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An ergonomic approach for modifying the workstation design of food processing enterprises

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Abstract
Present observational study was conducted to assess the workstation and thereby modify it according to the requirement of workers by using the ergonomic guidelines. The study was conducted in six micro, three small and two medium scale enterprises. Workers were observed while working on their existing workstation and their images and videotapes were prepared for analysis. Quick exposure checklist (QEC) was used to assess the risk of developing work related musculoskeletal disorders (WMSDs) to the workers while working on particular workstation. On the basis of analysis, the workstations with improper design were identified and modifications were suggested on the basis of ergonomic principles. It was observed that workers were working for long hours on an inappropriate workstation which may lead to various musculoskeletal discomforts. Therefore, modifications were suggested to design a sit-stand workstation, modified packing and washing workstations to simplify the work in micro, small and medium scale food processing enterprises.

Keywords: Ergonomics, food processing enterprises, workers, workstation design

Introduction
India being a developing country is at the verge of increasing Work Related Musculoskeletal Disorders (WMSDs) among the workers engaged in the Industries (Chaudhary and Singh 2013) [2]. In food processing industries above 50 percent of workers are engaged in production works in which they have to work in adverse environment which exposes them to the high risk of occupational health hazards (Anonymous 2009) [1]. Three things that are most crucial for developing work related musculoskeletal discomforts are awkward posture while working, forceful and repetitive works. The problem becomes more critical when one or more factors are combined. In most of the food processing plants, the workers have to perform highly repetitive as well as forceful work during whole day. Major body part involved in repetition was hands (60%). More than one third of them used more than one body parts while repetition whereas few of them also used their feet (3%) while repetition. Highly repetitive hand and wrist movement is observed in packaging tasks as the workers are supposed to place the finished products intact in the packets. Most of the workers involved in packaging tasks were the sufferers of repetitive strain injuries (RSIs) which are developed due to repetitive movement of body parts (Malagie *et al* 2012) [7]. This study deals with the awkward postures adopted by workers in food processing enterprises. Poor workstation forces their workers to work with an awkward body posture due to which the work becomes strenuous. Improper posture results in permanent bending of some body parts if worked continuously in the same manner. It may also lead to the development of work related musculoskeletal discomforts if continued for longer duration (Puttewar and Jaiswal 2014) [8]. To design the proper workstation according to the requirement of workers, the ergonomic consideration is needed. Ergonomics is the field dealing with the prevention of injury by improving the body posture and designing and setting-up workstation according to the work requirement. This entails reviewing the work environment and procedure that contribute to hazards and discomforts to the workers (Stalin and Dhiravidamani 2014) [9]. Ergonomic approach for designing the industrial workstation is the attempt to achieve an appropriate balance between the worker's capability and worker's requirements as well as provide the worker with physical and mental well-being, job satisfaction and safety (Das and Sengupta 1996) [3]. On the basis of Punjab's anthropometric data the height of workstation should be 83 cm (Gite and Majumder 2007) [5] and it was observed that in small as well as medium scale enterprises it was higher but in micro scale enterprises respondents were working on ground so there was no work counter height. The workstation dimensions in micro, small and medium scale enterprises were not in

Accordance with the recommendations (Kumari and Kaur 2018) [6]. Inappropriate height of work counter may cause discomfort in the spine and shoulders if left unattended. Therefore, there was a great need of modification and improvement in the workstation of food processing enterprises. In the light of above, present observational study was planned with the following objectives:

- To identify the workstation having the risk of developing work related musculoskeletal disorders.
- To use the ergonomic guidelines to modify the existing workstations of selected food processing enterprises.

Methodology

For conducting the present observational study, six micro scale, three small scale and two medium scale food processing enterprises were selected purposively from Punjab. Selection of enterprises was done on the basis of maximum manual involvement of workers. Literature suggests that among different food materials; fruits and vegetables processing was the most complex involving maximum manual involvement and it was done in all the three scales of industries in Punjab. As our purpose was to study the workstation of micro, small and medium scale food processing enterprises so, we selected the fruit and vegetable processing enterprises where workers were involved in cutting, preserving and packing of fresh fruits and vegetables. From each type of enterprises, five workers were observed while working on a particular workstation making a total of 15 workers. They were observed while working on a particular workstation, thrice a week on random days in first and last weeks of the month.

The Videos and photos of the workers were collected while working on the existing workstation which were further analysed. Quick exposure checklist (QEC) was used to assess the risk of developing work related musculoskeletal disorders (WMSDs) to the workers while working on particular workstation. The problems associated with the existing workstation were identified and on the basis of those, the modifications were suggested.

A well planned workstation allows the work to flow smoothly without putting extra stress on the workers. Appropriate designs were suggested for a low cost workstation by making slight changes in the arrangement. The height of workstation was decided on the basis of the anthropometric dimensions of the female population of Punjab. For the work to flow comfortably, the workstation should be just below the elbow height. Since the workstation height is a reach parameter hence 5th percentile data was considered. The elbow height of 5th percentile population of Punjabi females was 83.1 cm (Gite and Majumder 2007) [5]. Therefore all the workstations were designed with the height of 83 cm.

Quick Exposure Checklist (QEC): It was developed by David *et al* (2008) [4]. It is a quick technique to assess the exposure of the people to the risk of developing work related musculoskeletal disorders. It is done through the observer and worker assessment sheets. In this the workplace and equipment designs are evaluated to facilitate the redesigning. The risk is assessed by using the Observer's Assessment Checklist for a particular task either by direct observation or by using the video recording. It quickly identifies the exposure levels for different body parts like back, shoulder/arm, wrist/hand and neck. The exposure scores have been further classified into following four categories of low, moderate, high or very high which is depicted in Table 1.

Table 1: Classification of exposure scores

Body parts	Exposure level (scores)			
	Low	Moderate	High	Very high
Back (static)	8-15	16-22	23-29	29-40
Back (moving)	10-20	21-30	31-40	41-56
Shoulder/arm	10-20	21-30	31-40	41-56
Wrist/hand	10-20	21-30	31-40	41-46
Neck	4-6	8-10	12-14	16-18

Results and discussion

Different workstations in the food processing enterprises were studied and on the basis of QEC results it was observed that four workstations needed modifications which are discussed in following subheads:

1. Modification and redesigning of standing workstation
2. Modification and redesigning of packing workstation
3. Modifications and redesigning of washing area
4. Modifications and redesigning of the workstation for seated task

1. Standing workstation

In medium scale food processing enterprises, almost all the activities were performed in standing posture. Workers used to stand with flexed neck and work continuously for 8-9 hours (Fig 1). In between they were provided either one or two breaks depending on workload in the enterprises but the breaks were not sufficient to provide rest to their bodies. When the workload was more and they had to meet the target, they used to cut off the breaks. To study the risks associated with continuous standing posture, the QEC analysis was done and its results are presented in Table 2. Results revealed that very high exposure was recorded at neck (100.00%), high exposure was recorded at wrists (73.91%) and shoulders (60.71%) whereas, moderate exposure was recorded at back (50.00%). Therefore, there was a great need to modify the workstation so that the exposure at neck, wrist/hand, shoulder and back could be minimized.

Table 2: Assessment of risk of developing WMSDs by using Quick Exposure Checklist (QEC)

Parameters	Back posture (Score A)	Shoulder Posture (Score B)	Wrist/Hand posture (Score C)	Neck posture (Score D)
Scores	20	34	34	18
Percentage of exposure (%)	50.00	60.71	73.91	100.00
Exposure level	Moderate	High	High	Very high

On the basis of above observation, modifications were suggested in the existing workstations by providing seating option and the provision of armrest which are described as under:

1.1 Adjustable sit-stand workstations: Continuous standing exposed the workers to the risk of developing WMSDs of back/spine. The workstations can be modified by having a height adjustable seating option with back rest and foot rest which could allow the worker to sit and work when tired (Fig 2). Provision of seats would reduce the risks of developing WMSDs at back and legs due to continuous standing. Adjustable seats could help in accommodating the workers of

different anthropometric dimensions. An alternation between sit and stand helps to reduce the fatigue as the workers can change their posture without affecting their work. Back rest and foot rest would allow the workers to rest their back and foot respectively while working or in between.

Fig 1: Workers working in standing posture

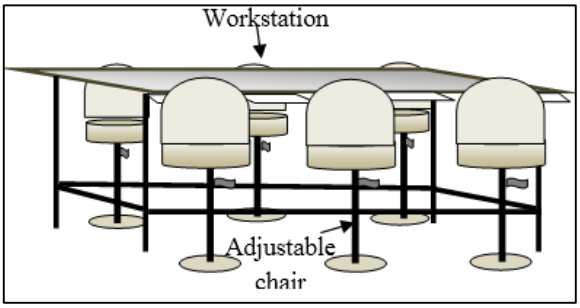

Fig 2: Modified sit-stand workstation

1.2 Arm support on workstation: The workers had to work continuously for long hours in the same posture without any arm support which puts extra stress on their shoulders and arms/hands (Fig 3). They used to rest their hands on the edge of the table which was raised and uncomfortable to place their hands. Therefore, an arm rest can be provided so that they could place their hands on it and work for the long hours and eliminate the risk of developing WMSDs of shoulders/arms/ hands. Fig 4 shows the provision of arm rest on the workstation so that the fatigue in hands and arms could be minimized.

Fig 3: Workers working without armrest

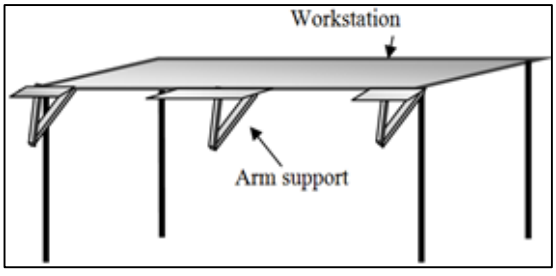

Fig 4: Provision of armrest

2. Packing workstation

In small scale enterprises, for packing the processed food products, workers used to fill the packets from the storage drum (Fig 5.1) in standing posture then bend to weigh it on the weighing balance (Fig 5.2) and finally squat to pack the products (Fig 5.3). This led to the unnecessary movements of the worker and cause fatigue. Since, packing work was traditionally done on the ground (Fig 6); hence, the workers had to fluctuate between standing, bending and squatting for each packet they packed. The QEC analysis (Table 3) of the activity shows that there was moderate risk of developing WMSDs at back (42.85%), shoulder (42.85%), wrist/hand (65.21%) and neck (55.55%). Therefore, there was a need of modification of the packing workstation in small scale enterprises.

Table 3: Assessment of risk of developing WMSDs by using Quick Exposure Checklist (QEC)

Parameters	Back posture (Score A)	Shoulder Posture (Score B)	Wrist/Hand posture (Score C)	Neck posture (Score D)
Scores	24	24	30	10
Percentage of exposure	42.85	42.85	65.21	55.55
Exposure level	Moderate	Moderate	Moderate	Moderate

Fig 7 shows the modification in the existing packing workstation by providing a table and placing the tools in the sequence of use. The storage drum can be placed at the extreme right and the storage basket is placed at the extreme left to make the flow of work from right to left. Weighing machine is placed adjacent to the storage bin so that the products could easily be placed on the weighing machine. Then the sealer can be placed for sealing the products and finally the storage basket to store the products.

Fig 5: Packing activity being performed traditionally

Fig 6: Existing Packing workstation

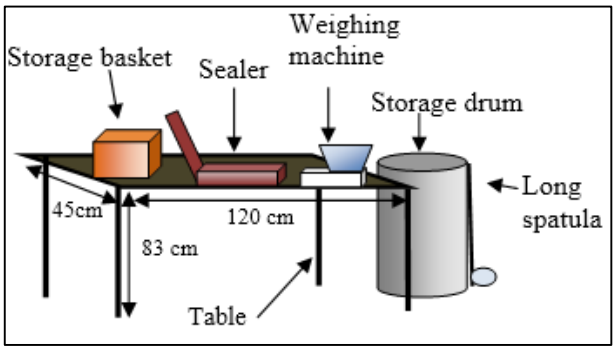

Fig 7: Modified packing workstation

3. Washing workstation

Washing was the very first step of food processing. In medium scale enterprises, it was done mechanically but in micro and small scale enterprises, it was done manually. In micro scale enterprises, it was done totally by the workers sitting on the ground. Proper drainage of water was also a problem associated with the washing area. Therefore, a workstation (Fig 8) was planned and designed to reduce the drudgery during washing of fruits and vegetables in micro scale enterprises. It included two sinks, one for washing whereas, the other for draining extra water. After washing, the fruits and vegetable can be shifted in the basket placed on the trolley adjacent to the workstation and can be shifted to the cutting area. Small scale enterprises had installed a drum shaped washer but it was not properly placed. Workers had to bend their back to put the vegetables in the washer leading to multiple flexion of spine. The other basket containing washed vegetables was placed below the outlet of the washer which was again lifted by the respondents by bending their back (Fig 9). The QEC analysis (Table 4) of the washing activity in small scale food processing enterprises revealed that high exposure level was found at back (58.92%), moderate at neck (55.55%) and shoulders (42.85%) and low at wrist/hand (43.47%).

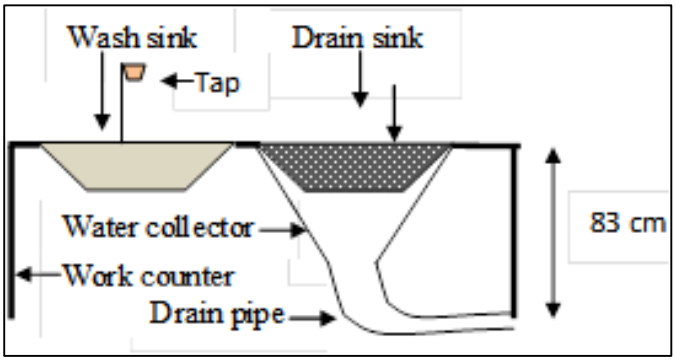

Fig 8: Washing workstation for micro scale enterprises

Table 4: Assessment of risk of developing WMSDs by using Quick Exposure Checklist (QEC)

Parameters	Back posture (Score A)	Shoulder Posture (Score B)	Wrist/Hand posture (Score C)	Neck posture (Score D)
Scores	33	24	20	10
Percentage of exposure	58.92	42.85	43.47	55.55
Exposure level	High	Moderate	Low	Moderate

The risk of developing WMSDs can be avoided by placing the basket containing unwashed vegetables on an 83 cm high counter (Gite and Majumder 2007) [5]. A multipurpose trolley was available in the enterprise but it was not used frequently. If used, it was used only to shift the heavy drums of processed vegetables and fruits. The same trolley can be used to shift the basket having washed vegetables from the washing area to the cutting area which would eliminate a frequent strenuous load carrying activity. The empty basket can be placed on the trolley which can be further placed under the outlet of the washer. As soon as the basket fills it can be shifted to the cutting area. This process will save time as well as manual effort. The design of modified workstation is given in the Fig 10. All the things used in design were already available in the enterprises except the counter which can be made in nominal cost.

Fig 9: Existing washing workstation in the enterprises

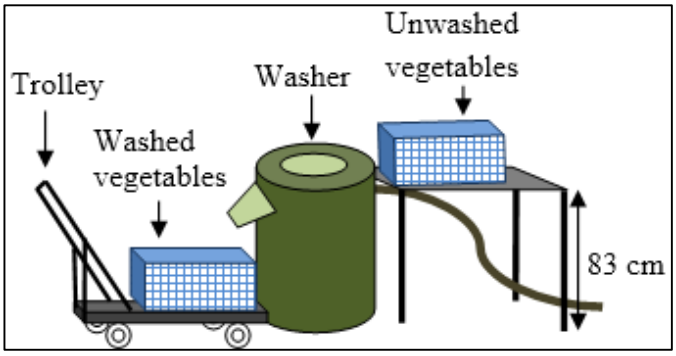

Fig 10: Modified washing workstation

4. Workstation for seated task

In micro scale enterprises and sometime in small scale enterprises, workers were observed to be working on the ground by sitting on wooden low rise sitting stools (Fig 11). The QEC analysis of the activity (Table 5) showed that while sitting on ground and working, very high risk was observed at the neck, high risk was observed at back and wrists/hands whereas moderate risk was observed at the shoulders. To avoid the risk of developing WMSDs at neck, wrists, back and shoulders there was a great need of modification in the existing workstation.

Table 5: Assessment of risk of developing WMSDs by using Quick Exposure Checklist (QEC)

Parameters	Back posture (Score A)	Shoulder Posture (Score B)	Wrist/Hand posture (Score C)	Neck posture (Score D)
Scores	26	26	34	18
Percentage of exposure	65.00	46.42	73.91	100.00
Exposure level	High	Moderate	High	Very high

To eliminate the risk of developing WMSD at neck, back, hands and shoulders, a height adjustable working table should be provided to the workers (who usually sit on the ground and work) so that their cervical flexion could be minimized and better spinal curvature could be achieved and maintained for better health. There should be enough leg space under the workstation so that workers can alternate their posture by spreading and folding their legs while working. Workers of same height should sit on one table so that the adjusted height could fit all the workers.

Fig 11: workers working while sitting on ground

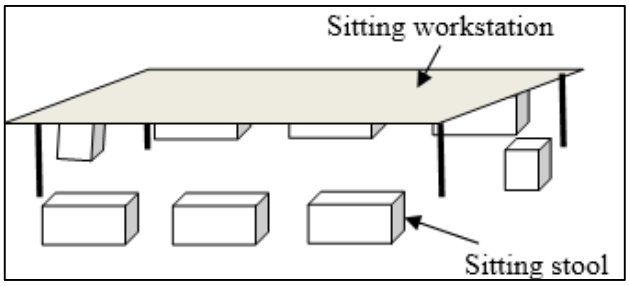

Fig 12: Modified sitting workstation

Along with the modification in workstations, there is a great need of small exercises in between the activity to allow proper blood circulation and eliminate the fatigue. Stretching exercise of back, legs, hands, shoulders and neck should be done to promote proper blood circulation and reduce the lactic acid deposition in the blood which is the main cause of fatigue.

Conclusion

The workplace analysis of micro, small and medium scale food processing enterprises shows that the existing workstation forced its workers to work with awkward postures for too long duration of 8 to 9 hours which may lead to the development of musculoskeletal discomforts if not changed urgently. To avoid the extreme postures adopted by respondents, modifications in the workstation were needed so that they could work with ease and the work could fit the worker rather than workers fitting to the work. Low cost modifications were suggested in the form of line diagram which could be adopted by the enterprises to provide comfort to their workers.

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