

Original Research Article

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Drudgery Reduction through Ergonomic Evaluation of Women Farm Workers using Local Sickle and Serrated Sickle During Harvesting in Wheat Crop of Udaipur District

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ABSTRACT

Women play a major and crucial role in doing the agricultural operations. The women workers in Udaipur district mostly uses local made sickle for doing harvesting operation. This study was conducted in 2019-20 at instructional Farm, CTAE, Udaipur with ten women farm workers during the manual harvesting operation by using local sickle along with serrated sickle. The main objective of the study was to investigate the most drudgery prone tool and to recommend the proper tool for doing harvesting operation in wheat crop. Use of proper tools not only reduce the drudgery but also improves the operating efficiency along with the comfort, besides improving the productivity of the women farm workers in doing the operation. In view of this, an effort has been made to assess the physical and physiological parameters of women farm workers who are using local sickle along with the serrated sickle for doing harvesting operation in wheat crop. The whole study was conducted on ten female farm workers identified from the population of workers in the age group of 18 to 45 years. During the experiment, the average working heart rate, Energy expenditure rate, Oxygen consumption rate, physiological cost of work of women farm workers using local sickle was 103.65 beats/min, 11.67 kJ/min, 0.57 l/min, 18.44 beats/m² and for serrated sickle 111.55 beats/min, 15.62 kJ/min, 0.62 l/min, 14.96 beats/m². The overall discomfort rate at the end of the work for local and serrated sickle was 7.6 and 6.8. The reduction of drudgery by using serrated sickle over local sickle was found to be 18.87%. The rating of perceived exertion given by the female farm workers at the end of the work was found to be less for serrated sickle i.e., 3.6 and for local sickle, it was 4.2.

Keywords

Agricultural activities, Women farm workers, Harvesting, Ergonomic assessment

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Introduction

Female agricultural workers in India play dominant role in agriculture production and productivity. They are involved in various agricultural operations and their participation

varies with region, crops, commodities and socio-economic studies. Drudgery is mostly perceived as physical and nervousness, exhaustion, tedium and sufferings experienced while doing a particular task. It is evident, that if proper drudgery reducing

farmstead implements are made available to the rural agricultural farm women, these would contribute to reduction in drudgery, increase ability, throughput and subsequently the greater workload thereby enhanced efficiency. Harvesting operation in wheat crop is mostly done by the female farm workers manually under heat stress and also very laborious operation. These agricultural operations performed by women involve a lot of physical strain, which create serious health problems in the long run, besides developing some Musculo-skeletal problems which mainly occurs due to the inconvenient work postures (Chauhan, 1999). It is also concluded that combination of standing and bending postures were generally used by most of the farm women for performing cutting operations (Bora and kalita, 2002).

Harvesting operation in wheat crop is arduous and extremely demanding the women farm workers especially for those farm units less than 2 hectares and experiences drudgery while doing the operation. Daily with eight hours of labour, starting from morning to evening, besides women farm workers usually adopts squatting, bending position for extended duration. It is also revealed that the foremost of the women experienced severe to moderate severe pain in neck due to the constant muscle contraction and also suffered from pain in upper leg, lower back and calf muscles, ankle and wrist who were involved in cutting (Anon, 2001-02)

Research studies considering women's role especially that of rural women in agriculture activities are inadequate. In terms of research very few studies regarding women participation in agriculture activities and extremely limited studies are available to ease the drudgery perceived and physiological cost during the farm operations in Udaipur district. Keeping in sight the dearth of information alarming women participation in agriculture

activities, the study in hand is instigated to fill these gaps.

Justification of the Research Study

Research studies investigating the Ergonomical studies on agriculture workers particularly about rural women workers in agriculture activities are scarce. In terms of research very few studies pertaining to ergonomics in agriculture activity i.e., during harvesting operation in wheat crop have been carried out in India, in particular, Udaipur district.

The objectives of the study include to assessment of physiological parameters, heart rate (HR), cardiac cost, oxygen consumption rate (OCR) and Energy expenditure rate (EER) during harvesting operation in wheat crop with local sickle and ergonomically improved serrated sickle. Assessment of overall discomfort rating (ODR) before and after the operation. Assessment of Rating of perceived exertion after the operation. Assessment of Musculo-skeletal problems after the operation. Problems faced by the women farm workers with local sickle and comparison of local sickle with serrated sickle.

Materials and Methods

Physiological and physical workload was calculated during the harvesting operation of wheat crop which was performed in the month of April, 2019-20 at CTAE Instructional farm, Udaipur. The study was conducted on ten female farm workers selected from the representative population of workers between 5th and 95th percentile of the anthropometric criteria. During the study period all the operations were performed by these ten female farm workers only. Selected subjects had agriculture as their main source of occupation.

All the subjects selected did not have the habits of chewing tobacco and taking any type of liquor. Subjects were between 18-45 years of age. Subjects were free from any chronological disease, physical disorder and were medically fit. In morning, the uniform time of 6h for weeding operation was given in between 9 AM to 1 PM and in evening from 2 PM to 5 PM.

All the female farm workers were allowed to take rest for 15 minutes before performing the task and asked to perform the harvesting operation continuously for 30 minutes and then allowed to take rest for 15 minutes. The same procedure was followed for both sickle and ergonomically developed serrated sickle by following proper work-rest cycle.

For assessment of effect of physiological and physical work load on the performance of female farm workers, two different tools namely local sickle and serrated sickle in wheat crop during harvesting operation were taken as independent parameters.

Six dependent parameters includes three physiological workloads namely heart rate (HR), oxygen consumption rate (OCR) and energy expenditure rate (EER) and three physical workloads namely, Overall discomfort rate (ODR), Rate of perceived exertion and Musculo-skeletal disorders were selected for this study.

Instrumentation

During the experiment, the measuring tape and weighing scale were used to measure the physical characteristics like height and weight. Instrumentation used to conduct the experiments for measurement of physiological and physical workload is described below.

Physiological workload

Computerized ambulatory metabolic measurement system

The computerized ambulatory metabolic measurement system measures the oxygen consumption at every breath that's why it is known for breath by breath measurement and is more accurate than mixing chamber measurement. Heart rate (resting HR, working HR) and oxygen consumption rate and energy expenditure rate (EER) were directly measured by using K4b² make by Cosmed (Italy). Varghese *et al.*, 1994 given the following formula. Increase in Heart rate (Δ HR), cardiac cost and output was calculated by using the following given formula.

1. Increase in Heart rate, Δ HR (beats/min) = Average working heart rate – Average resting heart rate
2. Output (m²/h) = area covered x duration / average time
3. Cardiac cost/physiological cost of worker per unit of output (beats/ m² area covered) = Δ HR x duration / output.

Physical workload

Overall Discomfort Rating (ODR)

Overall discomfort rating (ODR) had been defined by using a 10-point psycho-physical rating scale developed by Borg in 1990. A scale of 70 cm length was fabricated having 0 to 10 digits marks on it equidistantly as shown below. A flexible pointer to indicate the rating was provided. The subject was asked to report her discomfort level on the scale before start of work. She was again asked to report the discomfort level at the end of work. The difference in the score of before and after the work was the real discomfort score.

Rating of perceived exertion

Rating of Perceived Exertion was measured at 5-point scale developed by Varghese *et al.*, (1994) very light -1, light-2, moderately heavy-3, heavy-4, very heavy-5

Body part discomfort score (BPDS)

The Musculo-skeletal problems during the activity were identified with the help of body map (Corlett and Bishop, 1976) known as Body part discomfort score (BPDS), which indicates different body parts (Figure-2) viz; upper body parts (eye, neck, shoulder joint, upper arm, elbows, wrist/hands) and lower body parts (lower arm, low back, upper leg/thigh, knees, calf muscles, ankles, feet).

Results and Discussion

The performance of Local sickle and serrated sickle was compared. The physical dimensions of studied sickles were compared against standards given by BIS (1967). The details are indicated clearly in Table 1. and Fig 2. shows the sickles used in this study for harvesting operation in wheat crop.

To reduce the drudgery in the harvesting operation through ergonomic point of view, ten female farm workers were selected in the age group of 18 to 45 years were selected at random and average age of the respondents engaged in wheat harvesting operation was counted as 33.30 years measuring body height of 149cm, weight as 45.4 kg and Body mass index (BMI) as 20.58 respectively. The Physical characteristics of ten selected female farm workers are indicated in Table 2.

Physiological workload during the harvesting operation of wheat crop was determined on the basis of various parameters like average heart rate during work and rest, oxygen

consumption rate energy expenditure rate and physiological cost of work while performing the activity.

Physiological workload from the observation given in Table 3, clearly indicated the area covered by the local sickle was 72.68 m²/h by local sickle as compared to serrated sickle which was 90.18 m²/h. Alka *et al.*, (2014) also stated that the serrated sickle resulted in higher output than local sickle because of the less pushing force required, which was resulted in higher cutting speed and hence resulted in increased output and reduced drudgery by 18.87%. Gite *et al.*, (2000), also stated that the serrated sickle reduces the drudgery by 16.50% when compared to local sickle.

During harvesting with local sickle, the average Δ HR was 22.12 beats/min, Energy Expenditure Rate was 11.67 kJ/min, Oxygen consumption rate was 0.57 l/min and physiological cost of work was 18.44 beats/m² whereas with serrated sickle, the average Δ HR was 24.23 beats/min, Energy Expenditure Rate was 15.62 kJ/min, Oxygen consumption rate was 0.62 l/min and physiological cost of work was 14.96 beats/m². Dilbaghi *et al.*, (2008), Alka *et al.*, (2014) also found the maximum output and reduction in physiological cost of work with serrated sickle.

Fig 3(a), Fig 3(b), shows female farm workers while doing harvesting operation using local sickle and serrated sickle. The overall discomfort rating (ODR) at the beginning of the operation and at the end of the operation using plain sickle was 1.5 and 7.6 and for serrated sickle, 1.5 and 6.8 respectively. The Rating of perceived exertion for local sickle was given as 4.5 and for serrated sickle as 3.4.

Table.1 Physical dimensions of studied sickles against standards given by BIS (1967)

sno	particulars	BIS (1967)	Local sickle	Serrated sickle
1.	Total Weight, g		0.206	0.172
2.	Base plate for blade of sickle, mm	12±2	8	57
3.	Maximum width of the blade, mm	28±3	30	24
4.	Blade thickness, mm	4±0.5	2.59	1.69
5.	Outer length of blade	-	172	261
6.	Blade concavity, mm	59	62	43
7.	Sickle length, mm		285	350
8.	Maximum length of handle, mm	125	105	135
9.	Effective handle length, mm		105	100
10.	Max diameter of handle, mm		40	30
11.	Size of sickle, mm	224±3	155	238

Table.2 Physical characteristics of selected female farm workers with number of subjects (N=10)

SNo	Physical characteristics of female farm workers	Mean±Standard deviation
1.	Age (years)	33.30±9.25
2.	Height (cm)	149±7.18
3.	Weight (Kg)	45.4±5.72
4.	Body mass index (BMI)	20.58±2.03

Table.3 Evaluation of performance data of different parameters of the farm women while performing harvesting operation(N = 10)

Particulars	Mean±Standard deviation	
	Local plain sickle	Serrated sickle
Type of tool used	Local plain sickle	Serrated sickle
Time of operation per subject (hours)	1	1
Average working heart rate (beats/min)	103.65±3.62	111.55±3.96
Average resting heart rate (beats/min)	81.53±2.38	87.32±2.07
Average recovery heart rate (beats/min)	90.12±4.04	96.7±1.62
ΔHR (working HR - resting HR) (beats/min)	22.12±3.81	24.23±4.89
Area covered/output (m ² /h)	72.68±4.8	90.18±5.84
Energy Expenditure Rate (kJ/min)	11.67±0.98	15.62±1.54
Oxygen consumption rate, OCR, l/min	0.57±0.05	0.62±0.03
Physiological cost of work (beats/m ²)	18.44±4.03	14.96±3.61
Reduction in drudgery (%)	-	18.87
Overall discomfort rating (ODR) at the starting of work	1.1	1.25
Overall discomfort rating (ODR) at the end of the work	6.9	5.5
Overall discomfort rating (ODR)(start-end)	5.8	4.3
Rating of perceived exertion (RPE)	4.2	3.6

Table.4 Correlation coefficient computed between different variables and energy expenditure with two different tools (N = 10)

Particulars	Energy expenditure rate (EER) (kJ/s)	
	Local plain sickle	Serrated sickle
Age (years)	-0.56*	-0.33*
Height (cm)	0.0096	0.54
Weight (kg)	0.04	0.25
Average working heart rate (beats/min)	0.60**	0.95**
Average resting heart rate (beats/min)	0.19**	0.21**
Average recovery heart rate (beats/min)	0.42**	0.75**
Oxygen consumption rate, OCR, (l/min)	0.90	0.52
ΔHR (beats/min)	0.45	0.86
Area covered/duration (m ² /hr)	0.36	0.09
Physiological cost of work (beats/m ²)	0.44	0.54

*Significant at P = 0.05, **Significant at P = 0.01

Table.5 Correlation coefficient computed amongst the variables of serrated sickle with number of subjects (N=10)

Particulars	Age (years)	Weight (kg)	Average WHR(bp m)	ΔHR (bpm)	Area covered/duration (m ² /hr)	Cardiac cost (beats/m ²)
Age (years)	1.00					
Weight (kg)	0.04	1.00				
Average WHR(bpm)	-0.35	0.14	1.00			
ΔHR (beats/min)	0.57	0.20**	0.91*	1.00		
Area covered/duration (m ² /hr)	0.17	-0.05	0.01	-0.05	1.00	
Cardiac cost (beats/m ²)	-0.0005	0.55**	0.57*	0.38**	-0.13	1.00

*Significant at P = 0.05, **Significant at P = 0.01

Table.6 Problems faced by the women farm workers with local sickle and comparison of local sickle with serrated sickle

Local sickle	Serrated sickle
Feels heavy with sickle while doing the operation	Feels light in weight
Due to heaviness of handle, more stress on hand and elbow which leads to pain	No heaviness and easy to handle
Sharpening of blade frequently before doing the operation	No sharpness required due to serrated edge of blade
Minimum area is covered per unit time	More area is covered in same time
No proper cutting of crop	Proper cutting of crop from the bottom

Table.7 Mean scores of The Body part discomfort score (BPDS) of female farm workers during harvesting of wheat crop (N=10)

Subjects	Body part discomfort score(BPDS)	
	Local sickle	Serrated sickle
S1	67	55
S2	50	61
S3	58	52
S4	55	50
S5	55	41
S6	56	49
S7	57	39
S8	56	46
S9	56	51
S10	52	50
Mean score	56.2	49.4

Fig.1(a) ODR 10-Point Scale

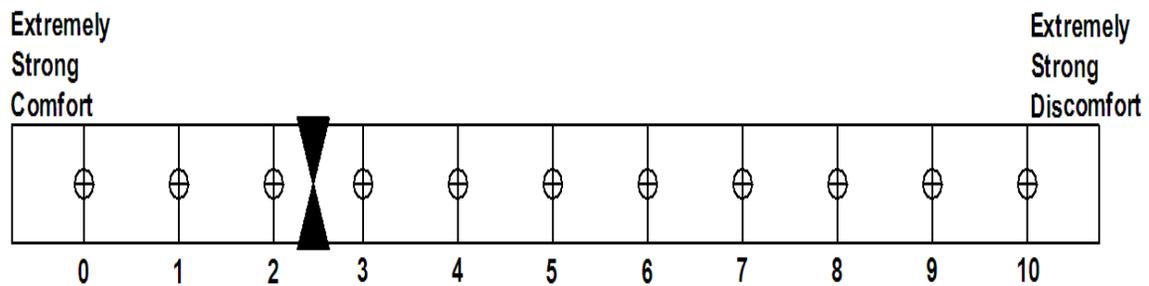


Fig1(b) Body parts for evaluation of body part discomfort score using Corlett and Bishop (1976)

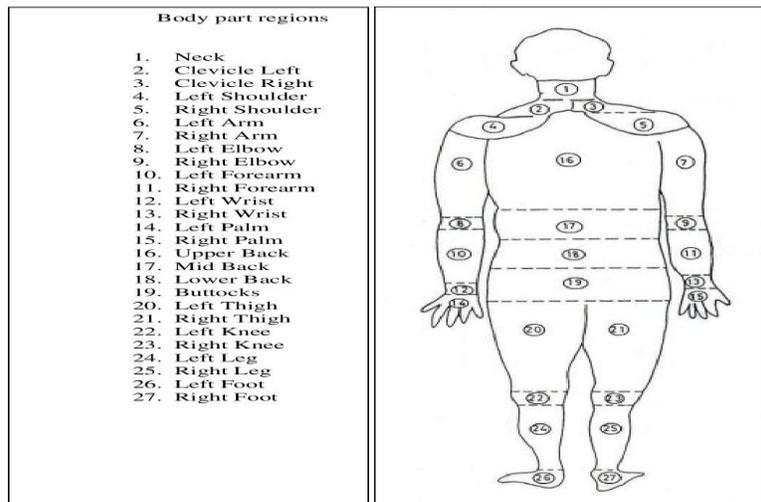


Fig.2



Fig.3



Table 4. shows the correlation coefficient computed between different variables and energy expenditure. It reveals that the age of the respondents showed non significant negative correlation ($r = -0.56$, $r = -0.33$) for local sickle and serrated sickle which means that age is not responsible for effecting efficiency of the work. Remaining all the parameters showed positive correlation with energy expenditure rate. Table 5. Shows the correlation coefficient among the variables of the serrated sickle. Singh *et al.*, (2014), has also reported the positive correlation between cardiac cost and average working heart rate during harvesting operation with improved sickle.

Table 6. shows the problem faced by the women farm workers while doing harvesting operation with local sickle and the problems are compared with the solutions with serrated sickle.

Body parts discomfort score(BPDS)

The subjects were allowed to perform harvesting operation in wheat crop by using sickle and serrated sickle. Evaluation of body part discomfort score (BPDS) was carried out by using Corlett and Bishop (1976) technique. The discomfort in different body parts was identified by the female farm workers by using the body map shown in Fig 1(b).

The values of Body part discomfort score of ten female farm workers are indicated below in table 7. It indicates the BPDS for sickle ranged between 50-67 and for serrated sickle BPDS score was 39-61. The majority of discomfort experienced by female farm workers was more in case of sickle. The Body part discomfort score(BPDS) was less in serrated sickle as compared with the local sickle.

In conclusions the serrated sickle when compared to local sickle is more women friendly following all the ergonomic considerations for reducing the drudgery of the women farm workers by 18.87%. It also reduces the Musculo-skeletal problems as indicated in mean score using the body map during the harvesting operation and also provides safety and reliability to the farm workers due to lower weight, easy to handle and better construction and it requires no frequent sharpening of the blade sue to its serrated edge which makes the cutting more easier and faster compared to local sickle. This not only reduces the drudgery but also reduces the fatigue, tiredness, exertion when proper work-rest cycle and proper posture is followed in hot sunny atmosphere. Proper training regarding the operating of serrated sickle is very important to reduce the squatting postures to avoid the Musculo-skeletal problems associated.

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