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Superiority of the Naveen serrated sickle over the traditional sickle for wheat harvesting

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ABSTRACT

The experiment was conducted involving twenty non-pregnant farm women voluntarily joining the study using serrated and non-serrated sickles in Neemuch district of Madhya Pradesh. The results showed that the total cardiac cost of work was 290 beats, the physiological cost of work was 7.45 beats/min, the average working heart rate was 115 beats/min and the average energy expenditure was 8.26 KJ/min during the harvesting activity performed by improved tool, the Naveen serrated sickle. The sickle proved efficient on ergonomic parameters as it reduced average working heart rate and energy expenditure along with increased output when compared to traditional tool. The per cent reduction in average working heart rate was 8.00 with the use of Naveen serrated sickle. It was observed that harvesting was classified as moderately heavy and heavy while using Naveen serrated sickle as compared to very heavy while using traditional tool. Hence it was found that the improved tool was ergonomically good, friendly to women, reduced drudgery and thus was helpful in improving the efficiency of women.

Keywords: Heart rate; energy expenditure; cardiac cost; physiological cost

INTRODUCTION

In India the grain has been harvested by sickle for centuries. Today with advancement in the technology a few combines are finding their way in to speed up the harvest. However combines are out of reach of the majority of small farmers and thus most of the fields are still harvested with sickles.

Sickles are hand-held agricultural tools with a sharply curved metal edge. Sickle blades are intended primarily for the cutting of grains or grass and most often have serrated edges. The serrated edges on sickle tools are to aid in cutting vegetation in a quick pulling motion as opposed to a chopping motion. The sickle is still an ultimate choice hand tool for harvesting the wheat. This preference continues. The sickle used by farm women of Neemuch district of Madhya Pradesh, India is non-serrated. The sharpness of non-serrated sickle is reduced quickly therefore the harvester needs time to sharpen it frequently which means time loss and productivity reduction. Simultaneously because of plain edge it brings discomfort and drudgery.

The present work was based on Naveen serrated sickle to study the ergonomic parameters on it to reduce drudgery, to find out its performance over the traditional sickle and find out the perceived exertion by farm women.

Features of a sickle: Sickle is one of the most common hand tools used for harvesting of the crops, grass and cutting of other vegetative matters. It consists of curved steel edged blade fixed to the wooden handle. The cutting edge may be plain or serrated depending upon the design. The curvature of the blades differs widely in plain edged and serrated sickles. The blade is fabricated from medium carbon or high carbon steel and hardened to resist wear. Manganese steel, tool steel and alloy steel can also be used to produce better quality sickles which have more life than the sickles fabricated from the plain carbon steel. The blade has a knife section with thickness reduced towards the cutting edge. The tang of the blade is inserted in to the wooden handle for joining the blade to the handle. The wooden handle is either straight or bent at the end. For cutting, the part of the plant to be cut is held in one hand and sickle operated with other hand. Cutting is achieved by imparting translatory and rotary movement to the blade around the point of cut. This action leads to applying frictional and shearing force components required to achieve cutting. The overall length, width and height of a sickle are 260-420, 145-200 and 25-75 mm respectively. The blade thickness is 1.5-4 mm which is tapered to the cutting edge. Length and hardness of the cutting edge are 130-210 mm and 37-46 HRC respectively whereas the weight of the sickle is 150-400 g. The sickle is general purpose harvesting hand tool. It is used for the harvesting of vegetables, cereal crops and cutting of the grass and other vegetative matters.

Naveen sickle: It is a serrated blade sickle suitable for harvesting wheat, rice and grasses. The blade is made from medium carbon steel or alloy steel, hardened and tempered to suitable hardness. The back of serrated edge is ground to bevel profile to expose the cutting teeth. Upon wearing of teeth, the bevel profile is ground and teeth are exposed again. The wooden handle has a bend at the rear for better grip and to avoid hand injury during operation. It saves 26 per cent labour and operating time and 27 per cent on cost of operation compared to harvesting by local sickles. The sickle is outcome of the research and has been adopted by manufacturers for commercial production. The dimensions of a Naveen sickle are 260 x 33 x 1.7 mm. The weight, length of cutting edge, radius of curvature, number of teeth per cm and diameter of handle are 0.257 kg, 225 mm, 260 mm, 5 and 40 mm respectively whereas power source is one person. Its field capacity is 0.018 ha/h and labour requirement is 80 man hours/ha wrt performance results in wheat crop. It is suitable for harvesting wheat, rice and cutting of grasses. Plate 1 shows the traditional sickles, serrated (Naveen) sickle and the serrated sickle in operation.

METHODOLOGY

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 for the study. Height, weight and BMI of each subject were measured. The grading of health status of women was done on the basis of BMI. 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 harvesting activity for 30 minutes and heart rate was recorded at an interval of 1 minute each and then 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 Naveen serrated sickle.

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:

Energy expenditure= 0.159 x HR (b/min)–8.72 …..(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):

Cardiac cost of work= Average heart rate (AHR) x Duration of activity …..(2)

where AHR= Average working heart rate – Average resting heart rate

CCR= (Average recovery HR – Average resting HR) x duration …..(3)

TCCW= Cardiac cost of work (CCW) + Cardiac cost of rest .....(4)

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

Classification of workload

Workload of activity was categorized as per the following classification of workload in different occupations proposed by Varghese et al (1994) (Table 1).

Musculo-skeletal problems: Incidence of musculo-skeletal problems was identified using the body map (Fig 1) 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 1 for the intensity of pain as very severe, severe, moderate, mild and very mild respectively.

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.

RESULTS and DISCUSSION

As shown in Table 2 mean age of the selected farm women was 38 years with the average height of 155 cm and gross body weight being in the range of 45 to 54 kg. The mean body mass index was calculated to be 21.00 which meant they were in the normal category.

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 3 which shows that majority of the respondents (45%) fell 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 mild grade and 10 per cent of respondents were in exceptional health category of obesity grade I. It can thus be concluded that 15 per cent of respondents did not enjoy good health status as per BMI scores.

Table 1. Classification of workload

Physical work load	Physiological variables	
	Energy expenditure (KJ/min)	Heart beats/min
Very light	Up to 5.0	Up to 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	>151

Table 2. Physical characteristics of the respondents (n= 20)

Physical characteristics	Mean	SD
Age (years)	38	±5.040
Height (cm)	155	±3.406
Gross weight (kg)	50.10	±6.250
Body mass index	21.00	±2.780

Table 3. Percentage distribution of respondents as per BMI scores

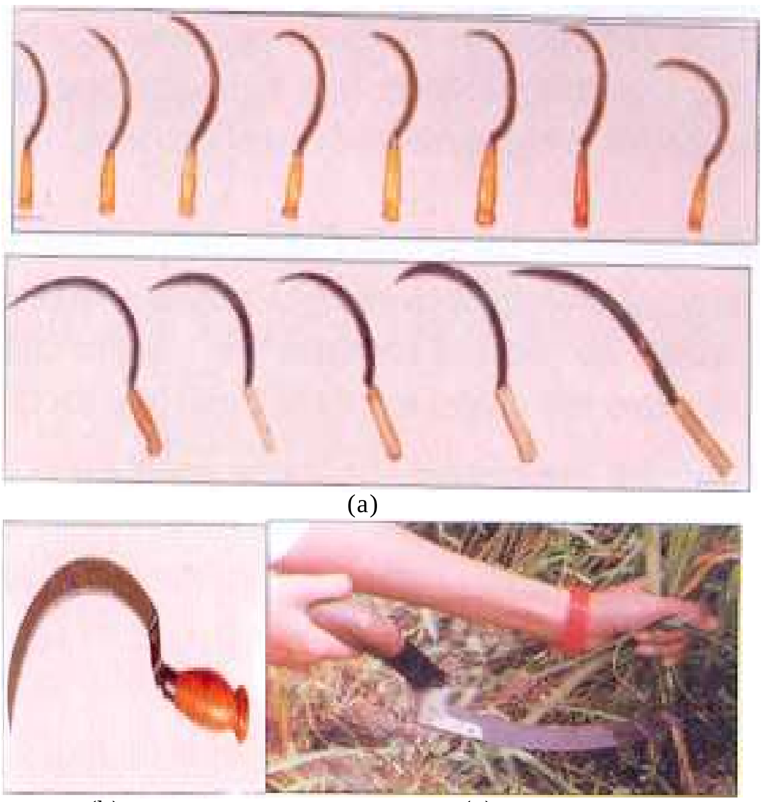
BMI score	Interpretation	Percentage of respondents
<16.0	CED grade III (severe)	—
16.0-17.0	CED grade II (moderate)	—
17.0-18.5	CED grade I (mild)	5
18.5-20	Low weight normal	45
20.0-25.0	Normal	40
25.5-30.0	Obese grade I	10
>30.5	Obese grade II	—

CED= Chronic energy deficiency

Physiological workload: Analysis of data (Table 4) indicated reduction in percentage of average working heart rate as well as energy expenditure with use of improved sickle. It was clearly depicted that Naveen serrated sickle proved efficient on ergonomic parameters as it reduced average working heart rate and energy expenditure along with increased output as compared to traditional tool. The per cent reduction in average working heart rate was 8.00 with the use of Naveen serrated sickle. Similar trend was observed for average energy expenditure also. The percentage increase

Table 4. Percentage change in heart rate, energy expenditure and output by use of improved weeder over traditional one (n= 20)

Physiological parameter	Traditional weeder	Improved weeder	% reduction in improved over existing
Average resting heart rate (b/min)	84.95	84	1.11
Average working heart rate (b/min)	125.0	115.0	8.00
Δ AWHR over rest (b/min)	40.05	31.0	-
Average energy expenditure resting (KJ/min)	4.78	4.63	3.15
Average energy expenditure working (KJ/min)	12.60	8.26	34.44
Output (m^2/h)	50.0	65.0	‘!30.00
Total cardiac cost of work (TCCW)	440.0	290.0	34.09
Physiological cost of work (PCW)	9.80	7.45	23.97



(b) (c)

Plate 1. (a): Different types of sickles, (b): Serrated (Naveen) sickle, (c): Serrated sickle in operation

in output was 30.00 for Naveen serrated sickle as it could harvest out more land than by traditional weeder. Singh (2012) also carried out studies to find out effectiveness of three harvesting tools with reference to physiological responses. The data on improved and local sickles were compared. Mean heart rate during work in operation of these sickles was 103 beats/min, 107 beats/min and 106 beats/min. The output of Naveen, Vaibhav and local sickles was 47.3, 60.7 and 65.4 m^2/h respectively. Similar results have been observed by Gite and Agarwal (2000) and Singh et al (2014).

Classification of workload: The classification of workload while performing harvesting 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 harvesting was classified as moderately heavy and heavy while using Naveen serrated sickle as compared to very heavy while using traditional tool.

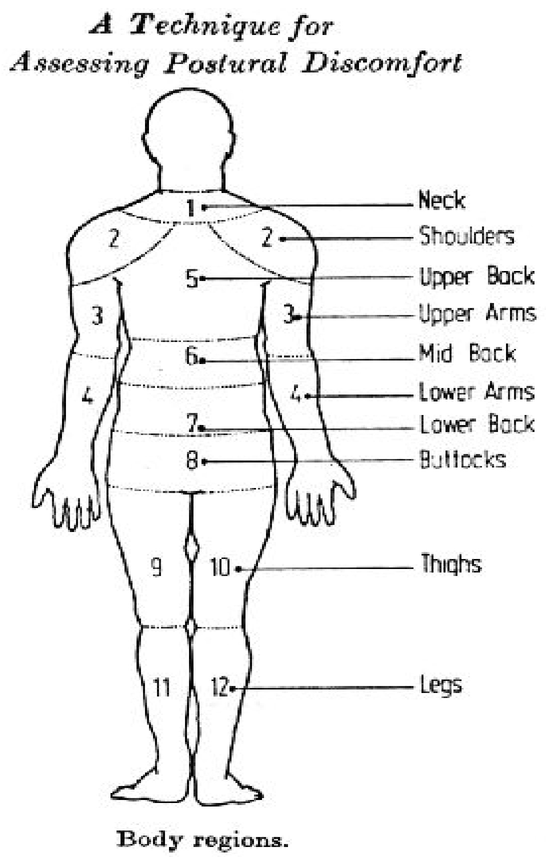
Musculo-skeletal problems: Harvesting is an agro-activity where musculo-skeletal problems are very pronounced. The reason being that the activity is time bound and performed continuously for prolonged hours. The traditional method employs sitting posture while harvesting using short handled Khurpi.

Musculo-skeletal problems and posture were evaluated by asking the respondents as to where they felt pain in their body after harvesting with traditional and improved technology. Table 5 depicts that harvesting with traditional tools in strenuous posture caused severe pain in shoulders, upper and mid-back and upper arms. The women perceived the task as heavy. On the contrary using improved harvesting tool induced moderate to light discomfort/pain in shoulders, arms, wrist and neck. They were relieved from hand pain as improved tool employed cutting the crop fast due to serration. The rating of perceived exertion was also reported as moderately heavy with the use of improved tool.

The results showed that the total cardiac cost of work was 290 beats, the physiological cost of work was 7.45 beats/min, the average working heart rate during

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



Severity scale: 5. Very severe, 4. Severe, 3. Moderate, 2. Mild, 1. Very mild

Fig 2. Body map technique for assessing body part discomfort

harvesting was 115 beats/min and the average energy expenditure was 8.26 KJ/ min during the harvesting activity performed by improved tool, the Naveen serrated sickle.

CONCLUSION

Naveen serrated sickle 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. It was observed that use of improved tool helped in increasing the efficiency of worker. The body discomfort reduced with the use of serrated sickle because it eliminated muscular fatigue and excessive loading of inter-vertebral discs of backbone. This proved that serrated sickle was ergonomically sound, women friendly, drudgery reducing and improved efficiency of women.

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