

Ergonomic evaluation of different improved sickles in paddy harvesting

■ V.K. PANDEY, R.K. SINGH, V.P. RAI, D. ORAON, S.K. DUBEY, U.K. SINGH AND Z. ALAM

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See end of the Paper for authors' affiliation

Correspondence to:

V. K. PANDEY

Birsa Agricultural University,
Krishi Vigyan Kendra,
CHATRA (JHARKHAND) INDIA
Email :
vinod.bau@rediffmail.com

■ **ABSTRACT** : Naveen, Baibhav and Local sickles were evaluated for harvesting paddy crop with 20 farm women age 30-50 years (Subjects) at surrounding villages of KVK, Chatra, Jharkhand. The data of improved and Local sickles were compared. During the harvesting session, they spend nearly 7-8 hours daily to perform the activity. The Naveen sickle was the heaviest weight 229g followed by Baibhav and deshi was 202 and 178g, respectively. Deshi sickle was the lightest in weight (178g). Blade of both improved sickles were made up of high carbon steel except for deshi sickle that was made up of iron. The output was found maximum for Naveen sickle (74.2kg) this sickle resulted 6.9 per cent more output over the deshi sickle and also increase area covered 4.7 per cent over the deshi sickle. Average working heart rate (104bpm) and corresponding energy expenditure (7.81kg/min) was found minimum for Naveen sickle. Total cardiac cost of work for all sickles ranged from 840 beats to 1010 beats TCCW for Naveen sickle was 19.38 per cent less over deshi sickle. Therefore, Naveen sickle was suitable for crop harvesting under prevailing bio-physical and social economic condition of Chatra district, Jharkhand.

■ **KEY WORDS** : Improved sickles, Women workers, Heart rate, Paddy harvesting

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Rice (*Oryza sativa*) is the most important crop of Chatra district in Jharkhand. It occupies about 60 per cent cultivated area of Chatra District. This district land slope is more than 6-7 per cent and also very small, so the combine harvester, power reaper operation is very difficult. Also due to easy availability of human labour, easy available tools, simplicity in design and operation the most of farmers are depended on sickles. The relative performance evaluation of sickles for paddy crop harvesting is being felt important in order to reduce the drudgery of harvesting. Hence, the study was under taken with the objectives to study the physical characteristics of the women involved in paddy harvesting to assess the physical work load of the women using deshi and improved sickles.

■ METHODOLOGY

The study was undertaken in four villages viz., Turag, Dhamania, Uta, Kharik in Chatra block of Chatra District under KVK, Chatra with three treatments in Randomize Block Design with four replications during *Kharif* 2009-2010 and 2010-11, On 20 farm women subject ranging from 30-50 years of age using three different sickles viz., T₁- Local sickles T₂- Vaibhav sickle T₃- Navin sickle for paddy harvesting. To maintain

uniformity in on farm trail data, physically fit women was selected, physical fitness of the women was studied through step-stool ergo meter.

Health status through step stool test :

Selected farm women was given enough of rest and her resting heart rate was measured with the stethoscope. After the completeness, then after they ready to perform the stepping activity on the step test ergometer for maximum 5 min with uniform stepping rate of 30 steps/min. During the stepping activity the heart rate was recorded every minute. After 5 min of stepping activity, the farm women was asked to stop the activity and sit comfortably on resting chair. Then recovery pulse rate was recorded after every minute for a period of 5 min.

Physical fitness t index (PFI) was calculated by using the formula which interpretation of scores was given by Varghese *et al.* (1994).

$$PFI = \frac{\text{Duration of stepping (sec)} \times 100}{\text{Sum of 1st, 2nd \& 3rd min recovery HR}}$$

Health status through Aerobic capacity (VO₂max)

VO₂ max was calculated by using the regression formula:

$$VO_2(\text{MI} / \text{Kg} \times \text{min}) = 0.377 \times \text{step stool test (PFI)} - 12.767$$



Fig. A: Farm women while harvesting paddy with Naveen sickle

The subject coming within the normal range of health they were selected for experiment.

Finding of body composition and lean body mass body composition :

Body composition of selected subjects was measured using large's spenfold calliper. Biceps triceps, subscapular and suprailliac muscles were measured to calculate lean body mass (LBM) which has direct relation with heart rete of person. The following formula (Durmin and Rahaman, 1967) were used to calculate body density lean body mass and body composition of selected subjects.

$$\text{Body density (D)} = 1.1599 - (0.0717 \times \log \text{ of sum of 4 skinfolds})$$

$$\text{Per cent fat} = (4.95/D - 4.5) \times 100$$

$$\text{Fat weight} = \text{Body weight} \times \text{per cent fat}/100$$

$$\text{Lean body mass (kg)} = \text{Body weight} - \text{fat weight}$$

Body mass index (BMI) :

Body mass index was derived by measuring weight and height of women using quetelet index (QI) in the following

formula given by Garrow (1981)

$$QI = \frac{\text{Weight (kg)}}{\text{Height (M)}}^2$$

Ergonomic parameters :

Physiological workload :

This is to refer that physiological or muscular effort required on the part of worker to accomplish a task or an activity. The period during which the work continues is known as work period and period during which the physiological function return to resting level is known as recovery period. Hence, to evaluate total physiological expenditure, physiological reaction both during the work and during the recovery period are considered. Hence heart rate was recorded using stethoscope firstly at rest and then after 30 minute during the experiment till the recovery of subject. From the values of HR total cardiac cost of work (TCCW) and physiological cost of work (PCW) for paddy harvesting using various sickles were calculated. Following formula (Dilbaghi *et al.*, 2008) were used to calculate total cardiac cost of work (TCCW) and physiological cost of work (PCW)

$$TCCW = \text{Cardiac cost of work (CCW)} + \text{Cardical cost of recovery (CCR)}$$

$$CCW = \text{Average working heart rate} - \text{Average resting heart rate} \times \text{duration of activity}$$

$$CCR = (\text{Average recovery heart rate} - \text{Average resting heart rate}) \times \text{duration of activity}$$

$$\text{Physiological cost of work (PCW)} = \frac{TCCW}{\text{Total time of activity}}$$

Energy expenditure :

Energy expenditure during work was also calculated by average heart rate (AHR) by using regression equation given by Varghese *et al.* (1994).

$$\text{Energy expenditure (KJ/min)} = 0.159 \times \text{AHR (bpm)} - 8.72$$

RESULTS AND DISCUSSION

Physical characteristic of women harvesting paddy is given in Table 1. It depicts that mean age of woman was 30.8

Table 1: Physical characteristics of farm women in rice harvesting (n=20)	
Parameters	Mean ± standard deviation
Age (year)	30.8 ± 5.4
Weight (Kg)	45.6 ± 5.2
Height (cm)	142.3 ± 6.4
VO ₂ (ml/kg x min)	29.12 ± 5.6
BMI	32.04 ± 4.2
LBM (kg)	36.98 ± 3.1
Fat %	18.2

years having weight and height of 45.6kg and 142.3 cm, respectively. Aerobic capacity (VO_2 max) was found to be 29.12 $ML/kg \times min$ exhibiting that the subjects were having good health's. Fat percentage was found 18.2. Therefore, lean body mass (LBM) was found 36.98kg. Body mass Index (BMI) was observed as 32.04.

About 40 per cent women were having mesomorph body type which is considered as the perfect body type and 40 per cent were under endomorph (obese) body type and rest 20 per cent farm women were having ectomorph (Very thin) body type.

Three different type of sickles *i.e.* one deshi sickle and two improved sickles *i.e.* Baibhav and Naveen were tested.

Activity parameters :

The weight of deshi, Baibhav and Naveen sickle was 178, 202 and 229g, respectively. Naveen sickle was the heaviest weighing about 229g and lowest weighing of deshi sickle was 178g cutting blade of all the improved sickles was made up of high carbon steel except of deshi sickles which was made up iron (Table 2).

Output parameters :

Distance traveled :

A women walked maximum of 33.2m with Naveen Sickle. Distance traveled with Baibhav and deshi sickles was 31.4 m and 30.2m, respectively for 30 min duration of experiment. Results shows that good sickle resulted in more distance traveled in field leading to more output than other Baibhav and deshi sickles. Naveen sickles resulted 10 per cent more distance traveled over the deshi sickles (Table 2).

Output operation :

Output of operation includes amount of paddy harvested during specified period of different sickles. Results shows that the maximum output was found 74.2kg by Naveen sickle followed by 72.3 and 69.4 kg by Baibhav and deshi sickles, respectively. Naveen sickle resulted 6.9 per cent more paddy weight over the deshi sickle (Table 2).

Area covered :

Area covered by Naveen sickles was found maximum 44.4 m^2 followed by 43.6 m^2 and 42.4 m^2 of Baibhav and deshi sickle, respectively. Naveen sickle resulted 4.7 per cent more area covered over the deshi sickle.

Physiological parameters :

Working heart rate :

Table 3 revealed that during paddy harvesting mean working heart rate was 104 bpm with Naveen sickle and 106, 108 for Baibhav and deshi sickle, respectively. The minimum working heart rate 104 bpm for Naveen sickle which was 3.7 per cent minimum from deshi sickle. Similar trend was observed in case of peak heart rate. Average peak heart rate was found 121 bpm for deshi sickle where as Naveen and Baibhav sickle were 118 bpm and 119 bpm, respectively. The average peak heart rate was 2.4 per cent less with Naveen sickle over deshi sickle.

Energy expenditure :

Average energy expenditure during paddy harvesting was found minimum 7.81 KJ/min with Naveen sickle over the 8.13 and 8.45 KJ/min for Baibhav and deshi sickle, respectively.

Table 2 : Activity profile of women in paddy harvesting

Activity parameters	Sickles		
	Deshi	Baibhav	Naveen
Type of tools			
Weight of sickle (g)	178	202	229
Material of blade	Iron	HCS	HCS
Output parameters.			
Total distance traveled (m) (30 min)	30.2	31.4	33.2
Output (kg) 30 min	69.4	72.3	74.2
Areas covered (m^2) (30min)	42.4	43.6	44.4

Table 3 : Physiological workload of women harvesting paddy with various sickles

Physiological parameters	Deshi	Baibhav	Naveen
Average working heart rate (bpm)	108	106	104
Average peak heart rate (bpm)	121	119	118
Average energy expenditure (KJ/min)	8.45	8.13	7.81
Average peak energy expenditure (KJ/min)	10.84	10.02	9.88
Average TCCW (beats)	1010	900	840
Average PCW (beats/min)	29	26	24

The Naveen sickle resulted 8.1 per cent less energy expenditure over the deshi sickle (Table 3).

The average peak energy expenditure was found 10.37 KJ/min with deshi sickle where as with Naveen and Baibhav sickle were about 9.88 and 10.02 KJ/min, respectively. The average peak energy expenditure was 9.09 per cent less with Naveen sickle over deshi sickle (Table 3).

Total cardiac cost of work (TCCW) :

With Naveen sickle it was 846 beats followed by 900 and 1010 beats with Baibhav and deshi, respectively. The total cardiac cost of work with Naveen sickle was less (19.38%) over the deshi sickle (Table 3). Singh *et al.* (2007) reported about 15 per cent saving in cardiac cost of work per unit of output with improved sickle as compared to deshi sickle.

Physiological cost of work (PCW) :

Average physiological cost of work for Naveen sickle was 24 beats/min followed in 26 and 29 beats/min of Baibhav and deshi sickle, respectively.

The physiological cost of work for Naveen sickle was less (20.80%) over the deshi sickle.

Conclusion :

Naveen sickle, Baibhav sickle and deshi sickle among all the three, Naveen sickle was found efficient in output parameter and physiological parameters. Naveen sickle harvested 6.9 per cent more paddy weight over deshi sickle. The drudgery of women by reducing energy expenditure was upto 8.1 per cent over the deshi sickle. The total cardiac cost of work (TCCW) of Naveen sickle was 19.38 per cent less over

the deshi sickle. The use of Naveen sickle reduced physiological work load and increase output activity thereby decreasing the drudgery of women in harvesting of paddy. Therefore, Naveen sickle was suitable for harvesting of crop under prevailing bio-physical and socio economic condition of Chatra district, Jharkhand.

Authors' affiliations:

R.K. SINGH, V.P. RAI, D. ORAON, S.K. DUBEY, U.K. SINGH AND Z. ALAM, Birsa Agricultural University, Krishi Vigyan Kendra, CHATRA (JHARKHAND) INDIA

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