Scale measurements before and after treatment of patellofemoral pain syndrome in women, " Scand J Rehabil Med, 27 pp.145-51, 1995.

[11] **S. Gangopadhyay, B. Das, T. Das and G. Ghoshal**, "An Ergonomic Study On Posture Related Discomfort Feeling Among The Pre-adolescent Agricultural Workers of West Bengal, India, " International Journal of Occupational Safety and Ergonomics, 11 pp.315-322, 2005.