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A Case Study

An ergonomic study on evaluation of single wheel hoe in reducing drudgery

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SUMMARY : Women constitute a major task force in agricultural operations in India. Therefore, it becomes necessary to study the ergonomics of women operators involved in weeding and to suggest modifications for further reduction of human drudgery. Heart rate is one of the accurate means to evaluate the functional demands of work on the worker. Hence, the study was done to know the performance of improved weeder that is single wheel hoe in reducing drudgery among women engaged in weeding activity. The results showed that the total cardiac cost of work was 285.0 beats, the physiological cost of work was 6.33 beats/min, the average working heart rate during weeding was 112.5 beats/min and the average energy expenditure was 9.16 KJ/min during the weeding activity performed by improved tool , the single wheel hoe. Weeding activity was performed for maximum number of days in a year from morning till evening in squatting position majority of women perceived it as moderately heavy activity.

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KEY WORDS :
Heart rate, Energy expenditure, Total cardiac cost of work, Physiological cost of work

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BACKGROUND AND OBJECTIVES

In most of the developing countries women constitute as one of the important sources of farm power. About 6.5 per cent of the power used in crop production and related activities in the country like India is contributed by about 241 million workers, of which about 42 per cent (*i.e.* 101 million) are female workers. Among all agricultural activities, weeding is predominantly the responsibility of farm women. Weeds are unwanted plants that grow in various fields and gardens, these weeds must be removed for proper cultivation of crops. Weeding is an agricultural activity of removal of unwanted plants manually or with traditional tool like khurpi and kudali (Singh *et al.*, 2007). Therefore, in agriculture, the application of ergonomics can help in increasing the efficiency and thereby productivity of the women without jeopardizing their health and safety.

Traditional method of weeding takes longer time for weeding. Women generally adopt squatting and bending posture while doing the activity and maintain it for long hours, which cause musculo-skeletal problems (Sharma, 1999). Now a days different types of weeders are developed in India. These weeders are helpful for weeding in agriculture. Weeding by manually operated weeder increase the efficiency of workers and productivity of work. Manual weeding requires huge labour force and accounts for about 25 per cent of the total labour requirement which is usually 900 to 1200 man-hours/hectare. In India, this operation is mostly performed manually with cutlass or hoe that requires high labour input, very tedious and it is a time-consuming process.

Moreover, the labour requirement for weeding depends on weed flora, weed intensity, time of weeding, and soil moisture at the time of weeding and efficiency of worker. Behera and Swain (2005) reported that manually operated

weeders have found acceptability due to their low cost. According to Nag and Dutt (1979), manually operated weeders need human effort to operate. The performance of the weeders as well as the operator vastly depends on the design of the weeders. A weeder if designed without taking human capabilities into consideration will fail to deliver the desired result and will be finally rejected by the worker.

Presently there are many types of weeders available from simple to complex and motorized weeders. Several innovative and cost effective designs were developed and experimented according to the requirements of the farmers and soil conditions. Efforts are still on to reduce the drudgery in weeding operation (Khogare and Borkar, 2012).

In the present study improved weeder *i.e.* single wheel hoe designed by CIAE, Bhopal was tested on ergonomics parameters in comparison to the traditional method of weeding.

Single wheel hoe :

It is manually operated equipment for weeding and inter-culture in upland row crops spaced above 240 mm. It consists of wheel frame, V-blade with tyre and handle. Weeds cutting and uprooting are done through push and pull action of the unit (Fig. A).

Fig. A: Single wheel hoe- weeder used in the study

Specifications and working features :

Length (mm)	:	1790
Width (mm)	:	660
Height (mm)	:	520
Weight (kg)	:	9.5
Working width (mm)	:	135-211
Working depth (mm)	:	25-28
Weeding efficiency (%)	:	80-83
Plant damage	:	0.8-1.6
Field capacity (ha/h)	:	0.009
Labour requirement) (Man-h/ha	:	111
Operating cost (Rs./ha)	:	1100/-

Khurpi :

The Khurpi also known as a hand hoe is most commonly used hand tool for weeding. The tool is used in squatting position. The Khurpi consists of a sharp, straight-edged metallic blade with a tang embedded into a wooden handle. The blade and a tang are forged in single piece to a shape from medium or high carbon steel. In some cases alloy steel (nickel, chromium or molybdenum or manganese) is also used for the fabrication of blade. The cutting edge is hardened and sharpened. The tang is joined to the wooden handle with the help of rivets. The shape and design of the Khurpi are region or location specific depending upon the soil and cultural practices. For operation the Khurpi is held in one hand and pushed into the soil for removal of weeds or unwanted plants. The cutting or uprooting of the weed or undesired plant takes place due to shear and impact action of the blade of the Khurpi.

Specifications and working features :

Overall length (mm)	:	up to 350
Length of blade with tang (mm)	:	150-250
Width of the cutting edge (mm)	:	65-150
Weight (kg)	:	0.3-0.70

RESOURCES AND METHODS

Selection of subjects :

Twenty non-pregnant women from KVK adopted village Hanumantiya panwar of Neemuch district, Madhya Pradesh, India with normal health without any major illness or cardio-vascular problems in the age range of 25 to 40 years having normal blood pressure and body temperature were selected.

Body height, weight and BMI of each subject were measured. The grading of health status of women on the basis of BMI was done. The BMI scores were interpreted as per the classification given by Garrow (1987).

Each respondent was tied the heart rate monitoring machine and was switched on to record the heart rate at every minute. In order to record the resting heart rate, five minutes rest was given. They were then asked to perform the weeding activity for 30 minutes and heart rate was recorded at an interval of 1 minute each and than five minutes rest was given. The heart rate monitor was switched off and removed. The heart rate during rest, work and recovery were recorded while working with traditional as well as single wheel hoe weeder.

Assessment of physiological cost of work :

The energy expenditure (KJ/min) was estimated using the following formula proposed by Varghese *et al.* (1994)

for Indian housewives.

$$\text{Energy expenditure} = 0.159 \times \text{HR (bmin}^{-1}) - 8.72 \quad \text{....(1)}$$

Circulatory stress was estimated from cardiac cost of work and cardiac cost of recovery. The cardiac cost of recovery is the total number of heart beats spent above the resting level in order to perform the work. The cardiac cost of recovery is the total number of heart beats above the resting level occurring between the end of work and return to the pre-activity state (Saha, 1976).

Following formulae were used for calculation of physiological cost of work (PCW) and total cardiac cost of work (TCCW).

$$\text{Cardiac cost of work} = \text{Average heart rate (AHR)} \times \text{Duration of activity} \quad \text{...(2)}$$

where,

$$\text{AHR} = \text{Average working heart rate} - \text{Average resting heart rate}$$

$$\text{CCR} = (\text{Average recovery HR} - \text{Average resting HR}) \times \text{duration} \quad \text{...(3)}$$

$$\text{TCCW} = \text{Cardiac cost of work (CCW)} + \text{Cardiac cost of rest} \quad \text{...(4)}$$

$$\text{PCW} = \frac{\text{TCCW}}{\text{Total time of work}} \quad \text{..(5)}$$

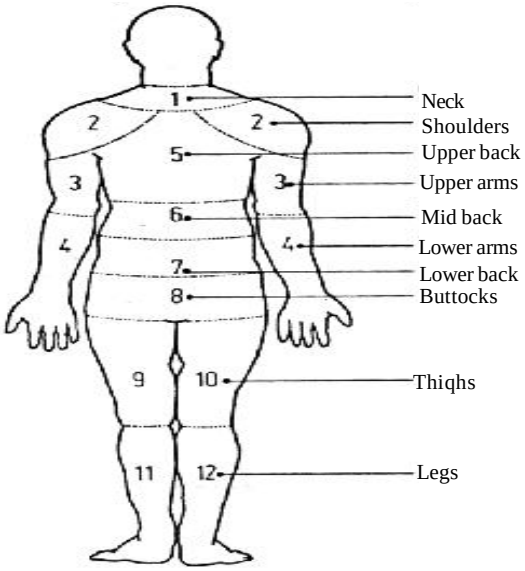
Classification of workload :

Workload of activity was categorized as per the classification of workload in different occupations proposed by Varghese *et al.* (1994).

Musculo-skeletal problems :

Incidence of musculo-skeletal problems was identified using the body map (Fig. B) indicating pain in different parts of the body before and just after the completion of the activity. Five-point scale was used to record the intensity of pain in the various body parts *viz.*, 5, 4, 3, 2 and I for the intensity of pain as very severe, severe, moderate, mild and very mild, respectively.

A technique for assessing posiural discomfort



Body regions

Severity scale

5. Very severe 4. Severe 3. Moderate 2. Mild 1. Very mild

Fig. B: Body map technique for assessing body part discomfort

Rating of perceived exertion :

Pain is the indicator of discomfort. The perceived discomfort was recorded in terms of pain felt in various parts of the body by the subjects while performing the activity. The rating exertion scale developed by Varghese *et al*. (1994) was used to subjectively assess the exertion perceived.

OBSERVATIONS AND ANALYSIS

As shown in Table 1, mean age of the selected farm women was 37 years with the average height of 152 cm and gross body weight being in the range of 42 to 54 kg. The mean body mass index was calculated to be 21.00, which meant they were in the normal category.

Table 1: Physical characteristics of the respondents (n=20)

Physical characteristics	Mean	Std.deviation
Age, years	37	±7.044
Height, cm	152	±3.640
Gross weight, kg	48.56	±6.393
Body Mass Index	21.00	±2.676

Health status of farm women :

The rating of health status of women on the basis of BMI was done as per the classification given by Garrow(1987). The distribution of respondents as per BMI scores is presented in Table 2.

Table 2: Percentage distribution of respondents as per BMI scores

BMI Scores	Interpretation	Percentage of respondents
< 16.0	*CED grade III (severe)	-
16.0-17.0	*CED grade II(moderate)	5
17.0-18.5	*CED grade I (mild)	-
18.5-20	Low weight normal	45
20.0-25.0	Normal	40
25.5-30.0	Obese grade I	10
>30.5	Obese grade II	-

*CED = chronic energy deficiency

As evident from Table 2, majority of the respondents (45%) fall in low weight normal category. Only 40 per cent of women were having BMI scores in normal range. It was observed that 5 per cent women belonged to poor health status in chronic energy deficiency of moderate grade. It is seen that 10 per cent of respondents were in exceptional health

Table 3: Percentage change in heart rate, energy expenditure and output by use of improved weeder over traditional one (n=20)

Physiological parameters	Traditional	Improved	% reduction in improved over existing
Average resting heart rate, $bmin^{-1}$	84.95	84	1.11
Average working heart rate, $bmin^{-1}$	129.6	112.5	13.19
Δ AWHR over rest, $bmin^{-1}$	44.65	28.5	-
Average energy expenditure resting, KJ/min	4.78	4.63	3.15
Average energy expenditure working , KJ/min	11.88	9.16	22.89
Output, m^2/h	160.0	230.0	↑ 43.75
Total cardiac cost of work (TCCW)	446.5	285.0	36.17
Physiological cost of work (PCW)	9.92	6.33	36.19

↑ Indicates % increase in output

category of obesity grade I. It can thus, be concluded that 15 per cent of respondent did not enjoy good health status as per BMI scores.

Physiological workload :

Analysis of data (Table 3) indicates reduction in percentage of average working heart rate as well as energy expenditure with use of improved weeder. It was clearly depicted that single wheel hoe weeder proved efficient on ergonomics parameters as it reduced average working heart rate and energy expenditure along with increased output when compared with traditional tool. The per cent reduction in average working heart rate was 13.19 per cent with use of single wheel hoe weeder.

Similar trend was observed for average energy expenditure also. The percentage increase in output was 43.75 for single wheel hoe weeder as it could weed out more land than by traditional weeder. Nag and Dutt (1979) also carried out studies to find out effectiveness of seven weeders with reference to physiological responses. The mean heart rate varied from 105 to120 beats/min and the oxygen uptake from 0.569 to 1.158 l/min in weeding operations.

Classification of workload :

The classification of workload while performing weeding was done on the basis of average heart rate and average energy expenditure as per classification of Varghese *et al.* (1994). It was observed that weeding was classified as moderately heavy and heavy while using single wheel hoe as compared to very heavy while using traditional tool, Khurpi (Table 4).

Table 4 : Classification of workload

Physical work load	Physiological variables	
	Energy expenditure KJ/Min	Heart beats, beats /min
Very light	Upto 5.0	Upto 90
Light	5.1-7.5	91-105
Moderate	7.6-10.0	106-120
Heavy	10.0-12.5	121-135
Very heavy	12.6-15.0	136-150
Extremely heavy	<15.0	Above 151

Musculo skeletal problems :

Weeding is an agro activity where musculo-skeletal problems are very pronounced. The reason being the activity is time bound and performed continuously for prolonged hours. The traditional method employs bending and squatting posture while pulling out weeds either with bare hands or using short handled Kudali or Khurpi.

Musculo-skeletal problems and posture were evaluated by asking the respondents as to where they felt pain in their

body after weeding with traditional and improved technology. Table 5 depicts that weeding with traditional tools in strenuous posture caused severe pain in shoulders, upper and mid back and upper arms. The women perceived the task as very heavy. On the contrary using improved weeding tool induced moderate to light discomfort/pain in shoulders, arms, wrist and neck. They were relieved from back pain as improved tool employed standing posture and eliminated back breaking bending and squatting posture. The rating of perceived exertion was also reported as moderately heavy with use of improved tool.

Table 5 : Responses on musculo-skeletal problems and perceived exertion experienced by respondents

Weeding method	Musculo-skeletal problems	Rating of perceived exertion (RPE)
Traditional	Severe pain in shoulders, upper and lower back and upper arms	Very heavy
Single wheel hoe weeder	Moderate to light pain in shoulders, hands and arms	Moderately heavy

Conclusion :

Single wheel hoe was found useful in terms of saving time, human effort, increasing work capacity and productivity. It was found to be compatible, easy to handle and applicable in field situation as well as most efficient for weeding vegetable fields. It was observed that use of weeder improved posture and efficiency of worker. The body discomfort reduced with use of weeder because it employed standing posture eliminating muscular fatigue and excessive loading of inter-vertebral discs of backbone. This proved that weeder are ergonomicsally sound, women friendly, drudgery reducing and improves efficiency of women.

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