Case Study on Ergonomic Assessment and Reduction of Workplace Hazards at Pearl Millet Processing Unit

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Abstract: Present study had been conducted to assess the work profile of the worker working on the selected machines, conduct their ergonomic assessments and identify the work-place hazards and find ways for their reduction. A case study was conducted in the pearl millet processing unit of CCS Haryana Agricultural University at Hisar, Haryana. Results revealed that for processing of one batch of bajra, *masala* mixing was done for the longest duration (90 min). On the basis of classification given by Varghese *et.al.*(1995)[3], the raised heart rate indicated that working on mixer, *kurkure* maker, puff maker and *masala* applicator were classified as heavy activities. Kyphosis at lumbar region was highest while working on the mixer (195.2^0) whereas lordosis was highest while working on *Kurkure* maker (190.4^0). The most hazardous machine was *kurkure* maker because it involved continuous strenuous hand movement and awkward body posture along with several risks of accidents. Hence, modifications were needed to provide comfortable and hazard free environment to the worker.

Keywords: *Kurkure* making, Pearl millet processing, Workplace hazards.

1 Introduction

India is the largest producer of pearl millet / *bajra* in Asia which is a grain rich in several useful nutrients (Anonymous, 2010)[1]. For the fortification of food it is processed and used to make several products. While working on processing machines worker has to make different awkward postures to operate the machines which may lead to the development of musculoskeletal disorders if continued for longer time. Labor is an important factor of any kinds of industry because they are directly related to the productivity of the system. Their ability, skills, productivity and performance have a great importance towards the increased production (Chaudhary and Singh, 2013)[2]. Work environment should be safe and healthy to increase the efficiency and comfort of the worker. In the light of above, an ergonomic study was conducted with the following objectives to evaluate the pearl millet processing unit.

1. Assessing the work profile of the worker while working on the selected machines
2. Ergonomic assessment of the worker
3. Identifying the workplace hazards and their reduction

2 Methodology

A case-study was conducted in the Centre of Excellence on *Bajra* situated in the I.C. College of Home Science, CCSHAU in Hisar district of Haryana state. There was only one worker operating all the machines, therefore, he was selected for the study. Among the different machines used for making the products of *Bajra*, only seven of them were selected which were situated in a single hall. The machines involving continuous attention and involvement of worker were pearling machine, hammer mill, sieve separator, mixer, *Kurkure* maker, Puff maker and *masala* applicator hence, they were selected for the study. These

machines were present in a single hall and only one worker operated all of them at a time. The study was conducted in following steps to achieve the objectives one by one:

2.1 Observations for achieving 1st objective

The worker was observed while working on the selected machines and his duration of work and body parts involved were recorded on the observation sheet.

2.2 Experiment for achieving 2nd objective

The worker was allowed to operate each machine one by one and his physiological as well as biomechanical parameters like heart rate, pulse rate, blood pressure, grip strength and spinal angles were recorded in triplicates. The experiment was conducted on three random days in a month for six months. A self-designed worksheet was used to record the results.

2.2.1 Heart rate (HR)

Heart rate of the subject was measured with the help of Polar heart rate monitor while at rest, during the period of the activity and recovery thereafter. Values of resting, working and recovery heart rate were averaged out each time to make a final assessment. The workload of the worker after the completion of the activity was found out on the basis of HR as given by Varghese *et al* (1995)[3] (table 1).

Table 1 Workload classification

Workload	HR ($b.min^{-1}$)
Very light	Up to 90
Light	91-105
Moderately heavy	106-120
Heavy	121-135
Very heavy	136-150
Extremely heavy	150

2.2.2 Grip fatigue

It is the stress experienced by the grip muscles during or after an activity. It was measured using grip dynamometer. Grip strength of the worker was measured before the start of the activity separately with right and left hand. After the completion of the activity, the grip strength was again measured. Reduced muscular strength during activity is an indicator of muscular fatigue because of the activity. The grip fatigue was calculated using the following formula:

Grip fatigue (%) = Sr-Sw x 100 /Sr
Sr = Strength of muscles at rest; Sw = Strength of muscles after work.

2.2.3 Spinal angle

Flexi curve was used to measure the angle of deviation (degree) between the normal spinal curve and maximum deviated posture. The flexi curve was mounted to the contour of the spine and immediately drawn on a plain paper to measure the angle of deviation. The angle of bent of the back during the performance of the activity was measured and

compared with the normal bent of the back and the angle of the deviation was determined by subtracting the normal angle of bent from the angle of bent during the bending posture (Fig 1).
Required angle = x
Measured angle = y

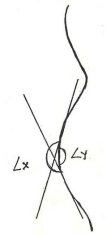

Fig. 1 Identification of spinal Angle

Required angle (x) = 360-y

2.1 Hazard Identification

The worker was observed while working on different machines for hazard identification. The activities as well as the machines were observed while working and the hazards associated to it were recorded with the help of checklist. Further, the possible solutions were given for the simplification of work and reduction of hazards.

3 Results

3.1 Work profile of the worker

Table 2 portrays the machines along with the activities performed by the worker and the duration of activity along with the body parts that are under stress. It was observed that for processing of one batch of bajra, *masala* mixing was done for the longest duration (90 min) followed by *Kurkure* and puff making (60 min), grinding (45 min), milling (30 min), sieving (25 min) and mixing (15 min). This table also shows the body parts involved while working on different machines.

Table 2 Description of machines selected for the study

Name of machine	Activity	Duration of activity (min)	Stressed body parts
Pearling machine	Milling	30	Legs , hand, shoulders and neck
Hammer mill	Grinding	45	Lower back
Sieve separator	Sieving	25	Shoulder and arm
Mixer	Mixing	15	Shoulder, arm and back
Kurkure maker	*Kurkure* making	60	Shoulder, arm and upper back
Puff maker	Puff making	60	Shoulder, arm and upper back
Masala applicator	*Masala* mixing	90	Shoulder, arms, lower back and legs

3.2 Ergonomic assessment of the worker

Table 3 displays the physiological changes of the worker while working on different machines. It was recorded that maximum working heart rate was observed while working on pearling machine (136 bpm), followed by mixer (134.8 bpm), *masala* applicator (133.2 bpm), puff maker (125.3), *Kurkure* maker (123.8), sieve separator (106.2) and hammer mill (105.8). The raised heart rate indicates that working on mixer, *kurkure* maker, puff maker and *masala* applicator were classified as heavy activities whereas working on sieve separator was moderately heavy. Working on hammer mill and pearling machine were light and very light activities respectively. Slight variation in pulse rate was observed after working on the machines. Highest rise in pulse rate was observed after working on pearling machine (9.8%) followed by *masala* applicator (7.4%), *kurkure* maker (3.7).

Table 3 Physiological parameters of worker while working on different machines

Machines	Heart rate, bpm			Pulse, bpm	% increase in pulse rate
	Working	Category*	Recovery		
Pre- testing	82	---	---	81	---
Sieve separator	106.2	Moderately heavy	97.3	83	2.4
Pearling machine	136	Very heavy	98.6	89	9.8
Hammer mill	105.8	Light	98.2	81	0
Mixer	134.8	Heavy	90.8	82	1.2
Kurkure maker	123.8	Heavy	96.3	84	3.7
Puff maker	125.3	Heavy	95.8	82	1.2
Masala applicator	133.2	Heavy	97.4	87	7.4

* Varghese *et al*. (1995)[3]

Table 4 represents the biomechanical changes in the body of worker while working on different machines. Very irregular variation in grip strength after working on the machines was observed, it either increased or decreased after working on certain machines. It increased after working on hammer mill (R=35.9, L=33.2), pearling machine (R=34.5, L=33.5) and mixer (R=32.8, L=31.5) whereas decreased after working on *kurkure* maker (R=31.2, L=27.4), puff maker (R=30.8, L=26.9), sieve separator (R=28.9, L=27.4) and *masala* applicator (R=27.5, L=26. Highest grip fatigue was observed while working on *masala* applicator (R=13.7, L=10.5). Lordosis as well as kyphosis was observed in the spinal angle at lumbar as well as cervical regions. Kyphosis at lumbar region was maximum while working on the mixer (195.2^0) followed by pearling machine (193.9^0), hammer mill (188.9^0), puff maker (188.8^0), sieve separator (186.8) whereas lordosis was maximum while working on *Kurkure* maker (190.4^0) followed by *masala* applicator (186.2^0). At the cervical region, kyphosis was maximum while working on hammer mill (195.7^0) followed by *masala* applicator (193.4^0), sieve separator (192.2^0), *kurkure* maker (185.2^0), mixer (184.5^0), pearling machine (183.5^0) and puff maker (183.1^0). Fig 2 illustrates that highest deviation at lumbar and cervical region was observed while working on mixer (11^0) and hammer mill (12.9^0) respectively.

Table 4 Biomechanical parameters of worker while working on different machines

Machines	Grip strength, kg		Grip Fatigue, %		Spinal angle, degree	
	Right	Left	Right	Left	Lumbar	Cervical
Pre- testing	31.9	29.5	---	---	184. 2	182.8
Sieve separator	28.9	27.4	9.4	7.1	186.8	192.2
Pearling machine	34.5	33.5	-8.1	-13.5	193.9	183.5

Hammer mill	35.9	33.2	-12.5	-12.5	188.9	195.7
Mixer	32.8	31.5	-2.8	-6.7	195.2	184.5
Kurkure maker	31.2	27.4	2.1	7.1	190.4	185.2
Puff maker	30.8	26.9	3.4	8.8	188.8	183.1
Masala applicator	27.5	26.4	13.7	10.5	186.2	193.4

Table 5 gives the details of problems related to the worker as well as organization while running the machines along with the possible solutions. The most hazardous machine was *kurkure* maker because it involved continuous strenuous hand movement to operate the tough handle of the machine for separating the heating plates. Worker had to raise his body and hands too high to feed the material in the machine and an open revolving wheel was located near the operator which may cause accident if his clothes get stuck to it. Burning of hands was also reported while cleaning the hot plates. No proper cleaning tool was available; therefore, worker used to clean it with the help of screw driver which involved more effort and time. Hence, modifications were needed to provide comfort and hazard free environment to the worker.

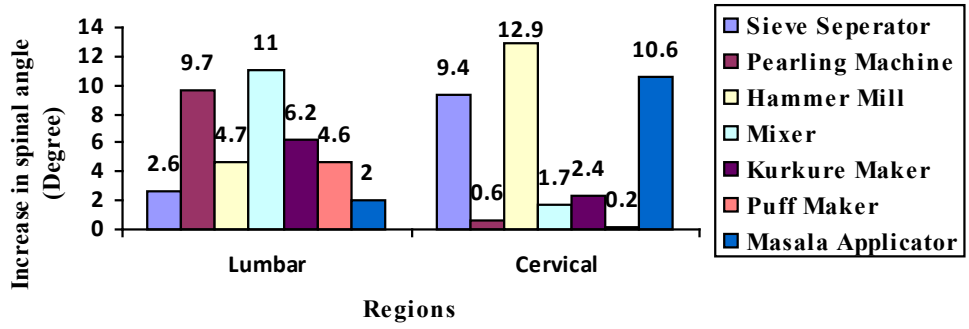

Fig. 2 Difference in the spinal angle at lumbar and cervical regions while working on different machines.

Table 5 Hazards pertaining to the use of machines at the unit and their reduction

Machines	Hazards	Solutions
Sieve Separator	1. Prolonged static standing posture.	1. Raised stool/table should be provided so that worker may alternate the posture between sit & stand.
	2. Continuous picking and holding of the produce in one hand and twisting of body to put it apart.	2. Picking basket should be attached to the sieve so that worker may put the produce on it nearby.
	3. Kyphosis of spine.	3. Its height should be made adjustable
Pearling machine	1. Raising high of the worker due to feeder being too high.	1. Stairs should be provided
	2. Vibration	2. Raised platform or stairs should be provided so that worker's body could not come in direct contact of the machine.

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Hammer mill	1. Bending low of the operator due to inappropriate height.	1. An adjustable chair should be provided so that the work may be done while sitting.
	2. Wastage of material	2. Outlet should be guided by some pipe or collector container should be attached to the outlet
Mixer	1. Bending low of the operator due to low height and continuous attention	1. Adjustable chair should be used since the work is time taking and requires continuous attention.
	2. Tight opening of the outlet leading to stress in hands	2. Smoother opening should be provided by imparting grooved slide type model
Kurkure maker	1. Continuous strenuous hand movement to operate the handle of the machine to separate the plates.	1. Button control could be used to move the plates apart.
	2. Burning of hands while cleaning the hot iron plates.	2. Heat resistant gloves should be provided
	3. Use of screw driver to clean the plates required more time and effort	3. Metallic brush should be provided
	4. Raising high of the worker due to feeder being too high	4. Stairs should be provided
	5. Final products got scattered	5. Outlet should be guided by some pipe or collector container should be attached to the outlet.
	6. Uncovered revolving wheel in the easy reach of worker.	6. Proper protective cover should be provided on the wheel.
Puff Maker	1. Cleaning part is again a problem	1. Metallic brush should be used
	2. Final products got scattered	2. Outlet should be guided by some pipe or collector container should be attached to the outlet.
	3. Feeding and collecting points are too far, increasing the movement of worker.	3. Feeding point should be made close to the collecting point.
Masala applicator	1. Raised hands above shoulder level to feed the material.	1. High rise platform with stairs should be provided.
	2. Prolonged bending of neck to feed the oil.	2. Sitting stool or chair should be provided.

4 Conclusion

However, due to unavailability of workers, the study was limited to only one worker and it was found that pearl millet processing was a strenuous activity for him as it involved working on large sized and heavy machines for long hours. Working on pearling machine was a very heavy activity (136 bpm) while on the basis of spinal deviation of the worker, *kurkure* maker was found to be the most strenuous machine as it involved the lordosis and stretching of spine. On the basis of hazards observed while running the machine, *kurkure* maker was found to be most hazardous.

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References

1. Anonymous (2010) International Crops Research Institute for Semi-Arid Tropics, Available via http://googleweblight.com/?lite_url=http://www.icrisat.org/crop-pearlmillet.htm&ei=0WHowDaM&lc=en-IN&s=1&m=960&ts=1436112524&sig=AG8UcukAL8mKf4wqrod2VolxPTk1QqKmaw
2. Chaudhary, H. and Singh, J. (2013) A study of work related musculoskeletal disorders by using RULA and REBA among the workers working in a card-board industry. *International J Scientific Research* 2: 142-144.
3. Varghese, M.A., Saha, P.N. and Atreya, N. (1995) A rapid appraisal of occupational work load from a modified scale of perceived exertion. *Ergonomics*, 37 (3): 485-491.