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A Comparative Study on the Manual Beating of Paddy and Manually Operated Paddy Thresher on Farm Women

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ABSTRACT An ergonomic study was taken up to compare paddy threshing activity undertaken by farm women using two methods wiz manual beating of paddy on wooden platform and by using manually operated paddy thresher. The mean ▲HR work for manual beating of paddy was found to be 154.5 beats/min, whereas it was 122.5 beats/min with the use of manually operated paddy thresher. A significant reduction in heart rate of 20.71 percent was observed by improved method. The energy expenditure rate (EER) found to be 17.64 kj/min for manual beating whereas with the use of paddy thresher, the EER recorded was 12.80 kj/min. The total cardiac cost of work (TCCW) and physiological cost of work (PCW) reduced by 60.28 percent with the use of paddy thresher. Higher application force with double operators increased the total output capacity of the thresher per hour per person. Suggestions in the design of threshing drum can be incorporated to make it more acceptable in the field.

INTRODUCTION

Agricultural sector continues to be an important component of Indian National Economy with a contribution of about 22 percent to the GDP. In India, paddy occupies about 44 million hectares, which is, nearly 40 percent of the total cereals. India with highest area under this crop is the second largest producer of rice in the world after China but ranks 35th with respect to its productivity. China and India are the world's major rice producing countries with approximate contribution of more than 90 percent. Studies on agricultural operations show an increasing involvement of women in crop production (Gite et al. 1997).

Rural women have primary responsibility of running household, procuring fuel, fodder, water and care of children as well as other family members. Women play a significant and crucial role in agricultural operations, including different crop production activities, post harvest activities etc. In Uttarakhand state, agricultural operations are not so advanced, like some northern and southern states of India where paddy threshing is completely mechanized.

Threshing consumes 25 percent of the total energy utilized in paddy cultivation (Kathrivel and Shivakumar 2003). Bullock treading and beating of paddy bundle on wooden or stone platform are the two methods farmers still practice in state although it has low output, higher grain damage and involved more drudgery to the farmers.

Paddy threshing by manually operated paddy thresher is gaining popularity among the farmers since more than 60 percent of the cultivated land in hill area is under the category of small and marginal farmers. The threshing requirement of small and marginal farmers is less and can be met with a low capacity thresher. Moreover, the economic condition does not permit them to own a power thresher. Limited requirement, low cost of manual operated thresher and erratic electric supply in the rural areas create a huge potential for large scale adoption of manual thresher. Hence need was felt to study its ergonomic cost. Since women constitute a major task force in agricultural operations in India and hill region in particular so it becomes necessary to study the ergonomics cost of work of farm women involved in paddy threshing.

METHODOLOGY

The ergonomic evaluation of paddy threshing activity was conducted with farm women in Tarai and Hill Region of Uttarakhand using two methods wiz manual beating of paddy and by the use of manually operated paddy thresher (Fig. 1). The paddy thresher was operated for 20 minutes for threshing in the month of December.

One person was engaged for supplying the crop bundle to the thresher and other person

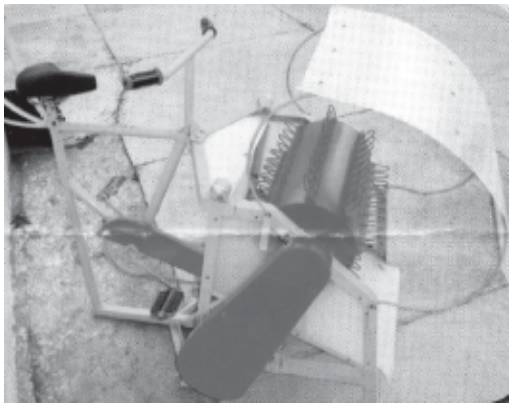

Fig. 1. Manually operated paddy thresher

was engaged for manually moving the handle to operate the thresher. At the end of each experiment, the subjects were given 30 minutes rest so that all the physiological parameters regained to their resting level. The detailed specification of the thresher is given in table 1.

Table 1: Salient specification of the thresher.

S. No.	*Specification*	*Dimensions*
1.	Height	1.3 mt.
2.	Length	1.0 mt.
3.	width	60.0 cm.

A total of thirty respondents were taken up for the study. Subjects were asked to perform the action manually by beating of paddy on wooden log for a time period of 20 minutes and their physiological parameters were noted down. After completing the task for scheduled time, subjects were given adequate rest to reduce deviation of physiological parameters from resting state.

Selection of Subjects

The selected thirty subjects were in the age group of 20-45 years because they usually attain their highest strength level between 20-45 years (Mc Ardle et al. 2001). All the subjects were right handed, physically fit and were not suffering from any physical anamalities to perform the selected activity.

Calibration of the Subjects

The subject were allowed to take sufficient rest before starting the activity to determine the resting heart rate (HR rest) and grip strength which was measured for both the hands at rest and 15 minutes prior of conducting experiment.

Measurement of Physiological Cost of Work

Circulatory stress was evaluated from the cardiac cost of work and cardiac cost of recovery. 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 resting state (Saha 1976). Heart rate was measured with polar heart rate monitor and recorded as HR=beat/min.

Following formula was used to calculate the total cardiac cost of work (TCCW) and physiological cost of work (PCW) (Singh et al. 2007).

Total cardiac cost of work = cardiac cost of work + cardiac cost of recovery.

TCCW = CCW + CCR; where
CCW = AHR × Duration of activity; where
AHR = Avg. working HR- Average resting HR
CCR = (Avg. recovery HR- Average resting HR) × Duration.

$$\textit{Physiological cost of work} = \frac{TCCW}{\textit{Duration of word}}$$

Energy Expenditure was calculated using the formula: *EE (Kj/min) = 0.159 × HR (beats/min) –8.72*

Measurement of Muscular Stresses

Muscular stresses during the performance of the activity were measured by recording the incidences of pain perceived by the subjects from the body map indicating different parts of the body. Intensity of pain in the above stated parts of the body was measured on five-point scale given below:

Score	*Intensity of pain*
4	Very severe
3	Severe
2	Moderate
1	Mild
1	very Mild

RESULTS AND DISCUSSION

Physical and Physiological Characteristics of the Subject

The mean resting heart rate of the subject was

found to be 82.2 beats/min with a range of 70-80 beats/min. The peak heart rate values were recorded between 143 to 166 beats/min with mean value of 154.5 beats/min. The average energy expenditure was found 10.80 kj/min. The peak energy expenditure values were recorded between 14.01 to 17.64 kj/min with the mean value of 15.82 kj/min. The blood pressure of the subjects was found in the normal range (Table 2).

Table 2: Physical and physiological characteristics of the subjects

Physical and Physiological characteristics	*Range*	*Mean*
Age, years	20-45	34.5
weight, kg	45-59	51.7
Height, cm	142-162	152.3
HRrest, beats/min	80-85	82.2
HRmax,beats/min	143-166	154.5
EErest, kj/min	8.10-9.10	8.6
EEmax, kj/min	14.07-17.67	15.82
Blood pressure (Sys/Dias mm Hg/mm Hg	100/72-122/86	111/79

Ergonomic Evaluation of Paddy Threshing Activity

Heart Rate

The average working heart rate (HR work) of the subjects when the paddy threshing was done manually by beating ranged between 143 to 166 beats/min. with a mean HR value of 154.5 beats/min. The corresponding HR values with the use of manual paddy thresher ranged between 120-125 beats/min. with a mean value of 122.5 beats/min. The trend in the rise of ▲HR (work) has been shown in figure 2. The ▲HR work increased till six minutes of threshing in cases and stabilized thereafter. The peak heart rate values were found to be 166 beats/min with manual beating of paddy whereas by using manual paddy thresher peak HR values was found to be 134.6 beats/min (Table 3). The heart rate recovered to its pre-work stage after 9 minutes of rest in case of manual beating of paddy whereas it was 7 minutes in cases when manual paddy thresher used for threshing. This showed that a rest pause of 9 minutes could be given to the operator before restarting the job. However more rest may be needed to subside the muscular fatigue developed during the threshing operation.

Table 3: Comparison of physiological parameter between manual beating of paddy and using manual paddy thresher

Parameter	*Manual beating*	*Paddy thresher*
HRrest beats/min	82.2	78.9
HRavg	154.4	122.5
HRmax	166.0	134.6
EEavg	14.04	10.80
EEpeak	17.35	12.68
TCCW	1965	780.4
PCW	131	52.03
ODR	3.7	4.7

Yadav and Pund (2007) reported a rest pause of 14 minutes while working with a manual weeder to restart the work where the peak heart rate of the subjects ranged between 142 to150 beats/min. The increase the heart rate per kg of grain threshed was compared to assess the extent of

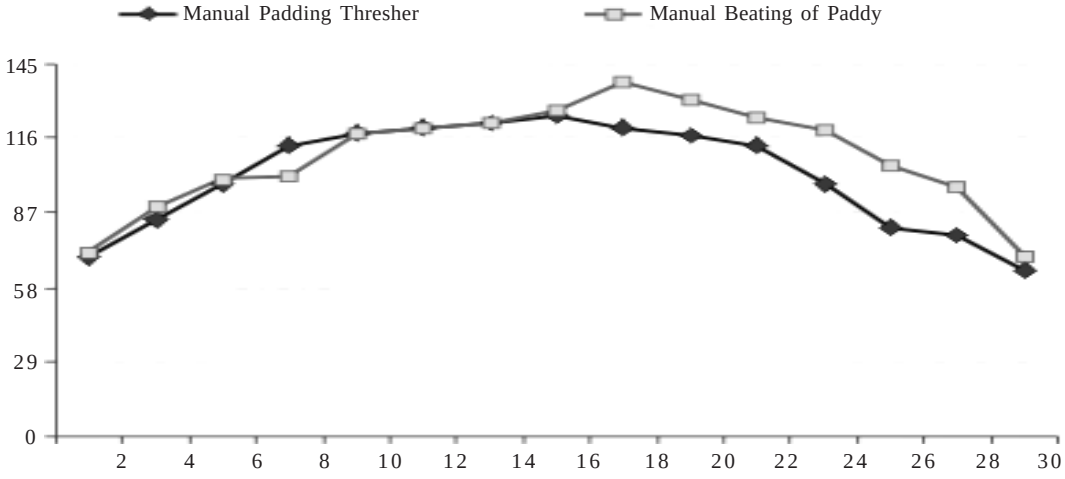

Fig. 2. Mean heart rate and recovery pattern at different duration of threshing operation

drudgery, as heart rate is a major parameter in quantification of drudgery (Astrand and Rodahl 1977). Dewangan (2007) reported that the heart rate values per kg. of grain threshed was found in the range of 123 - 179 beats/kg. with manual beating of paddy with the mean value of 154.4 beats/kg. However with the manually operated paddy thresher there was reduction in total heart rate per kg. of grain threshed to the tune of 134.6 beats/kg., a reduction of approximately 20 per cent. At the same time output of the thresher increased which resulted in a decrease of total heart rate per kg of grain threshed.

Energy Expenditure Rate

Peak values of energy expenditure rate (EER) with use of manual beating of paddy for threshing was observed to be 17.64 Kj/min. whereas with the use of manually operated paddy thresher it decreased to 12.80 Kj/min. Based on the energy expenditure values the categorization of the agricultural work was done as per classification by Nag et al. (1980) given in table 4.

Table 4: Categorization of the agricultural work (Nag et al. 1980).

Variable	*Light*	*Moderate*	*Heavy*	*Extremely heavy*
Energy cost (Kj/min.)	< 9.10	9.11-18.15	18.16-27.22	> 27.23

An extensive study on Indian Agricultural Operators to assess the occupational workload on the basis of individual capacity to perform work was conducted. Accordingly, manually threshing of paddy by beating on drum can be put into the 'heavy' category but with use of manual paddy thresher, it is categorized as a 'moderate' work.

The Total Cardiac Cost of Work (TCCW) was found to be 1965 beats for manual beating of paddy and 780.4 beats by the use of paddy thresher (manually operated). Results show that with the use of manually operated paddy thresher TCCW reduced by 60.28 per cent. The corresponding Physiological Cost of Work (PCW) was found as 131 beats for manual beating of paddy whereas 52.03 beats with the use of manually operated paddy thresher.

Overall Discomfort Rating (ODR)

The overall discomfort rating (ODR) of the respondents was found with a score of 4.6 ± 0.12 with manual beating of paddy whereas 3.7 ± 0.20 by using manually operated paddy thresher. ODR decreased significantly by 19.56 percent with use of paddy thresher. The body parts with maximum discomfort were lower back, right upper leg, right lower leg, right foot, right upper arm, right forearm in the descending order as expressed by the subjects. The body parts discomfort was mainly due to bending posture adopted while beating of paddy crop bundle on the drum whereas in case of manually operated paddy thresher discomfort was maximum in lower leg due to pedaling and feeding the crop in bent posture. Similar observations were reported by Dewangan (2007).

CONCLUSION

The ergonomic evaluation of paddy threshing activity revealed that the physiological responses and physiological cost of work reduced significantly by using paddy thresher (manually operated) The HR work, ODR, ERR, and physiological cost of work reduced from 154.5 to 122.5 beats/ min, 4.6 a score of 3.7, 17.64 to 12.80 kj/min and 131 to 52.03 respectively when comparative study was undertaken between manual beating of paddy on drum and the use of paddy thresher (manually operated). The increase in Heart Rate per kg of grain threshed reduced significantly contrary to reduction of ▲HR work by 20.71 percent.

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