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An ergonomic study of maize shelling

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Abstract
In India, post harvest agricultural activities are predominantly performed by farm women. Maize shelling is a crucial post-harvest operation involving separation of maize kernels from cobs. It is an important step in processing maize into a finished product majorly performed with traditional tools. But since these tools are not ergonomically designed they results in drudgery and low output. Thus, study was conducted in Hoshiarpur district to analyze these traditional practices and assess the ergonomics of conventional, improved and modified tools to alleviate the physical strain experienced by farmwomen. The study aimed to address the drudgery faced by farmwomen engaged in maize shelling activities. Results revealed that the modified tool had a substantial impact in reducing cardiovascular, physiological and musculoskeletal stress experienced by the farmwomen. Further the output was also enhanced with modified tool with 50 kg/hr of maize kernels, to that of the improved tool (26 kg/hr) and the conventional tool (14 kg/hr). Objective ergonomic scales like OWAS, RULA and HARM scales were utilized for analysis of working postures which further revealed significant improvement in postures while utilizing Modified tool. Thus, it was evident that modified tool had shown significant improvement in productivity and improvement in postures which had reduced the drudgery significantly.

Keywords: Musculoskeletal problems, physiological cost of work, cardiovascular stresses, drudgery reducing tools

1. Introduction

According to the Food and Agriculture Organization (FAO, 2011) [5], women in developing economies such as India hold significant responsibilities in the agricultural sector. Women comprise approximately 43% of the overall agricultural workforce (Raney *et al.*, 2011) [8]. But unfortunately rural farmwomen encounter arduous physical exertion while performing agricultural activities specifically for post-harvesting activities while prolonged utilization of hand-operated tools and equipment (Desai *et al.*, 2021) [3]. Maize (Zea mays) is considered to be the most abundant and versatile seed crop globally (Aremu *et al* 2015) [2]. It is commonly referred to as the "Queen of cereals" and the "King of fodder" due to its significant capacity to yield substantial quantities of food for both human and animal consumption. According to Akubuo (2002) [1], almost all part of maize including the grain, stalk, leaves, tassel and cob, possess economic value as they can be utilized in the production of both food and non-food items. The processing of maize involves a series of sequential steps including harvesting, drying, dehusking, shelling, milling and storing. The process of maize shelling involves removal of kernels from the cobs. Maize shelling is an important post-harvest procedure that can be conducted either in the field or in the storage area for processing of maize to finished product.

Traditionally farmwomen perform maize shelling manually through finger nails, sickle or beating of cob by wooden sticks. Farm women perform this activity by either in sitting-cum-bending and squatting posture for extended periods of time. Prolonged use of these postures exacerbates the feelings of exhaustion and drudgery. There were numerous attempts to construct engine and tractor-driven high-capacity shellers. But the technology is out of reach for marginal farmers. Present motorized shellers are too expensive for marginal farm workers. Thus, post-harvest production requires well-designed and low-cost shelling tools in order to increase output. Improved maize sheller designs must not only reduce drudgery and but should be cheaper for making it more affordable. Some maize shellers were developed considering cost and availability for small or marginal farmers who cannot afford expensive machinery. However since they were not ergonomically examined these tools also resulted in drudgery and low output. Therefore, it is imperative to conduct ergonomic evaluations of maize shelling using conventional, improved and modified tools in order to optimize time utilization, boost productivity and alleviate the physical strain experienced by female farmers. Hence the study was conducted in Hoshiarpur district to increase efficiency and reduce the drudgery of farm women in maize shelling.

2. Materials and Methods

The research was carried out in Hoshiarpur district, specifically on Garshankar block due to its significant

involvement in maize production. Random selection was made between two villages, namely Talwara and Mahilpur with sample of 40 farmwomen from each village, resulting in a total sample size of 80 farmwomen. Further field experiments was performed with a sample of 20 physically fit respondents, 10 subjects from each village were selected randomly out of the total sample. The experiment consisted of performing maize shelling activity for duration of one hour using three different tools: conventional, improved and modified tool. From these samples, ergonomic parameters related to maize shelling activity were evaluated. Data was gathered pertaining to both objective and subjective factors. Subjective evaluation methodologies were employed to ergonomically analyze work-related risk factors, including musculoskeletal disorders, postural discomfort and physiological cost associated with doing the task. Initially, an ergonomic evaluation was carried out to assess the cardiovascular and physiological responses, grip strength, intensity of pain and level of drudgery experienced by farm women during the maize shelling activity between both conventional and improved tools. However, despite the implementation of improved tool, farm women continued to experience discomfort while performing the activity. Thus, in order to alleviate the laboriousness of maize shelling appropriate adjustments were made improved tool, resulting in the development of a modified tool. Later, field experiments were undertaken with modified tool against improved tool for extensive ergonomic evaluation of conventional, improved and modified tools. Then finally, comparative analysis of posture was conducted across conventional, improved and modified tools with use of objective assessment scales such as OWAS (Ovako Working Posture Analysis System), RULA (Rapid Upper Limb Assessment) and HARM (Hand Arm Risk-assessment Method) for objective evaluation of working posture.

3. Results and Discussion

3.1 Conventional Methods of Maize Shelling: As illustrated in Fig. 4.1, 60% of respondents performed maize shelling by hand while 25% of respondents used wooden sticks. However, only 15% used conventional maize sheller.

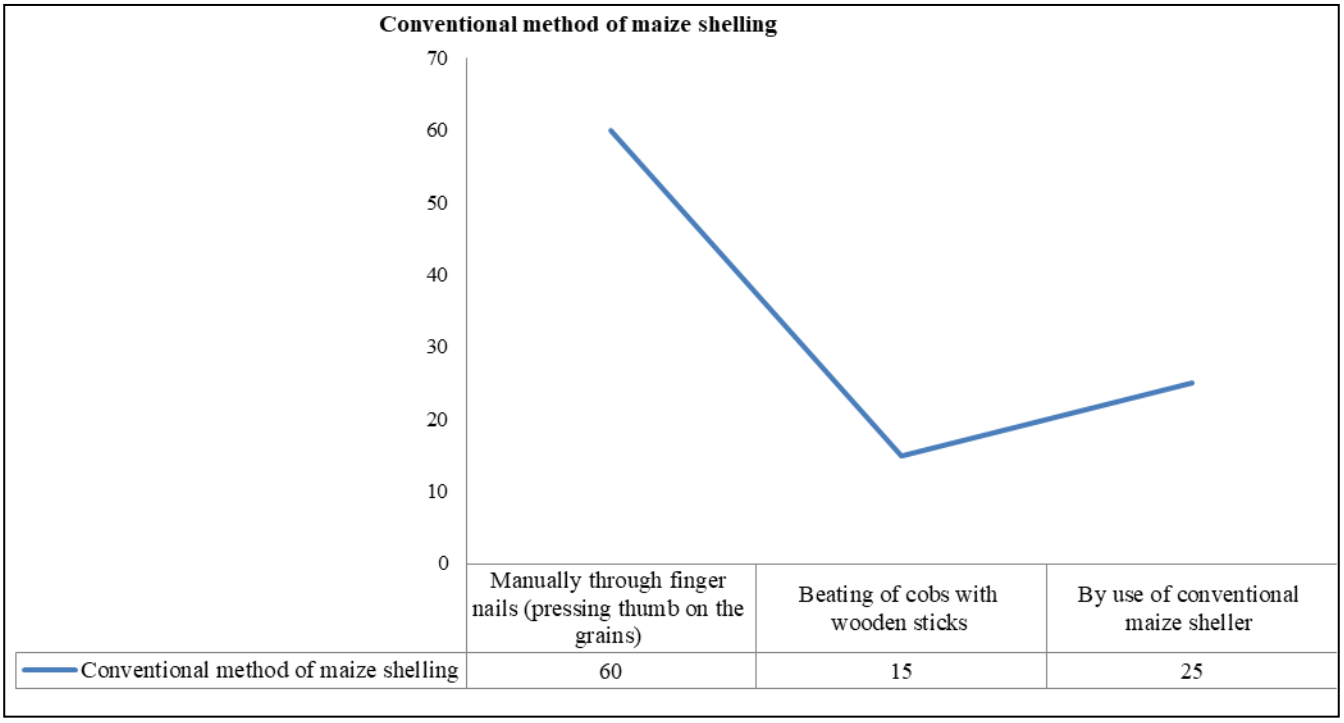


Fig 1: Conventional Methods of Maize Shelling

Shelling by Hands Shelling by conventional tool

Source: Author

3.2 Postures adopted by farmwomen using conventional practices

Based on the findings from Figure 2, it can be observed that maize shelling is majorly performed by sitting posture (55%) followed by squatting which constitutes 47.5% of the respondents and bending with 35 percent. Combinations of these postures for prolonged time potentially caused discomfort among farmwoman and will lead to the development of musculoskeletal disorders.

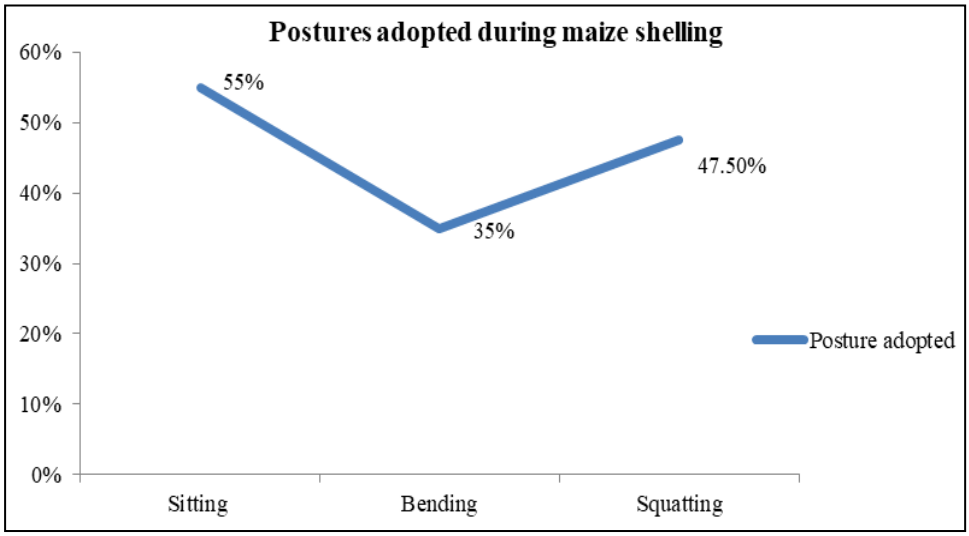


Fig 2: Postures adopted while performing maize shelling activity

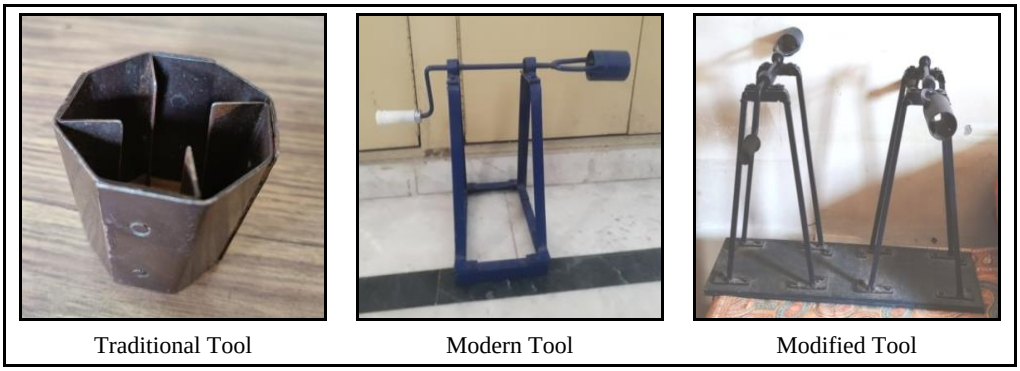


Fig 3: Tools utilized for maize shelling activity

3.3 Cardiovascular and Physiological parameters while working with conventional, improved and modified tools: Results revealed that heart rate, energy expenditure, TCCW and PCW declines significantly with the use of modified tool. The t-values were computed to evaluate the statistical significance of the variations observed between the different tools. While comparing the conventional tool with the improved tool, a notable reduction was found in heart rate (4.23% decrease) and energy expenditure (14.64% decrease) with corresponding t-values of 4.62 and 6.90 at 1% level of significance respectively. In a similar way, the TCCW and PCW exhibited a significant decrease of 18.50 percent and 17.61 percent respectively with t-value of 42.84 and 21.88 at 1% level of significance. While comparing the improved tool and modified tool, it was observed that there was reduction in heart rate (1.30% decrease) and energy expenditure (10.52% decrease). The statistical analysis revealed t-values of 2.83 and 4.51 at 1% level of significance for heart rate and energy expenditure respectively. Furthermore, the TCCW also showed a decrease of 0.26 percent whereas the PCW showed decrease of 0.54 percent with t-values of 4.93 at 1% level of significance and 1.78 at 5% level of significance respectively. These results suggest that the enhanced and updated tools were helpful in reducing physiological and energy-related parameters associated with the maize shelling activity. Thus, modified tool was more comfortable and easy to use since there is reduction in cardiovascular and physiological cost of work.

Table 1: Comparative evaluation of Cardiovascular and Physiological parameters while working with conventional, improved and modified tool.

Maize shelling activity	Conventional tool	Improved tool	t- value
Percentage change in Heart rate	4.23%↓		4.62*
Percentage change in Energy expenditure (kJ/min.)	14.64%↓		6.90*
Percentage change in TCCW (%)	18.50%↓		42.84*
Percentage change in PCW (%)	17.61%↓		21.88*
Maize shelling activity	Improved tool	Modified tool	t- value
Percentage change in Heart rate	1.30%↓		2.83*
Percentage change in Energy expenditure (kJ/min.)	10.52%↓		4.51*
Percentage change in TCCW (%)	0.26%↓		4.93*
Percentage change in PCW (%)	0.54%↓		1.78**

*Significant at 1% level of significance **Significant at 5% level of significance

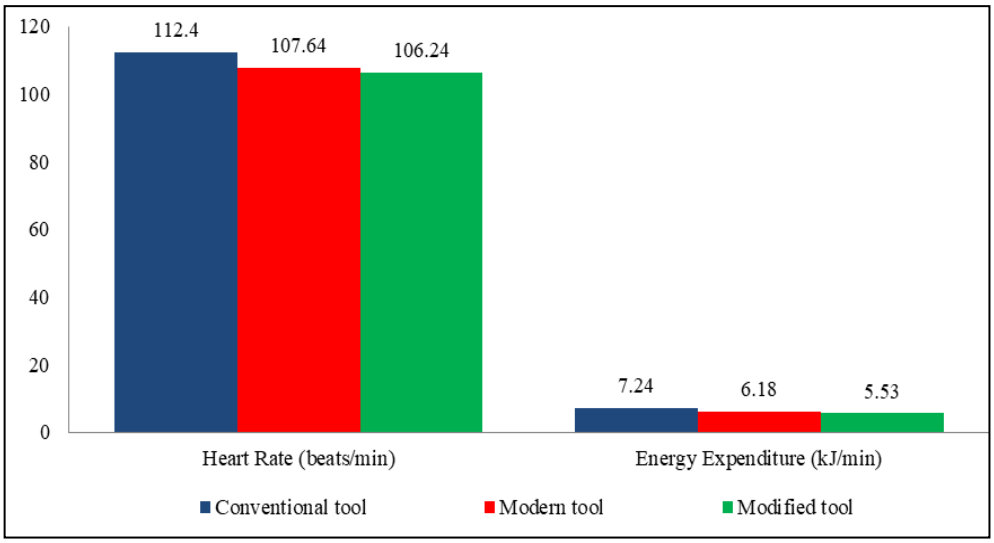


Fig 4: Cardiovascular parameters while working with Maize shelling tools

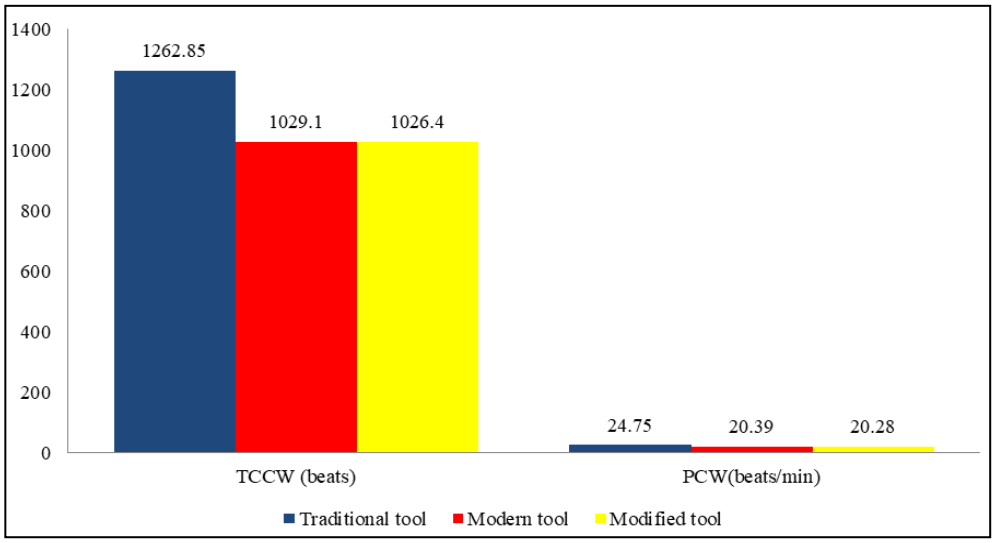
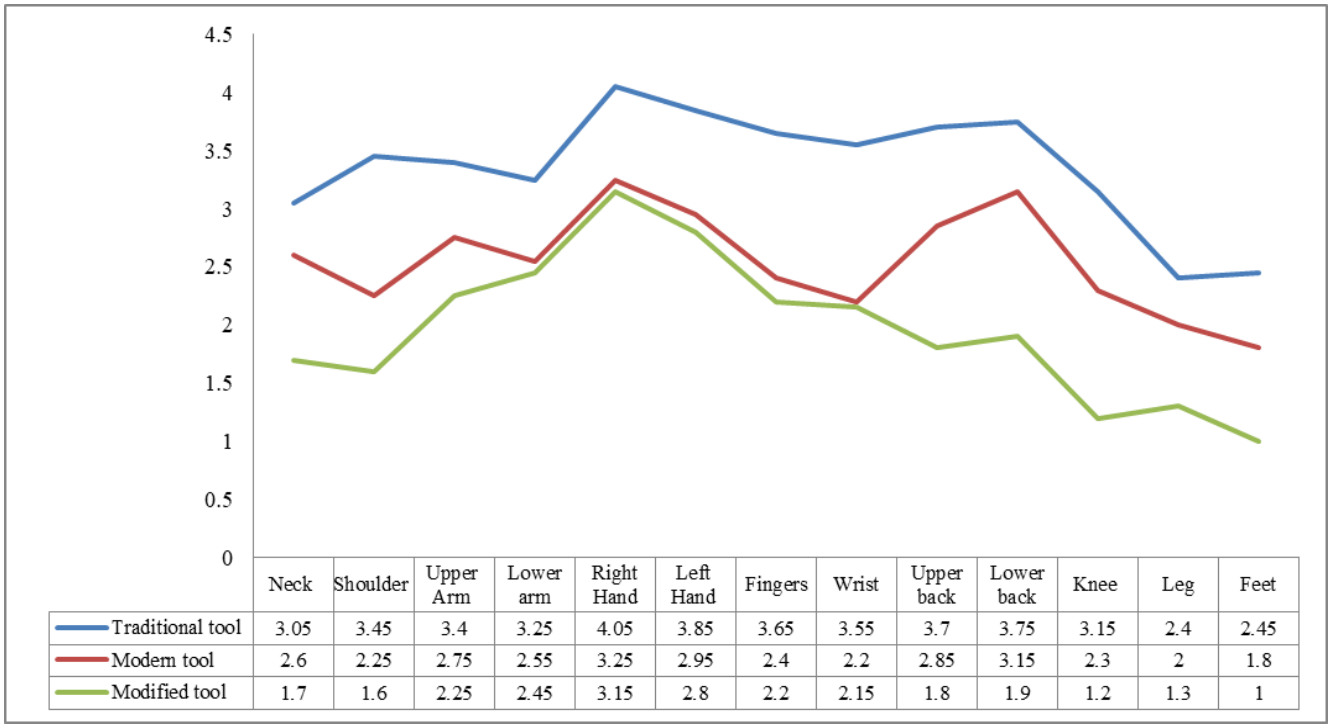


Fig 5: Physiological parameters while working with Maize shelling tools

3.4 Intensity of pain felt by farmwomen while working with Conventional, improved and modified tool: Results from Fig. 6 depicts that intensity of pain felt while working with conventional and improved tool shows that intensity of pain in right hand, left hand, lower back, upper back, fingers and upper arm shifts from severe to moderately severe pain For wrist, intensity of pain shifts from severe to mild. In case of neck, lower arm, knee, shoulder, leg and feet intensity of pain shifts from moderately mild pain.



	Neck	Shoulder	Upper Arm	Lower arm	Right Hand	Left Hand	Fingers	Wrist	Upper back	Lower back	Knee	Leg	Feet
Traditional tool	3.05	3.45	3.4	3.25	4.05	3.85	3.65	3.55	3.7	3.75	3.15	2.4	2.45
Modern tool	2.6	2.25	2.75	2.55	3.25	2.95	2.4	2.2	2.85	3.15	2.3	2	1.8
Modified tool	1.7	1.6	2.25	2.45	3.15	2.8	2.2	2.15	1.8	1.9	1.2	1.3	1

Fig 6: Intensity of pain felt by farmwomen while working with Conventional, Improved and Modified tool.

Further while working with modified tool in comparison to improved tool intensity of pain in Right hand, Left hand, Lower back, Upper back, Fingers and Upper arm shifts from moderately severe to mild pain. In case of Wrist, Neck, Lower arm, Knee, Leg, Shoulder and Feet intensity of pain shifts from mild to very mild pain. Therefore it can be concluded that discomfort felt by the respondents declined significantly while working with modified tool in comparison to improved and conventional tool.

3.5 Work output while working with Conventional, Improved and Modified tool

The average yield obtained with conventional tool was 14 kilograms of maize grains per hour in comparison to 26 kilograms per hour while utilizing an improved tool. Furthermore, with the use of a modified tool output is further increased to 50 kilograms per hour. Data highlights the significant effects that the enhancement of agricultural equipment has on increasing production and efficiency.

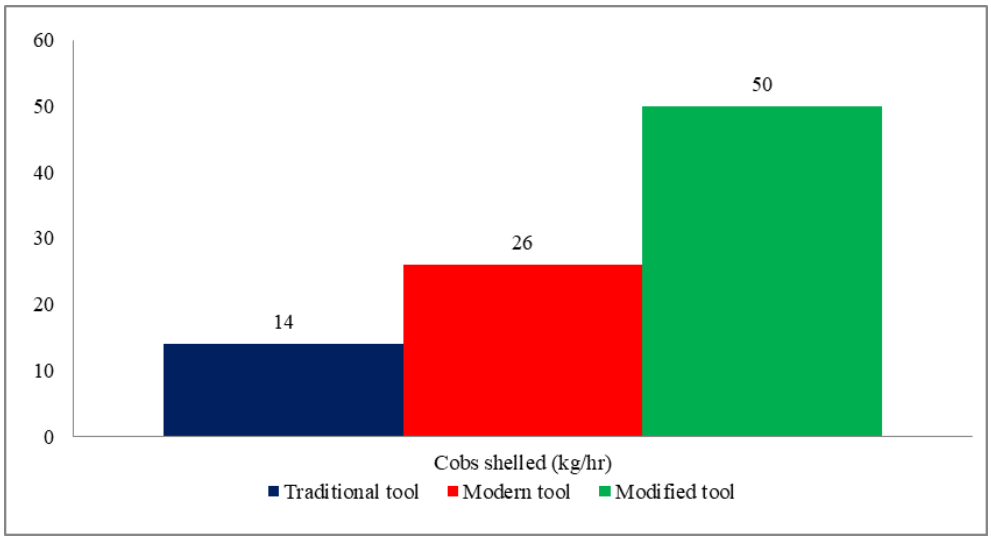


Fig 7: Work output while working with Conventional, Improved and Modified tool

3.6 Objective assessment of working postures while using Traditional, Modern and Modified tools.

For analyzing working posture objective posture analysis techniques i.e, Ovako Working Posture Analysis System (OWAS), Rapid Upper Limb Assessment (RULA), Hand Arm Risk Assessment Method (HARM) were used to analyze selected postures with statistical method ANOVA with Post-hoc tukey test. Results revealed that OWAS score was 2.60 for conventional tool depicting corrective measures to be required as soon as possible followed by improved tool with score 1.60 stating corrective measures in near future and whereas in case of modified tool 1.20 score depicts with no corrective measures.

Posture adopted while using Conventional Tool | Posture adopted while using Improved Tool | Posture adopted while using Modified Tool

Fig 8: Posture adopted while using Conventional, Improved and Modified Tool

Table 2: Analysis of working postures using OWAS, RULA and HARM

Particulars	OWAS Final Score (Action Category)	RULA (Final score)	HARM Risk score (A X T)
Conventional tool	2.60±0.50[a]~3.00 (Corrective measures as soon as possible)	6.60±0.82[a] ~ 7.00 (Investigate and implement change)	56.00±0.00[a] (High risk of arm, neck or shoulder complaints. Important to take preventive measures immediately.)
Improved tool	1.60±0.50[b]~2.00 (Corrective measures in the near future)	3.60±0.50[b] ~ 4.00 (Further investigation, change may be needed.)	37.60±2.01[b] (Increased risk of arm, neck or shoulder complaints. Preventive measures required)
Modified tool	1.20±0.41[c] ~1.00 (No corrective measures required)	2.40±0.50[b] ~2.00 (Acceptable posture)	29.60±2.01[c] (No risk of arm, neck or shoulder complaints for virtually the entire working population)

Values are Mean ± SD

Mean values in rows followed by different superscripts (a,b,c) differ significantly ($p \leq 0.05$) wherein superscript a depicts maximum score followed by b and then c.

Further, Analysis by RULA states that maximum scoring (6.60) was in case of conventional tool which recommends to investigate and implement change as soon as possible followed by improved tool with score 3.60 stating that further investigation might be needed and in case of modified tool score obtained was 2.40 depicting acceptable posture. The HARM risk score analysis revealed that with conventional tool maximum score was obtained of 56.00, indicating a substantial risk of arm, neck and shoulder issues. While with improved tool overall score of 37.60 is obtained, which implies increased risk and underscores the necessity for implementing preventative measures. On the other hand with modified tool obtained score was 29.60, indicating that the majority of the working population is not at danger of experiencing such complaints. These findings emphasize the necessity of ergonomic adjustments for improving working postures and reduction in occupational health risks.

4. Conclusion

In summary, it could be analyzed that there is significant contribution of farm women in maize shelling activity. But unfortunately these activities are associated with laboriousness and health concerns due to the utilization of conventional tool and awkward postures. The study demonstrates that the implementation of improved tool followed by subsequent improvements through a modified tool had a substantial positive impact on the drudgery experienced by farm women. Study revealed that while working with modified tool there is significant decline in physical, mental and cardiovascular strain, improvement in posture and substantially an increase in productivity. Furthermore, the results emphasize the significance of resolving ergonomic obstacles and offering appropriate resources to empower female farmers thereby augmenting their productivity and ultimately fostering the advancement and development of the farm women engaged in the activity.

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