Musculoskeletal & Risk Assessment during Threshing of Rice-grains

Debesh Mishra[1], *Suchismita* Satapathy[2,*]
[1,2]School of Mechanical Engineering, KIIT, Bhubaneswar, Odisha, India

Abstract. In the present study 25 farmers of five villages of South Odisha in India were considered to assess their musculoskeletal disorders (MSD) during threshing of crops. A "Standardized Nordic Questionnaire" was prepared to collect MSD data considering harvesting characteristics, socio-demographic characteristics, economical characteristics about the requirements, and work setting characteristics, by using a five point rating scale i.e. (1 = Very less, 2 =Less, 3 = Nil, 4 = Strong, 5 = Very Strong) for a period of 2 years i.e. from 2015 to 2017. Socio-demographic characteristics and Work setting characteristics of farmers were illustrated to depict the MSD level in different body parts like neck, shoulder, upper back, lower back, elbow, wrist/hand, thigh, knees and ankles, respectively. Factor analysis was performed for threshing characteristics, and economical characteristics, and different parameters under different dominant factors were grouped accordingly. To illustrate the linkage and linear relationship between important parameters, Pearson correlation coefficient matrix was generated for the threshing characteristics of farmers. Also the regression analysis was done to obtain the best-fit linear regression equations for the economic characteristics of farmers. Finally posture analysis was performed for different postures in threshing activities by using the Ovako Working-Posture Analysis System (OWAS) & Rapid Entire Body Assessment (REBA) technique.

1 Introduction

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. Most of the jobs are designed based on the anthropometric dimensions of men and this is the cause for lower productivity, discomforts 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 [9]. A detailed literature review of the musculoskeletal disorders of women farmers in India was studied [14] and concluded with a number of disorders in body parts with different body postures. Also it was recommended for ergonomically design of women tools and equipments, and to have work rest periods. Fifteen farmers were analyzed during milking, lifting, carrying a full bucket and in moving tractor. The surface electromyography system and Job Strain Index method were used to analyze the muscle load. Highest muscular tension and force were reported in the forearm muscle while attaching teat cups to udder [8]. The work related musculoskeletal disorder are aggravated mainly due to the performance of work, or associated work setting [3]. The musculoskeletal disorders are the most important cause of tenderness, disabilities, non-attendance, lower productivity and financial losses for the workers throughout the world [16]. The seriousness of work related musculoskeletal disorders were highlighted and it was also reported that the prolonged exposure to loads due to variable work intensity leads to musculoskeletal disorders [6]. The workers engaged in meat processing were studied and various activities involving repetitive movements, more application of forces, high working rate and incorrect postures for a longer duration were identified [1, 10]. It was suggested that the hazards such as infection, lung cancer and knife related injuries are more evident in case of butchers [4]. It was reported that the butchers are more subjected to work related musculoskeletal disorders [11]. It was suggested that as the farmers are self employed they have the right and freedom to change or stop some sort of work, if they feel inconvenience in their work due to fatness [12]. The bio-mechanical evaluation of manual material handling tasks of a construction site in India was studied and it was found that the compressive forces at some disc are above the threshold value for the construction workers. It was suggested to have improvement in ergonomic performance for manual material handling tasks [13]. The musculoskeletal disorders of the farmers of Kanpur in India was reported as lower back (60%), knee (39%), shoulder (22%), neck (10%); and a higher chronic afflicted for nearly a year [5]. The occurrence of work related musculoskeletal disorders was reported to be more between the butchers in Kano city and very few only avail the medical facility. Also age was found to be the main risk factor in this regard [2]. The development of musculoskeletal disorders (MSD) is mainly due to awkward and uncomfortable working postures [15].

* Corresponding author: suchismitasatapathy9@gmail.com

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India is well known for its agricultural sectors and Odisha being one of the prominent states in this country, where most of the farmers prefer cultivation of rice. The farmers in the rural areas mainly prefer to use the traditional tools and techniques for farming purpose, and very few of them use the modern mechanized techniques. It has been found that most of the farmers undergo the musculoskeletal disorders (MSD) because of a number of risk factors such as repetitive work, incorrect postures, improper use of tools and techniques etc. Hence an attempt was made to collect and analyze the MSD data for the farmers in South Odisha.

2 Methodology

The rice cultivation process involves land preparation, seeding and weeding, harvesting and threshing processes. For the present study five villages were selected randomly from Odisha state in India, and 25 farmers engaged only in threshing activities were considered. Before collecting the information and data, a team comprising of three members was formulated. The members were well informed about the purpose and methods to collect information and data. Prior consent was obtained from the respective village heads or leaders. All members visited the farmers personally in the evening time, and some on the morning time while they were in respective works. The information for the consequent visits to the farmers and other villages were obtained from the previous visits and talking to the farmers. The same procedure was followed in other villages also. A standardized Nordic questionnaire was prepared to collect the information and data regarding name, gender, age, other personal characteristics, socio-demographic characteristics, economical characteristics about the requirements, and work setting characteristics as the factors associated with the musculoskeletal disorders with a five point rating scale i.e. (1 = Very less, 2 =Less, 3 = Nil, 4 = Strong, 5 = Very Strong). Various body parameters considered to be affected with MSD were neck, shoulder, upper back, lower back, elbow, wrist/hand, thigh, knees and ankles, respectively. The information was collected considering 2 years period i.e. from 2015 to 2017. A total 25 farmers were selected from all the five villages and the MSD data were recorded based on their present and past experience involved in threshing operations. Stick diagrams were drawn based on the digital photography of different frequently occurring postures taken during threshing activities, and was subjected for analysis by using both the “Ovako Working Posture Analysis System (OWAS)” and the “Rapid Entire Body Assessment (REBA)” technique.

3 Result and Discussion

In the present study 25 farmers were selected for the analysis purpose. From the socio-demographic characteristics of farmers (Table.1), it was observed that maximum musculoskeletal disorders of farmers were reported in wrist for age groups <38 & >38, in lower back and shoulder of female farmers, in upper back of male farmers. For education levels, more disorders were reported in wrist for under primary, in thighs for primary to high schools, and elbow for more than high schools. Most of the disorders were found in various body parts irrespective of experiences, marital status, smoking habits, eating food habit per day, previous weaknesses. The shoulder and wrist were more affected by the left & right handed farmers, the farmers’ exposure to wet and humid soil, respectively. Similarly considering the work setting characteristics of farmers as shown in Table.2, high incidence of musculoskeletal disorders(MSD) were found in Lower back & Knees for sitting postures, and neck, upper back, lower back, Knees and Ankles in squatting postures, and upper back, lower back, Wrist and Knee in standing postures. The occurrence of MSD in shoulder & wrist were more significant irrespective of working hours per day, working days per week and working time per day, respectively. Also it may be observed that repetitive jobs produce more MSD in neck, elbow, wrist and knees. Carrying heavy loads resulted in high MSD in shoulder, lower back and wrist, respectively.

Table 1. Socio-demographic Characteristics of Farmers (n=25)

Sl. No.	Parameters		No. of farmers reported of suffering of musculoskeletal disorders (MSD)								
			Neck	Shoulder	Upper Back	Lower Back	Elbow	Wrist/Hand	Thigh	Knee	Ankle
1.	Age	< 38	16	21	19	22	15	23	14	15	19
		> 38	16	20	21	20	16	22	15	15	13
2.	Gender	Male	15	19	24	15	15	17	20	15	15
		Female	18	25	19	25	16	20	14	20	15
3.	Education Level	Under primary	15	10	13	16	15	18	16	23	16
		primary to High school	10	12	15	09	15	15	21	13	20
		More than High school	17	19	17	19	20	17	17	19	19
4	Exper	< 1	1	15	1	1	1	18	1	1	1

.	ience	Year	8		9	9	9		5	8	9
		1-10 Years	19	22	18	15	18	18	15	18	19
		>10 Years	19	17	19	14	21	18	19	18	19
5.	Marital Status	Un-married	13	25	18	15	19	25	16	14	14
		Married	16	23	21	25	18	25	16	17	17
6.	Smoking habits	Non-Smoker	20	25	15	11	10	25	12	17	11
		Smoker	22	25	25	25	11	25	02	25	09
7.	Eating food habit per day	< 2	08	25	17	16	15	25	17	14	07
		> 2	12	25	17	17	20	25	14	20	18
8.	Handedness/ Dominant hand	Left-handed	16	25	19	22	17	25	17	16	14
		Right-handed	15	25	15	15	15	25	15	18	18
		Mixed-Handed	12	19	13	16	15	14	12	15	15
9.	Exposure to wet and humid soil	Low land	12	25	17	14	15	25	15	12	15
		Up land	18	25	16	21	22	25	20	18	17
		Wet land	13	25	16	15	15	25	15	15	12
		Dry land	12	25	16	18	15	25	15	15	12
		Horizontal/Plain	21	25	21	22	18	25	15	21	09
		Sloped	15	25	22	20	22	25	15	15	16
10.	Previous weakness/injuries, if any		11	25	14	18	19	25	19	19	14

n= Total number of farmers.

Table 2. Work Setting Characteristics of Farmers (n=25)

Sl. No.	Parameters	No. of farmers reported of suffering of musculoskeletal disorders (MSD)								
		Neck	Shoulder	Upper Back	Lower Back	Elbow	Wrist/ Hand	Thigh	Knee	Ankle
1.	Working posture(s)	Sitting	12	18	16	24	16	16	19	24	16
		Squatting	25	19	25	25	15	18	15	25	25
		Standing	17	16	25	25	17	25	16	25	18
2.	Working hours/day	< 3	15	24	22	15	21	18	18	16	21
		> 3	21	24	21	18	15	23	16	15	14
3.	Working days/week	< 4	16	25	18	17	16	25	18	16	16
		> 4	15	25	15	12	16	25	16	17	16
4.	Working time(s)/day	Before 8 A.M.	17	25	19	15	17	25	16	18	17
		8 A.M. – 12 P.M.	12	25	12	12	25	25	07	13	17
		After 12 P.M.	10	25	25	25	18	25	14	25	25
5.	Nature of job	Repetitive/forceful	25	13	20	16	25	25	19	25	19
		Carrying heavy loads	20	25	19	25	15	25	17	17	13

n= Total number of farmers.

Factor analysis using SPSS 22.0 for the threshing characteristics of farmers, and economical characteristics of farmers was performed as shown in Table 3 and Table 4, respectively. The principal component analysis method with rotated component matrix was used and the variables with factor loading more than or equal to 0.5 were only considered. For factors selection, Kaiser's Eigen value criteria with Eigen value greater than 1 were selected [7]. The factor analysis of threshing characteristics of farmers (Table 3) resulted in 3 dominant factors with cumulative % of variance of 79.42 %. In factor1, the factor loading is high in both in Injuries from manually operated Thresher by using hand operated mechanical Thresher and in musculoskeletal problems from incorrect postures in Threshing which is 0.963. As the variables in factor 1, corresponds to injuries & musculoskeletal disorders. Hence the factor1 is named as Discomfort. The factor loading in factor 2 is high in Exposure to vibration of threshing machines which is 0.942. Other variables in factor 2 are related to the aid of external appliances. The factor 2 is named as External. The factor loading in factor 3 is high in Exposure to noise of threshing machines i.e. 0.933. The factor 3 is named as Operation.

Similarly, the factor analysis for economical characteristics of farmers resulted in 2 dominant factors (Table 4). The factor 1 is named as Tangibility and factor 2 as Intangibility, based on the physical characteristics of variables.

Table 3. Threshing Characteristics of Farmers (n=25)

Parameters		Factor 1 (Discomfort)	Factor 2 (External)	Factor 3 (Operation)
1.Injuries from manually operated Thresher	a) Striking on wooden frames	0.606		
	b) Using hand operated mechanical Thresher	0.963		
	c) Using Draft animal driven Thresher		0.853	
2.Exposure to vibration of Threshing machines			0.942	
3.Exposure to noise of Threshing machines				0.933
4.Musculoskeletal problems from incorrect postures in Threshing		0.963		
5.Exposure to grain dust			0.718	
Eigen value		2.66	1.82	1.07
Variance in %		38.11	26.01	15.28
Cumulative variance in %		38.11	64.13	79.42

n= Total number of farmers.

Table 4. Economical Characteristics of Farmers (n=25)

Parameters	Factor 1 (Tangibility)	Factor 2 (Intangibility)
1.Compliance with cost	-0.659	
2.Cost reduction of existing Appliances	0.665	
3.Quality	0.818	
4.Service capability		0.869
5.Innovativeness		0.909
6.New use of technologies / modifications of design	0.727	
Eigen value	3.03	1.05
Variance in %	50.61	17.49
Cumulative variance in %	50.61	68.11

n= Total number of farmers.

The Pearson Correlation coefficients between various dominant factors in the threshing characteristics of farmers, to illustrate the strength & linear relationship of various variables under consideration are shown in Table 5. The correlation coefficient matrix was obtained by using Pearson product moment correlation in IBM SPSS 22.0. Very high correlation coefficient i.e. 0.991 is in between the factor 1(Discomfort) i.e. in between 'Injuries from manually operated Thresher' by using hand operated mechanical thresher and by using Draft animal driven thresher. While the smallest correlation coefficient i.e. 0.012 is between the factor 1(Discomfort) and factor 3(Operation), which is between 'Injuries from manually operated Thresher' by striking on wooden frames and 'Exposure to noise of Threshing machines'.

Using regression analysis for the Economic Characteristics, the best fit linear regression equation between Innovativeness and other Economic Characteristics are illustrated in Table 6. The economic parameters such as Cost reduction of existing Appliances, Service Capability, and Innovativeness were found to be significant at $p< 0.01$.

Table 5. Correlation Coefficient matrix for threshing characteristics

Factors		A	B	C	D	E	F	G
Factor 1 (Discomfort)	A	1.000						
	B	0.397*	1.000					
	C	0.397*	0.991**	1.000				
Factor 2 (External)	D	-0.104	-0.282	-0.282	1.000			
	E	-0.213	-0.095	-0.095	0.789**	1.000		
	F	-0.197	-0.034	-0.034	0.405*	0.533**	1.000	
Factor 3 (Operation)	G	0.012	0.136	0.136	0.032	-0.141	0.182	1.000

*.Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Note: A-Injuries from manually operated Thresher by striking on wooden frames, **B**-Injuries from manually operated thresher by using hand operated mechanical thresher, **C**-Musculoskeletal problems from incorrect postures in threshing, **D**- Injuries from manually operated thresher by using draft animal driven thresher, **E**- Exposure to vibration of threshing machines, **F**- Exposure to grain dust, **G**- Exposure to noise of threshing machines.

Table 6. Best-fit Linear Regression Equation between Innovativeness (X_5) and other Economic Characteristics

Sl. No.	Parameters	Regression Equation	F
1.	Compliance with cost(X_1)	$X_5 = 4.615 - 0.313\ X_1$	2.77
2.	Cost reduction of existing Appliances(X_2)	$X_5 = 1.396 + 0.630\ X_2$	11.48**
3.	Quality(X_3)	$X_5 = 2.94 + 0.217\ X_3$	0.82
4.	Service capability(X_4)	$X_5 = 1.196 + 0.682\ X_4$	19.06**
5.	Innovativeness(X_5)	X_5= 1.82 - 0.149 X_1 + 0.486 X_2 - 0.312 X_3 + 0.509 X_4 - 0.048 X_6	5.28**

6.	New use of technologies/modifications of design(X_6)	$X_5 = 2.958 + 0.251\ X_6$	1.93

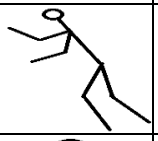
** Correlation is significant at $p < 0.01$

Cultivation of rice involves preparation of land, seeding, weeding, harvesting, & threshing activities. Usually the threshing of crops is done to separate the rice grains from the harvested stem of crops. In the traditional methods of threshing either the stems are stroked on some wooden frame, or some loaded element is made to move on the stems with the help of draft animals. Due to high fatigue involved in the traditional techniques, the farmers prefer to use the developed mechanical threshers. In the mechanical threshers, the stems of crops are fed against some rotating drum with projected fins such that the fins separate the grains from the stems. From the Analysis of Working Posture using Ovako Working Posture Analysis System (OWAS) as shown in Table 7, striking of stems on wooden frame involves back bent forward & back ward, both arms below & above shoulder level, both knees bent, weight or force less than 10 kg, and the obtained action category is 4 indicating an immediate corrective measure. Threshing using draft animals involves forward walking or movement, arms below shoulder level, knees bent & straight, force less than 10 kg and the obtained action category is 4 indicating an immediate corrective measure. Similarly, threshing using hand operated mechanical thresher involves back bent, arms below shoulder level, knees bent, force less than 10 kg and the obtained action category is 3 indicating corrective measure as soon as possible. The postures considered in OWAS are further analyzed by using Rapid Entire Body Assessment (REBA) technique and the corresponding REBA score, risk levels and remarks are illustrated in Table.8. The risk levels are found to be high for both threshing by striking on wooden frame & using draft animals, indicating the corrective measure as "necessary soon". While for threshing by using hand operated mechanical thresher, the risk level obtained is medium indicating the corrective measure as "necessary".

Table 7. Analysis of Working Posture using Ovako Working Posture Analysis System (OWAS)

Actions/Activities	Figure of posture	Code	Action Category	Remarks
a) Striking on wooden frames		4141	4	Corrective measures to take immediately
b) Using Draft animal driven Thresher		4142	4	Corrective measures to take immediately
c) Using hand operated mechanical Thresher		2141	3	Corrective measures to take as soon as possible

Table 8. Analysis of Working Posture using Rapid Entire Body Assessment (REBA)

Actions/Activities	Figure of posture	REBA Score	Risk Level	Remarks
a) Striking on wooden frames		8	High	Necessary Soon
b) Using Draft animal driven Thresher		8	High	Necessary Soon
c) Using hand operated mechanical Thresher		7	Medium	Necessary

4 Conclusion

A well designed job which is supported by an elegant place of work and proper tools, allow the farmers to avoid unnecessary movements and stresses of the neck, shoulder and upper limb. However the actual performance of various tasks depends on the farmer. The present study concludes that almost all parts of farmer's body such as neck, shoulder, upper back, lower back, elbow, wrist, thigh, knee and ankles were subjected to musculoskeletal disorders. The prevention of musculoskeletal disorders (MSD) depends on recognition of the risk factors by self assessment, study on the job or work place and the study of working postures in various activities while performing the required tasks. It is also important to consider the incidence rate of disorders in workplace and the exposure to hazardous working or environmental conditions. 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.

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