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Original Article

Risk factors for musculoskeletal disorders in manual harvesting farmers of Rajasthan

Rahul JAIN[1, 2]*, Makkhan Lal MEENA[1], Govind Sharan DANGAYACH[1] and Awadhesh Kumar BHARDWAJ[1]

[1]Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur, India
[2]Department of Mechanical Engineering, University Teaching Department, Rajasthan Technical University Kota, India

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Abstract: Manual harvesting is a physically demanding occupation with several work-related issues in which musculoskeletal disorders (MSDs) happen most commonly. The risk factors for MSDs among manual harvesting farmers are not investigated properly in low and low-middle-income nations. Therefore, a study among 140 farmers of Rajasthan, India was carried out through the usage of Nordic Musculoskeletal Questionnaire and the Rapid Upper Limb Assessment (RULA) technique to identify ergonomic risks. χ^2 analysis was used to find the relationship between the MSDs and various factors. Also, logistic regression methodology was applied to get the most influencing factor for MSDs in different body regions. The lower-back, fingers, shoulders and wrists/hands were the body parts in which more than 50% workers reported MSDs. MSDs in one or more body regions were found to be associated with age, daily working in farms, farming experience, gender, hand dominance and perceived work fatigue. The age was majorly associated with MSDs in all body regions except the shoulder and neck as per the outcome of logistic regression. The outcome of RULA grand score had been found higher than or equal to 5 in 92% of the farmers which give directions for further research and changes.

Key words: Agriculture, Farmers, Logistic models, Low back pain, Risk factors

Introduction

Agriculture is a challenging occupation in which farmers suffered from various work-related problems and musculoskeletal disorders (MSDs) are common problem[1)]. The main factors of these problems are among the less technically advanced sector workers (i.e., agriculture, construction, handicraft, etc.), especially involved in stooped posture and repetitive manual tasks. These factors can be divided into individual, work characteristics and tool-related factors[2–6)]. Manual harvesting expose farmers to risk of development of MSDs. The high prevalence of MSDs in this sector may be attributed to various types of repetitive awkward movements (i.e., frequently working with the flexed back area, lifting and bringing heavy loads, etc.) and poor working postures (i.e., squatting, kneeling, etc.) sustained by workers for long working hours[4, 7)]. In various operations (i.e., weeding, cutting, sowing, etc.) and during the manual harvesting work, the worker adopts such postures in which trunk and head move forward with slight inclination for better cutting/holding of the product/crop. Literature[8, 9)] shows that several operations such as cutting/harvesting crops and weeding, generates excessive physical strain on the musculoskeletal system which may further contribute to development of MSDs among

*To whom correspondence should be addressed.
E-mail: rjmahesh207@gmail.com

the farmers. Therefore, to reduce/prevent MSDs, there is a need to find out the possible risk factors related to such problems among the manual harvesting farmers.

MSDs, particularly in the trunk, shoulders, and hands/wrists are progressively frequent in Asian producers[10–15]. In India, various studies[10–12, 15] have reported MSDs in farmers and work related upper limb disorders occurrence rates for farmers reported at about 63–98%. To date there is limited study available on the prevalence of MSDs and their contributing risk factors for manual harvesting farmers.

Specific region or state wise study of MSDs in India is advantageous as the race and cultures of Indian populace variates from state to state[16]. Also, most of the manual harvesting farmers belong to India[17]. There are more variations in working culture, environment, resource availability for farming of Rajasthan and other Indian states. The Rajasthan, a part of low-middle-income nation in India has a population of 57 million. The economy is primarily based on agriculture. Roughly 70% of the people in Rajasthan live in rural regions and mainly reliant on farming and around 30% of the total state's income is generated by this occupation[18]. In this region, wheat and rice farming is a vital cultivation occupation done by farmers. The main activities in wheat and rice farming include carrying and planting seeds, picking and carrying crops, ridging, sowing, spading, sprinkling water, and weeding. During such strenuous activities, farmers most repeatedly have to take up awkward postures (i.e., squatting, kneeling) that causes discomfort in multiple body regions.

The current study was carried out to determine the MSDs prevalence and contributing risk factors (individual and work-related) among manual harvesting farmers in Rajasthan, India.

Subjects and Methods

The current study was conducted in the form of cross-sectional research among selected villages of Eastern Rajasthan, where manual harvesting is done mostly by farmers. According to Directorate of Economics & Statistics, Government of Rajasthan[19] data collected in the year 2011, there were 18.6 million farmers in the Rajasthan. Slovin's formula was used to find out the number of farmers to be surveyed. Therefore, to maintain the data collection error of 5%, a total of 100 farmers were required to be surveyed. The research was conducted on total 140 farmers (114 Males, 26 Females) on the field site.

In this study, the information was acquired by sets of the questionnaire used in the previous study[4] and direct observations of the farmers as a subject for posture analysis. The sets of the questionnaire were divided into following three segments.

Musculoskeletal disorders: Subjects were requested to report in the form of 'Yes' or 'No' if they had any trouble in various upper extremity body parts (i.e., neck, shoulders, upper and lower back, fingers, elbows/forearms, and hands/wrists) during the last six months.

Demographic information: The demographic section of the questionnaire consisted of demographic questions like age, gender, schooling, hand domination, anthropometric data (i.e., weight, height) and smoking habit.

Work history: In the last section of the questionnaire, questions were asked about daily working in farms and farming experience. The multi-method ergonomic review technique (MMERT) was used for salary, hand tool satisfaction, and perceived work fatigue. MMERT is an individual scale approach which has scores from 0 to 2.

Posture analysis

The static working posture taken by each subject was assessed using rapid upper limb assessment (RULA) method[20]. An independent RULA practice was done for every subject by direct observation. The study was approved by the ethics research committee of mechanical engineering at Malaviya national institute of technology Jaipur and conducted according to the Helsinki guidelines[21]. Each participating village (Dhulet, Bapawar, Chandresal, Arjunpura, Bajad, Keshoraipatan, Palayata, and Anta) from four districts (Kota, Bundi, Jhalawar, and Baran) of eastern Rajasthan approved the conduct of the survey and signed informed consent was taken from all the subjects.

Statistical analysis

The IBM SPSS (version 22.0) was used for statistical analysis. Statistical investigations of the individual, work-related factors and ergonomic risks among the subjects of current study were disclosed as a mean ± standard deviation (SD) and frequencies/rates for different categories of every factor. χ^2 analysis was used to evaluate the univariate association between factors (individual, work-related characteristics and RULA scores) and MSDs scores. Significance was checked for $p<0.05$ and χ^2 value calculated. Binary logistic regression examination was utilized to determine the odds ratio (OR) of various risk factors. The independent variables were age, daily working in farms, farming experience, gender, hand domination, perceived work fatigue and RULA scores. The dependent variables were discomfort scores in different upper extremity body

Table 1. Six month occurrence of MSDs by body site (N=140)

Body part	Rate	Proportion (%)
Neck	59	42.1
Shoulders	80	57.1
Elbows/forearms	66	47.1
Wrists/hands	78	55.7
Upper back	52	37.1
Lower back	103	73.6
Fingers	90	64.2
Any site	109	77.9

parts (i.e., elbows/forearms, fingers, lower back, neck, shoulders, upper back, wrists/hands, etc.). Significance was checked for $p<0.05$ and 95% confidence intervals (CI) computed.

Results

MSDs and investigating factors

The results of this study shows that the highest prevalence frequency of MSDs was found in the trunk region. Further, the results also showed that 77.9% of the subjects experienced MSDs on one or more body part over the last six months. Fingers, wrists/hands and shoulders complaint were reported by 64.2%, 55.7% and 57.1% of the subjects, respectively. Approximately 74% of subjects reported low back complaints. The occurrence of MSDs for various body regions during the six months is presented in Table 1.

The mean of the age groups of the males (81.4%) was 34.25 (SD: 9.65), females (18.6%) was 38.36 (SD: 10.42), and approximately. 81% subjects were greater than 26 yr. A high proportion (85.7%) of the subjects had high school knowledge. It was also identified that 77.1% of the subjects were smokers. Table 2 shows that the subjects' mean BMI was found to be 22.12 (SD: 3.61). Approximately one-fourth of subjects (24.2%) had a BMI in the range of 25–30.

The average year of working in farms was 10.62 (SD: 5.41) yr. The average daily working in farm by the subjects were 7.35 (SD: 2.29) h a day. It was observed that 63.57% of the subjects had been working from 5–15 yr, and 18.57% of them had been working as a farmer for more than 15 yr. Table 2 also shows that 70% of the subjects in the study worked for greater than or equal to seven hours a day. There was only one break during the whole working day: a one-hour lunchtime. Most of the subjects used hand tools like the sickle, spade, long and short-handled hoes. The majority of the subjects (80.71%) used their right arms during the work. Also, the greater amount of subjects (88.58%) indicated that they were dissatisfied by working with existing hand tools. Also, the disturbed or moderate level of fatigue due to working long hours was reported by 68.57% subjects. Most of the workers did not employ any gloves or safety accessories at work. Few of female subjects used cotton gloves, but they were very few (2 out of total 26 females). Before starting the investigation, knowledge and experiences of correct farm work approaches by subjects in current study sample was checked. No ergonomic or appropriate applications were being carried out by the subjects. According to χ^2 analysis most of the individual and work-related factors were associated with MSDs scores except smoking habit. When the relations between the prevalence of MSDs and RULA scores were evaluated, no statistically significant relation was found with score B (neck, trunk, leg score). However, score A (upper-lower limb and wrist score) and the RULA grand score were associated with MSDs ($p<0.05$).

Association of risk factors with MSDs in different body regions: regression analysis

Table 3 shows the associations of MSDs in various body parts with individual and work-related factors. Age was associated with the occurrence of pain in upper back (OR=1.06, 95% CI: 1.00–1.13, $p<0.05$), wrists/hands (OR=1.12, 95% CI: 1.04–1.21, $p<0.05$), fingers (OR=1.14, 95% CI: 1.05–1.24, $p<0.05$), and elbows/forearms (OR=1.14, 95% CI: 1.06–1.23, $p<0.05$). Neck complaints were only associated with the subjects having the higher RULA score (>8) ($p<0.05$). The perceived work fatigue was associated for high level of complaints in elbows/forearms (OR=3.03, 95% CI: 1.05–8.72, $p<0.05$).

From Table 3, it is clear that the RULA score A was associated with the complaints in hand region (wrists/hands, fingers and elbows/forearms) which shows that high risk was generated due to working on traditional hand tools. RULA score B was associated with the complaints in neck (OR=0.45, 95% CI: 0.20–0.98, $p<0.05$).

RULA scores

The sample's mean RULA score A, score B and grand score were obtained 4.6 (SD: 1.3), 6.3 (SD: 1.6) and 5.9 (SD: 1.1), respectively. The ultimate mean RULA score of 5.9 suggests that the subjects' positions at the farms require further examination, and some changes are needed instantly. Table 4 displays the action levels wise distribution of RULA scores for the subjects.

Table 2. Individual and work-related characteristics and their association with musculoskeletal disorders (N=140)

Independent factor (n[a])	Statistics mean (SD)	Musculoskeletal Disorders		Significance
		With MSDs %[b] (109)	Without MSDs %[b] (31)	
Age (yr)				
≤25 (26)	Male: 34.25 (9.65) Female: 38.36 (10.42)	50	50	S
26–40 (84)		81	19	
≥41 (30)		93.3	6.7	
Gender				
Male (114)	–	82.5	17.5	S
Female (26)	–	57.7	42.3	
Body mass index				
<18.5 or underweight (22)	22.12 (3.61)	68.1	31.9	S
18.5–24.9 or normal weight (84)		84.5	15.5	
25–29.9 or overweight (33)		66.8	33.2	
≥30 or obesity (1)		100	0	
Hand domination				
Left hand (27)	–	59.3	40.7	S
Right hand (113)	–	82.3	17.7	
Smoking				
Yes (108)	–	81.5	18.5	NS
No (32)	–	65.6	34.4	
Schooling				
Primary (15)	–	53.3	46.7	S
High school (120)	–	81.7	18.3	
Graduate (5)	–	60	40	
Farming experience (yr)				
≤5 (25)	10.62 (5.41)	68	32	S
5–15 (89)		76.4	23.6	
≥15 (26)		92.3	7.7	
Daily working in farms (h)				
≤6 (42)	7.35 (2.29)	64.3	35.7	S
≥7 (98)		83.7	16.3	
Salary satisfaction				
Low (54)	–	66.7	33.3	S
Moderate (50)	–	90	10	
High (36)	–	77.8	22.2	
Perceived work fatigue				
Low (44)	–	75	25	S
Moderate (63)	–	71.4	28.6	
High (33)	–	93.9	6.1	
Hand tool satisfaction				
Low (124)	–	81.5	18.5	S
Moderate (0)	–	0	0	
High (16)	–	50	50	
RULA/ A score				
≤5 (110)	4.66 (1.30)	81.8	18.2	S
≥6 (30)		63.3	36.7	
RULA/B score				
≤7 (100)	6.33 (1.58)	75	25	NS
≥8 (40)		85	15	
RULA/grand score				
≤6 (60)	5.94 (1.08)	71.7	28.3	NS
≥7 (80)		82.5	17.5	

MSDs: musculoskeletal disorders; S: significant; NS: not significant; SD: standard deviation.

[a]n: quantities in braces demonstrates the total count in that variable in the first column, [b]percentage computed for each category of all factors with MSDs and without MSDs.

Table 3. Factors related with risk of pain in different body parts of manual harvesting farmers—binomial logistic regression (N=140)

Factor	Neck (n=59)			Upper back (n=52)			Shoulder (n=80)			Lower back (n=103)			Wrists/hands (n=78)			Fingers (n=90)			Elbows/forearms (n=66)		
	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*
Age	1.02	0.96–1.08	NS	1.06	1.00–1.13	S	1.02	0.96–1.08	NS	1.05	0.97–1.13	NS	1.12	1.04–1.21	S	1.14	1.05–1.24	S	1.14	1.06–1.23	S
Gender																					
Female	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
Male[a]	0.39	0.14–1.08	NS	0.58	0.21–1.59	NS	1.17	0.46–3.01	NS	0.73	0.26–2.07	NS	0.24	0.08–0.70	S	0.45	0.15–1.31	NS	0.28	0.09–0.86	S
Hand domination																					
Left hand	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
Right hand[b]	0.74	0.30–1.83	NS	0.79	0.31–2.01	NS	0.57	0.23–1.38	NS	1.95	0.63–6.00	NS	1.07	0.41–2.76	NS	0.56	0.21–1.52	NS	0.69	0.26–1.85	NS
Farming experience (yr)	0.96	0.87–1.06	NS	1.01	0.91–1.11	NS	0.96	0.87–1.06	NS	0.99	0.88–1.11	NS	0.93	0.84–1.03	NS	1.01	0.90–1.13	NS	0.95	0.85–1.06	NS
Daily working in farms (h)																					
≥7	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
≤6[c]	0.99	0.37–2.65	NS	0.85	0.31–2.41	NS	1.54	0.58–4.12	NS	1.52	0.52–4.47	NS	0.74	0.26–2.07	NS	1.04	0.36–2.97	NS	0.92	0.33–2.63	NS
Perceived work fatigue																					
Low	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
Moderate	0.98	0.38–2.55	NS	0.88	0.33–2.31	NS	0.51	0.19–1.40	NS	1.23	0.44–3.49	NS	0.85	0.31–2.34	NS	1.61	0.55–4.74	NS	2.89	0.99–8.42	NS
High[d]	0.76	0.30–1.94	NS	0.78	0.30–2.00	NS	0.39	0.15–1.03	NS	2.68	0.89–8.11	NS	1.84	0.67–5.04	NS	2.51	0.84–7.46	NS	3.03	1.05–8.72	S
RULA/ A score																					
≤5	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
≥6[e]	1.29	0.51–3.22	NS	1.47	0.58–3.74	NS	1.54	0.62–3.80	NS	1.94	0.71–5.27	NS	3.29	1.23–8.77	S	4.66	1.63–13.34	S	3.1	1.12–8.60	S
RULA/ B score																					
≤7	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
≥8[f]	0.45	0.20–0.98	S	1.4	0.62–3.17	NS	0.75	0.34–1.66	NS	0.56	0.21–1.49	NS	0.51	0.22–1.21	NS	0.73	0.29–1.86	NS	0.48	0.20–1.15	NS

OR: odds ratio; p: significance value; 95% CI: 95% confidence interval; S: significant; NS: not significant.

[a]Interpretation: assessed for female subjects, the OR of pain in particular body part of male subjects.

[b]Interpretation: assessed for subjects who do work with the left hand, the OR of pain in particular body part who do work with the right hand.

[c]Interpretation: assessed for subjects who do farming more than 7 h daily, the OR of pain in different body part who do farming work less than 6 h.

[d]Interpretation: assessed for subjects who have high level of fatigue in using the existing hand tool, the OR of pain in a particular body part in those who stated they had high level of fatigue in using the current hand tool.

[e]Interpretation: assessed for subjects who have RULA score A higher than 6, the OR of pain in a particular body part in those who stated they had high score in using the current hand tool.

[f]Interpretation: assessed for subjects who have RULA score B higher than 8, the OR of pain in a particular body part in those who stated they had high score in using the current hand tool.

Table 4. RULA score categories (N=140)

Action Level	RULA Score	Level of MSD risk	Percentage (%)
AC1	1–2	Minor risk, no action necessary	0
AC2	3–4	Little risk, modification may be desirable	8
AC3	5–6	Medium risk, further examination, change soon	49.1
AC4	≥7	Very high risk, implement change promptly	42.9

Discussions

The outcomes showed that 77.9% of the participants reporting pain in at least one body part which proves that MSDs are prevalent among the manual harvesting farmers. This MSD prevalence outcome is more than the results of review done by Osborne *et al.*[22] in 2012 (six month MSD prevalence rate: 77.0%). After 2012, various researches have also determined the MSD prevalence rate. In farmers of Trinidad, Baksh *et al.*[23] found the overall MSD prevalence 61%, and in other study of Malaysian farmers by Ng *et al.*[13], MSD prevalence among manual working farmers was 43.4%.

In accordance with χ^2 outcomes, individual factors including gender (being male), age (>25 yr), hand domination (right-handed) and lower schooling (less than or equal to high school) were associated with the prevalence of MSDs. Work-related factors such as, working years as a manual harvesting worker (>5 yr), working on exiting hand tools (high amount of dissatisfaction), and working postures were also found to be associated with the MSDs. Furthermore, the results of this study showed that farmers with a higher schooling (graduate level) were less likely to report MSDs than others. Since the schooling level was a significant factor in the χ^2 analyses of MSDs, this result would have not been due to chance. Therefore, it is thinkable that, farmers with a lower schooling are less aware of ergonomic philosophies and appropriate methods of working compared to farmers with higher schooling. This outcome recommends the necessity for education/training of those farmers who are less knowledgeable about the effects of various awkward postures during the work which further develops MSDs among the manual farmers.

There were various significant outcomes concerning the relation of individual and work-related factors to MSDs in different body regions. The outcomes of regression analysis showed that gender was an important factor for MSDs development in various upper extremity body parts except shoulder problems, as males reported higher MSDs as compared to females. In a recent meta-analysis review[24] for risk factors for agriculture injury, it is reported that male farmers have greater amount of injuries than female farmers. It was also revealed that age was associated with pain in upper back, wrists/hands, fingers and elbows/forearms. It is observed that as a result of upgrading the activity (especially cutting and weeding) by designing new interventions may help for preventing MSDs among farmers in the near future[15]. The results dictates for the need to consider other physical and psychosocial factors of manual harvesting farmers. Excitingly, outcomes of current study showed that perceived stress due to work was one factor among the psychosocial factors that was associated with the prevalence of MSDs in the wrists/hands and elbows/forearms areas which is in line with the findings of Jain *et al*[4]. It must be noted that participants in the current study were paid per unit of land area they harvest/cut, which shows that employer provides an incentive to farmer only when they work at high speed and skip suitable rest breaks during the work. Furthermore, the outcome showed that the time of working as a manual harvesting farmer was associated with the occurrence of MSDs in the wrists/hands, which is in line with several previous findings among less advanced sector groups[5, 7, 25]. The outcomes from other earlier studies indicate that long working hours in the stooped postures without a break may increase the risk of MSDs among farmers[8, 9], and that consistent rest breaks may decrease/prevent the risk of MSDs[26]. Therefore, farmers involved in manual agriculture activities may be advanced to take consistent rest breaks so as to minimalize risk of MSDs.

According to the logistic regression outcomes, it is clear that awkward postures and traditional tool usage were also an important risk factor for pain in the wrists/hands, fingers, and elbows/forearms among farmers involved in manual harvesting. It is also observed that the manual harvesting farmers in the current study had repeated phases of uninterrupted work in stooped posture without breaks (e.g., cutting/harvesting task in a squatting posture), which was associated with the incidence of MSDs in lower back and wrists/hands areas. This outcome underlines the significance of biomechanical chances of risks for the farmers participated and presents further indication that manual

harvesting operations include repeated and twisting movements of the hand for the long period of the activity. Outcomes of current study also showed that the RULA scores for the farmers' arms and wrists (score A), necks, trunks, and legs (score B), and the grand scores were high. The high RULA scores in the current study emphasise that the stooped postures of the farmers were forced by features of the manual harvesting operations, and also the existing design of the hand tools had a significant effect on the postures taken. This implies that, in most of the situations, working postures of farmers under study required to be studied and changes/modifications are required instantly. These outcomes are in line with various previous studies[4, 8–12] of poor working postures (assessed by the RULA method) among agriculture farmers for various agriculture operations (i.e., cutting/harvesting crops, weeding, sowing, etc.).

The current study has an advantage that observer error was managed utilizing two qualified assessors in contrast to investigations in which there were single observers for each situation. However, the outcomes represented should be understood in the background of the cross-sectional study design. Furthermore, the outcomes underline the significance of both individual and work-related factors of manual harvesting operations in association with MSDs. Although the individual factors (i.e., age, gender, and schooling) have more significance as compared to the work-related factors, which can be treated as possible confounders in future investigation of MSDs among the farmers.

In conclusion, the outcomes emphasize the significance of both individual and work-related factors of manual harvesting operations in association with MSDs and underline the necessity for ergonomic interventions to enhance the farm working environment. Specially, one suggestion may help to correct working postures by designing the hand tools (e.g., based on anthropometry of Indian famers'). Furthermore, manual harvesting farmers involved in these operations may also be advised to use consistent rest breaks in order to lessen exposure and also to help recovery from awkward postures.

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Conflicts of Interest

Corresponding author declares that all the participating authors has no conflict of interest.

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