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EVALUATION OF WORK RELATED MUSCULOSKELETAL DISORDER AND POSTURAL STRESS AMONG FEMALE CULTIVATORS ENGAGED IN POST HARVESTING TASKS

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ABSTRACT ■ In rice cultivation, post-harvesting tasks are essential for the preparation of rice. Mainly females are engaged in post harvesting tasks and they perform a sequential work through manual efforts. The present study was aimed to evaluate musculoskeletal disorder (MSD) and postural stress of workers during performing two post-harvesting tasks. The study was conducted on 70 adult female subjects. The MSDs were assessed by modified Nordic questionnaire method. Posture analysis was made by video graphic technique. Center of gravity (CG) and spinal curvature and of the workers were measured in normal erect posture and in different working postures. The results showed that the prevalence of MSDs was very high among the workers and the most affected area were back, wrist, shoulder, calf and knee etc. The incidence of MSDs was comparatively higher in threshing task than that of the parboiling task. The subjects had to adopt different stressful postures during performing post-harvesting tasks. The CG and spinal curvature in working posture were significantly deviated from neutral posture. The awkward work posture might be related to the MSD of the workers. From this study it has been recommended that workers should avoid bad work postures as far as possible during their work for reducing job related health hazards.

Key words: Post harvesting tasks, work posture, MSD

INTRODUCTION:

Agriculture is one of the major occupations in India. Agricultural tasks are carried out mainly through manual efforts. A large number of agricultural workers are engaged in rice cultivation in different states of this country including West Bengal state. The female are the backbone of agricultural work force but world wide her hard work has mostly been unpaid. In India, a large number of females are involved in agricultural activities and exert manual labour for crop production. Hasalkar et al (2004) estimated that about 70% of the Indian females are engaged in agricultural work either in their own fields or as hired laborers. In West Bengal the participation of female in agriculture are about 46.3% (Census of India, 2001).

In rice cultivation, post harvesting tasks are essential for the preparation of raw food materials. Post harvesting tasks consists of several steps including threshing, winnowing,

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parboiling, drying and storing etc. In agricultural fields, post harvesting activities are such type of jobs, where mainly female perform a sequential work pattern to produce boiled and dried grain (paddy), from which rice are made finally. Most of this step is done manually. Some tools are also used often. Each of the steps is strenuous and physiologically demanding. Female workers perform different post harvesting tasks in different postures and in different working conditions. Due to adopting different inappropriate postures during performing different post harvesting tasks, they are exposed to postural stress and may suffer from discomfort / pain in different parts of body. In these activities workers are engaged in repetitive tasks with high postural load due to constraints of work method and the working condition. In different phases of post harvesting tasks different pattern of works are performed. Forward bending, semi bending, walking, squat sitting, and twisting are the common postures in different times of performing the tasks. Some of the works are dominated by static muscular contraction and some other works are involved with repeated dynamic activity. In agricultural works, discomfort in different body parts are prevalent and are related to several common risk factors, viz., awkward posture and repetitive movement (Meyers et al., 2000; Gomez et al., 2003; Struttmann and Reed, 2002). High repetition, excessive forces and awkward postures are major cause of musculoskeletal disorder and complaints in industries (Vanwonterghem, 1996; Westgaard, 2000). As the workers work in an awkward posture, the center of gravity of the body may also be changed. As a result the body becomes unstable and it may be one of the causes of lumber stress. The location of the line of gravity in relation to the lumber stress in standing posture had been studied by Klausen and Rasmussen, (1968). The shift of center of gravity during work may lead to pain and discomfort among agricultural workers.

In labour intensive countries like India, few studies were done on agricultural workers. Das and Gangopadhyay (2011) studied on posture related discomfort and occupational health problems among rice cultivators. Kar et al., (2010) studied on work-rest pattern and work component of different rice cultivation tasks. Nag and Nag, (2004) studied on drudgery, accidents and injuries in Indian agricultural worker. Kar and Dhara, (2007) studied on musculoskeletal disorder and socioeconomic status of farmers in West Bengal. Das and Gangopadhyay (2012) also studied on musculoskeletal disorders and physiological stress among the male potato cultivators in West Bengal. However, studies on post harvesting tasks of rice cultivation are scanty. Therefore, ergonomic studies are required to evaluate different aspects of post-harvesting tasks. In the present investigation attempts have been made to evaluate different musculoskeletal disorders and overall postural stress of female workers during performing two post harvesting tasks, viz., threshing and preparing parboiled rice.

METHODS:

Site and subjects:

The study was conducted on 70 female workers having the age range of 18-60 years. Ethical approval and prior permission was obtained from Institutional Ethics Committee before commencement of the study and the experiment was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. Prior to the experimental trial, the protocol was explained verbally in local language (Bengali) and informed consent was obtained from the

subjects during field visits and the available adult females who were involved in different tasks of post harvesting job were randomly selected as subjects from different villages of Midnapore (East and West), Howrah and Purulia districts of West Bengal state, India. The subjects engaged in two post harvesting tasks, viz., threshing and parboiling were selected for this study.

Musculoskeletal disorder:

The musculoskeletal disorders of the workers were evaluated by the modified Nordic questionnaire technique (Kuorinka et al., 1987). The questionnaire emphasized their individual details, type of work and the occurrence or frequency of pain felt in different parts of their body.

Postural pattern:

For evaluating the postural stresses, the postural pattern of the workers during performing their tasks was studied. The analysis of posture at different phases of post-harvesting tasks was made by direct observation method (Wilson and Corlette, 1985). The work posture of each subject was studied for each type of task for whole working period. The postural change during performing the work was noted carefully and the time for adopting each posture was recorded. The observation was made by employing one subject-one day strategy.

Center of Gravity:

The location of center of gravity CG of the female workers was determined by Segmental method (Page, 1978). At first the CG of different segments of the body was computed and then the resultant of the all segmental CGs was taken as the whole body CG. The location of whole body CG was expressed in percent of body height taking ground as the reference considering following formulae. The CG was determined in normal erect posture and in working postures.

Percentage of location of whole body CG = (Length of CG from the ground) / (Length of the whole body) ´100

Spinal Curvature:

The subjects were used to move their lumbar region frequently during performing different post harvesting tasks. To evaluate the lumbar stress, the measurement of lumbar sagittal posture by means of a flexicurve was made in different working postures (Gager et al., 1984). The subject was asked to adopt his natural erect posture with minimum cloths. The flexible cord was placed on the back along the vertebral column from the cervical segment to the coccyx segment. The upper lumbar segment, which fitted with the parallel of the last thoracic rib, was felt and a mark was made on the cord at that level. Similarly, the lower lumbar segment, which was fitted with the iliac crest, was also felt and a marked was made on the cord at that level. The flexible cord was placed on a good quality art paper and the outline was drawn. The upper and lower lumbar points were indicated in the outline by giving two small marks. Then two tangents were drawn on the two lumbar points and extended to cross them. The angle at the cross was measured. The same procedure was followed to measure the lumbar angle when the workers were working with different postures in different post harvesting tasks. The measured lumbar spinal angle in working posture was compared with that in normal erect posture and the deviation of the angle was computed.

Data were analyzed using STATISTICA (Vr. 6.0) for windows. Results for the general information items here expressed as mean ±SD. Among the different groups of parameters't'-test had also been performed.

RESULTS:

Female cultivators were compelled to adopt in different awkward postures for prolonged

period while performing different post-harvesting tasks. The direct observation method was used for the analysis of posture and results are shown in Table 1. It was noted from the results that the workers were compelled to adopt bend posture (including forward bend and twist) for about 33% of the work time in case of performing parboiling task and it was about 27.0% in case of threshing task. In threshing task the workers were compelled to spend maximum time (about 71%) for working under standing posture whereas in case of the female workers engaged in parboiling had adopted squatting posture for a long duration (41 % of work time).

Table 1: Mean ±SD and percentage (%) of time (min) for adopting different postures in a work shift by female cultivators during performing two post-harvesting tasks

Postures	Threshing	Parboiling
Standing	204.59 ±8.69 (70.63%)	3.35 ± 2.10 (6.32%)
Forward Bending	36.35 ±12.46 (12.55%)	9.29 ± 6.71 (17.52%)
Squat-sitting	-	21.82 ± 5.42 (41.15%)
Walking	6.35 ±9.39 (2.19%)	10.07 ± 4.81 (18.99%)
Side bending (Twisting)	42.36 ±10.35 (14.62%)	8.49 ± 3.32 (16.01%)
Total working period	289.65±10.25 (100%)	53.02±12.47 (100%)

In the present study the prevalence of musculoskeletal disorders (MSD) of the workers was evaluated for threshing and parboiling tasks of rice cultivation and the percentage of occurrence of MSDs in the workers has been presented in Table 2. From the results it has been revealed that the prevalence of MSDs was very high among the workers. The results also indicated that the incidence of MSDs was comparatively higher in threshing task than that of the workers engaged in parboiling of rice. However, lower back problem was found extremely prevalent in both tasks. It was the higher in parboiling task (95%) than the threshing task (90%). Middle back problem was also prevalent in both types of tasks of post-harvesting tasks. It was the higher in threshing task (80%) than the parboiling task (70%). The results also indicated that MSDs was prevalent in different parts of upper limbs. It was revealed that most of the workers reported disorders in wrist and shoulder. Problems in wrist were significantly higher in thrashing task (93%) than the workers engaged in parboiling task (52.5%). Shoulder problem was also higher in threshing operation (70%) than parboiling task (47.5%). From the results it was revealed that MSDs was also prevalent in different parts of lower limbs.

Table 2: Frequency (f) and (Percentage) of female cultivators reported problems in different body parts during performing post harvesting tasks

Body Segment	Parboiling (n=40)		Threshing (n=30)	
	f (%)	Rank	f (%)	Rank
Neck	22 (55.0)	6	16 (53.3)	11
Shoulder	19 (47.5)	8	21 (70.0)	6
Elbow	15 (37.5)	10	18 (60.0)	9
Wrist	27 (67.5)	3	26 (86.7)	3
Finger	21 (52.5)	7	28 (93.3)***	1
Upper Back	18 (45.0)	9	21 (70.0)*	6
Middle Back	28 (70.0)	2	24 (80.0)	4
Lower Back	38 (95.0)	1	27 (90.0)	2
Thigh	12 (30.0)	11	19 (63.3)**	8
Knee	23 (57.5)	5	18 (60.0)	9
Cuff	26 (65.0)	4	20 (66.7)	7
Ankle	5 (12.5)	12	17 (56.7)***	10
Foot	3 (7.5)	13	22 (73.3)***	5

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

The location of the CG of the workers engaged in two post harvesting tasks was evaluated and expressed as the percentage of body height (Table 3). The location of CG under normal erect posture was taken as reference. The change of location of CG from the reference position was regarded as the deviation of CG in the human body. The center of gravity of the female workers during performing parboiling and threshing operations was found to be deviated from that of normal erect posture. The deviation of CG was the higher (10.12%) during performing parboiling task than that of performing threshing task.

Table 3: Mean ±SD and deviation of center of gravity (CG) of the workers in different postures in post harvesting tasks

Working groups	Normal Standing (Erect)	Working	Deviation
Parboiling (n=15)	60.18 ±1.22	50.06*** ±1.45	10.12 ±3.04
Threshing (n=12)	60.49 ±0.83	64.33* ±5.37	3.84 ±5.50

*p< 0.05; ***P<0.001

The spinal curvature was measured in two postures and the deviation of lumber spinal angle from that of normal erect posture was calculated. The results are shown in Table 4. The results indicated that in both the tasks lumber spinal angle was reduced from that of reference position, i.e., from the normal erect posture. The deviation of lumber spinal angle was the higher (25.87) in case of parboiling task in comparison to that of in threshing task (4.33). Thus results indicated that in parboiling task there was more forward bending than that of threshing.

Table 4: Mean ±SD and deviation of lumber spinal angle (in degrees) of the workers in normal erect and working postures in post harvesting tasks

Working groups	Normal Standing (Erect)	Working	Deviation
Parboiling (n=15)	197.40 ±5.75	171.53*** ±3.35	25.87 ±5.63
Threshing (n=12)	196.93 ±5.56	189.8** ±4.52	4.33 ±1.59

** p< 0.01; ***P<0.001

DISCUSSIONS:

Female cultivators were compelled to adopt in different awkward postures for prolonged period while performing different post harvesting tasks. Although awkward work postures were most numerous in the job requiring high-energy consumption, it was also noted that there were a lot of unergonomic postures of certain parts of the body which may be the possible causes of pain at different segments of body. Thus assessment of work postures is one of the starting points to address the problem of work related body pain. The direct observation method was used for the analysis of posture and it was noted that the workers engaged in parboiling task were compelled to adopt bend posture (including forward bending and squatting posture) for most of the work-time. In threshing task the workers were compelled to spend maximum time in standing posture (about 70% of total work time). However, spinal curvature study showed that during threshing the workers had to bend a little in forward direction while working in standing posture. Thus the cumulative effect of forward bending for a long time, although in a lesser extent, imposed the postural stress in the lumber region. The

prolonged bending posture imposed high static muscular load particularly in the trunk region. So, bend posture in post harvesting tasks was generally stressful to the musculoskeletal structures, including the vertebral column. This was consistent with the past studies that have shown that bending and twisting of the back impose higher postural strain than the straight back postures which were important risks factor of origin of discomfort (Drake and Callaghan, 2008; Chaffin et al., 2006; Kothiyal and Yuen, 2004). Meyers et al. (2001) showed the relation between stressful work postures and functional disturbance of pain in various parts of the musculoskeletal system.

The studies of musculoskeletal disorders were showed that the workers were suffering from different degree of MSDs in their body segments. However, back problem particularly lower back pain was extremely prevalent in both the tasks. The predominant posture of post harvesting tasks was the bend posture. The female workers were found to adopt squat sitting, forward bending and twisting posture in parboiling task and standing, forward bending and twisting posture in threshing operation for a long time. All these awkward postures may be possible causes of back pain. According to the report of NIOSH (1997), the bending, squatting and non-neutral trunk postures are the awkward posture, which are responsible for lower back disorder. The National Research Council (NRC) and Institute of Medicine (2001) also reported that there is a clear relationship between back disorders and physical load. The prevalent MSDs were very high in different parts of upper limbs particularly in wrist and shoulder. Both the post harvesting tasks required frequent movement of the arm but the frequency of movement was very high in case of threshing task. In case parboiling task, the workers had to collect straw (fuel) and to insert into oven in a regular interval. Thus the frequency of arm movement was very high and this might be the reason for the occurrence of wrist and shoulder pain of the workers. The results revealed that MSDs was also prevalent in different parts of lower limbs. This might be due to imposing static load on the parts of the lower limbs as a result of prolonged standing during threshing operation. In case of parboiling task, the female workers adopted squatting posture for a significant time (41%) of the work time, which imposed strain on the different parts of the lower limb (Meyers et al., 2001). So the frequent occurrence of MSD might be related to their postural pattern as well as duration of work in awkward posture. Das and Gangopadhyay, (2012) studied on potato cultivators and reported that prolonged work activity, high repetitiveness and remaining constantly in an awkward posture for a prolonged period of time may lead to MSDs. The higher prevalence of work related MSD at different segments of the body of the workers might be due to use of significant force, repetitive movements and longer duration of exposure (Caicoyal and Delclos, 2010). Osborne et al., (2012) studied on farmers and reported that lower back pain was the most common MSD among the farmers, followed by upper and then lower extremity MSDs. They also suggested that the prevalence of MSDs in farmers was greater than in non-farmer populations. Long term adoption of bend and twist posture was associated with postural stress. Investigation suggested that bending and twisting of back awkwardly and working in same position were both significantly associated with prevalence of lower back problem (Roffey et al., 2010; Merlino et al., 2003) and both were judged by workers to be the most problematic job factors contributing to pain and injury. Goldsheyder et al (2002) reported that there was a significant association of awkward postures with back pain and the

prevalence of lower back problems was significantly increased with work tasks described as "bending or twisting back in awkward way". A constant repetition of movements imposes a cumulative work load which can cause pain and weakness and impaired function of the muscles and other soft tissues (Gangopadhyay et al., 2007). The physiologic problems that arise from repetitive work or overuse of certain muscles, tendons and soft-tissue structures have been addressed in terms of muscle fatigue, tissue density changes, and tissue strain (Valachi and Valachi, 2003). Physiologic evidence shows that the rate and degree of tissue damage depends on the amount of force, repetition and duration of exposure (Geronilla et al., 2003).

Human body has a center of gravity (CG) and in any consideration of human movement the position of the CG of the body plays an important role. In the present study the locations of CG of the female workers in normal erect posture was around 60 percent of the total body height. It was found to be deviated during performing post-harvesting tasks. The female workers chiefly adopted squatting postures during performing parboiling task. During this time the location of the whole body CG shifted downwards, that is, towards the base of the body. When the CG was shifted towards the base of the body, it became more stable than that in erect posture. However, squatting is a very awkward posture, which leads to strain in different joints and muscles of the lower limbs. Although location of CG indicating the stability of the body but the static postural load on the said areas caused musculoskeletal problems during performing parboiling tasks. In case of threshing the location of the CG shifted away from the base of the body causing the body relatively unstable than that of the reference position. The workers adopted standing or semi bend posture when they used mechanical thresher for threshing operation. As the CG shifted upward during this work biomechanical stress was imposed on the body which might be the cause of the prevalence of MSD among the female workers. Das and Ganguli, (1982) and Sen and Ray (1983) observed in their studies that the shift in CG imposed maximum postural load in forward bend postures when considered from the viewpoint of biomechanical stress.

The measurement of spinal curvature was a good indicator for biomechanical assessment of stress. The study of spinal curvature indicated that lumber spinal angle of working posture was markedly deviated from normal erect posture for the workers engaged in parboiling operation. In squatting posture the body becomes folded at hip and knee joints. The upper part of the lower limb (thighs) comes closer to the trunk causing a sliding of pelvic bone and the spinal angle become lower than that in the standing posture. The deviation of the spinal angle was related to the posture adopted by the workers during performing the task. According to Granata and Marras (1999), the rate of change of spinal load (load occurred during postural change) is one of the risk factor for spinal strain and injury, the cause for lower back disorders. According to Burton, (1986), the musculoskeletal symptoms are likely to develop in workers whose work environment produces high levels of dynamic and/or maintained postural load on their musculoskeletal system.

The workers suffered account of health problems, perhaps because of prolonged working hours, awkward posture and used less safety measures while working. The female cultivators had to start their day before dawn to finish off their household chores and cooking before they move off to the fields, which altogether puts them under stress. It may be suggested that immediate ergonomic interventions such as modifying work posture and redesigning the hand tools should be taken for improve the conditions and postures of the

female cultivators and reduce their work stress.

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