Ergonomic Evaluation of Seeding, Fertilizing and Weeding Postures in Agricultural Field

Bhawna Dube *, Debesh Mishra, Dr. Suchismita Satapathy, and Subhakanta Singh

School of Mechanical Engineering, KIIT, Bhubaneswar, India

Abstract. RULA (Rapid Upper Limb Assessment) tool is used for the ergonomic investigation where work related disorders are observed. It provides a quick evaluation of the postures of human body parts such as 'neck, upper limbs with muscle function, trunk, and the external loads experienced by the body' in the working environment. In the present study, the seeding, fertilizing and weeding postures in the agricultural fields in South Odisha (India) are virtually built and the RULA analysis was used followed by the CATIA V5 software. The RULA scores obtained by assessment of each posture are discussed for necessary actions to be followed, for farmer’s safety and healthy working environment.

1 Introduction

Agriculture is considered as the source of living for most of the Indians in rural areas, which is about greater than 70%. Its contribution is about 18% of the gross domestic product in India (Department of Agriculture, Cooperation & Statistics, 2014). Similarly agricultural sectors in India also largely contribute to 49 % of the total labor force. According to (NSSO, 2013) most of the Indian spends more than half of their income in food-preservation & security. However the growth rate of the agricultural sectors in India has been fluctuating. The growth rate of the agriculture in India is varying and primarily it depends on the rainfall as most of the cultivating area in India depend on rainfall (Dev, 2013). Farming is greatly influenced by the techniques and tools used in various stages and activities involved. With the development of machinery and equipments, the farming process has become easier, more efficient and productive. Still most of the farming activities are carried out by the conventional tools and methods. It has been reported by many authors and researchers that the farmers engaged in agricultural sectors are highly affected by musculoskeletal disorders (MSD) because of the risk factors evolved in the respective work places. The musculoskeletal disorders not only cause harm to the farmers but also is a threat to the health & life of them. Manually lifting, carrying loads or driving tractors were considered to be risk factors for the agricultural workers [Parson et al. (1990), Murphy (1992), Bobick et al. (1995)]. Pinzke et al. (2001) have reported the wrist, forearm, shoulder, neck and the lumbar spine as the most body parts exposed to heavy loads. Jakob et al. (2009) and Stål et al. (2003) have reported that most of the jobs are designed based on the anthropometric dimensions of men and this is the cause for lower productivity, discomfort level and the increase in energy expenditure for the women. Also it was reported that the women who work continuously for eight hours, usually suffer from pain in hand, wrist and neck. NIOSH (2002) and da Costa et al. (2010) have reported the risk factors associated with the musculoskeletal disorder in the workplaces as high rate of doing work, repetitive work, forceful exertion, incorrect body postures and vibrations.

The various risk factors for musculoskeletal disorders (MSD) were reported as physical, psychological and socio-demographic characteristics (Devereux et al, 1999, 2002), different postural actions (Reid et al, 2010), incorrect working postures (Scuffham et al, 2010), manually material handling (Yeung et al, 2002), standing and walking for a longer duration (Andersen et al., 2007; Balasubramanian et al, 2009), lengthy duration of shift works (Ranaas and Anderson, 2008), twisting of trunk (Hartman et al, 2005), doing repetitive jobs (Juul-Kristensen and Jensen, 2005) and poor working environment (Saurin and de Macedo Guimaraes, 2008). Silvia A. Pascual & Syed Naqvi (2008) have reported that Snook/Mital tables were used mostly by the certified-ergonomists, National Institute of Occupational Safety and Health (NIOSH) used equations and rapid upper limb assessment (RULA) or rapid entire body assessment (REBA). The ‘Joint Health and Safety Committee’ (JHSC) used injury reports and workers complaint, most commonly for assessment of work related musculoskeletal disorders (WMSD).

In the present study, the seeding, fertilizing and weeding postures are virtually built and the RULA analysis was used followed by the CATIA V5 software. The RULA scores obtained by assessment of each posture are discussed for necessary actions to be followed, for farmer’s safety and healthy working environment. RULA is used to depict the acceptability of various tasks & postures and suggests whether the task or posture is acceptable or need to be investigated further or need to be changed soon, based on RULA score values. RULA makes the posture analysis based on the parameters such as distance, weight, and frequency, considering various variables and user data. Ren & Xiao (2009) and Sanjog et al. (2012) have discussed the RULA analysis as a technique to optimize different human postures and resulting in a better design, widely acceptable products and the workplaces. Karandikar and Sane, (2014) have used the RULA analysis and based on its scores the "Job Difficulty Index (JDI)" was obtained.

RULA (Rapid Upper Limb Assessment) tool is used for the ergonomic investigation where work related disorders are observed. It provides a quick evaluation of the postures of human body parts such as 'neck, upper
limbs with muscle function, trunk, and the external loads experienced by the body in the working environment, as shown in Figure 1. Each posture is assigned a score after the analysis and based on the final score; four action levels are proposed which indicates the necessary actions to be taken to reduce the risk of musculoskeletal disorders or injuries during various tasks. Various proposed action levels of RULA analysis based on the final score is shown in Table 1.

Table 1: Action levels of RULA working posture

<table>
<thead>
<tr>
<th>Action level</th>
<th>Final RULA score</th>
<th>Final Score Color</th>
<th>Proposed Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-2</td>
<td>Green</td>
<td>The Posture is acceptable</td>
</tr>
<tr>
<td>2</td>
<td>3-4</td>
<td>Yellow</td>
<td>Further investigation is needed and changes may also be required</td>
</tr>
<tr>
<td>3</td>
<td>5-6</td>
<td>Orange</td>
<td>Investigation and changes are required soon</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>Red</td>
<td>Investigation and changes are required immediately</td>
</tr>
</tbody>
</table>


2 Methodology

While designing the conventional agricultural tools considering its operational environment, it is mostly observed that the ergonomic considerations for user friendly tools are almost neglected. Thus the farmers dealing with the tools and techniques during farming suffer from various musculoskeletal disorders (MSDs) and injuries. Seeding is the process of planting of required crops, which are done by the farmers either manually or with the help of animals or by mechanized techniques by harrowing of soil. In fertilizing the required fertilizers and pesticides, are applied to protect the crops from various diseases. While in weeding activity, the unwanted plants and grasses are removed from the cultivated areas. The weeding is done manually, or with the aid of some external agents such as machines. Based on the seeding, fertilizing and weeding of crops in agricultural fields in South Odisha (India), and the postures of the farmers, the assessment results are obtained. Different postures are virtually built and the RULA analysis was used followed by the CATIA V5 software. Most of the farmers in the present study, are found using manual methods in seeding, fertilizing and weeding operations, respectively and they are required to squat, forward/lateral bend or flex/extend hands, twist the wrist/spine etc., during various activities.

3 Result and Discussion

In posture 1 (Figure 2), in manual harrowing for planting, the observed body movements for the farmer are frequent spine bending forward, knee bending, neck bending, bending and twisting of the wrist of both hands. The corresponding RULA score obtained is 7 for both left and right side of the body (Figure 3), which indicates that “The posture needs to be changed immediately” as it results in musculoskeletal disorders (MSD). In posture 2...
(Figure.4), in animal driven harrowing the observed body movements for the farmer are- bending forward, knee bending, neck bending, bending and twisting of the elbow & wrist of both hands, flexion of upper and forearms with little load in hands. The corresponding RULA score obtained is 5 for left side and 6 for right side of the body (Figure.5), which indicates that “Investigation and changes are required soon” for both the sides of body. In posture 3 (Figure.6), in manual fertilizing for planting, the observed body movements for the farmer are- frequent spine bending forward, knee bending, neck bending, bending and twisting of the wrist of both hands. The corresponding RULA score obtained is 5 for right side of the body (Figure.7), which indicates that “Investigation and changes are required soon”. In posture 4 (Figure.8), in manual seeding the observed body movements for the farmer are- bending forward, knee bending, neck bending, bending and twisting of the elbow & wrist of both hands, flexion of upper and forearms with little load in hands. The corresponding RULA score obtained is 5 for left and 7 for right side of the body (Figure.9), which indicates that “Investigation and changes are required soon” for left side of the body and “The posture needs to be changed immediately” for right side of the body. Similarly in posture 5 (Figure.10), in manual weeding the observed body movements for the farmer are- bending forward, knee bending, neck bending, bending and twisting of the elbow & wrist of both hands, flexion of upper and forearms with little load in hands. The corresponding RULA score obtained is 7 for left side and 5 for right side of the body (Figure.11), which indicates that “The posture needs to be changed immediately” for left side of the body and “Investigation and changes are required soon” for right side of the body, respectively.
4 Conclusion

The application of RULA technique for agricultural posture analysis during seeding, fertilizing and weeding, indicates that the farmers must focus on the ergonomic principles by maintaining proper working postures in which the muscles will be at normal extent, developing the required forces, reducing the stresses and possible injuries to the body parts. Farmers should be encouraged to use ergonomically designed tools and machineries to stabilize their physical ability to the correct job, but it deal with designing/ modification of tools or machineries that is accurate for the task. Limiting heavy lifting, training and reporting early symptom of injuries are example that can prevent musculoskeletal disorders (MSD). The selection & choice of tools and techniques should match the socio-demographic & work setting characteristics. The frequency of lifting loads or carrying of heavy loads, handling of awkward shaped objects must be neglected or reduced, to avoid the musculoskeletal disorders.

References

5. M. Jakob, F. Liebers, Body posture variation during machine milking regarding weight of milking unit and working height—experimental