



# Ergonomic Evaluation of Brush Cutters for Women Users

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## ABSTRACT

There are different models of brush cutters available in the market. The safety and efficiency aspects of brush cutters are not being studied for women operators and needs to be evaluated. Therefore, a study was undertaken to ergonomically evaluate the commercially available two stroke and four stroke models of brush cutters with different cutting mechanism. Five female subjects were selected, those having anthropometric dimensions conforming to statistical requirements based on the anthropometric survey. There was significant difference in heart rate and energy expenditure rate in the operation of different models of brush cutters. Heart rate and energy expenditure were lowest for four stroke model brush cutter. A significant increase in heart rate was noticed while operating different cutter heads in the order of nylon wire, two blade cutter head and three blade cutter head for both models. The heart rate was maximum with a value of 165 beats  $\text{min}^{-1}$  while operating two stroke model with three blade cutter attachment. The overall discomfort rating varied from 5.8 to 8.5 on 0 - 10 discomfort scale and was in the range of moderate discomfort to uncomfortable. The body part discomfort score value was maximum in the operation of two stroke model with three blade attachment, where as it was minimum in the operation of four stroke model with nylon head. The operation of four stroke and two stroke models with nylon wire were safer for women operators. The operation of two stroke model brush cutter was difficult as compared to four stroke model for women operators.

**Key Words:** Brush Cutters, Discomfort, Energy Expenditure, Heart Rate, Women.

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## INTRODUCTION

Mechanization is considered as a remedy to the growing labour scarcity and to make cultivation profitable. The effective mechanization contributes to increase in production in two major ways, firstly through timeliness of operation and secondly having good quality of work. Trimmers and brush cutters are small machines that use a rapidly spinning plastic line or a metal knife to break off or cut the plants. Depending on the engine size, location, shaft design or handle shape design, there are several variations of trimmers and cutters. Numerous accidents by the rolling cutter blade have been reported (Kashima and Uemura, 2010). In some cases, the rolling cutter blade comes to the operator directly and his/her foot is seriously injured (Tsukamoto, 2013). Hence, research and development to reduce the accident have been carried out (Sasaki, 2004).

Men and women differ in their ergonomical

characteristics and therefore, it is necessary to give due consideration to their characteristics while developing farm equipment suitable to them. Also, skill up gradation of women workers is necessary to enable them to operate the machines ( Mehta *et al*, 2018).

At present there are different models of brush cutters commercially available in the market. The safety and efficiency aspects of brush cutters have not been studied for women and therefore, needs to be evaluated. Hence, a study was undertaken to evaluate the existing models of brush cutters to find the best one suited to women operators for more safety and output.

## MATERIALS AND METHODS

### Calibration of subjects

Five female subjects were selected, those having representative anthropometric dimensions

**Table 1. Specifications of selected brush cutters.**

Sr. No.	Model	HONDA UMK435T(GX35)	OLEOMAC 746 T
1	Engine	4-stroke, Over head Cam Single Cylinder	2-stroke, Single Cylinder
2	Displacement	35.8 cc	45.7cc
3	Power (max)	1.3 HP	2.5 HP
4	Fuel	Petrol	Petrol mixed with 2T oil (1 liter : 40ml oil )
5	Fuel tank	0.63 liter	1.50 liter
6	Total weight (kg)	8.45	8.55
7	Total length(mm)	1928	1915

conforming the anthropometric survey. The subjects pedaled a standard Bi-cycle ergometer at predetermined speed and with varying breaking loads. Standard protocol was followed to record the data of oxygen consumption rate and the corresponding heart rate at different load conditions. The oxygen consumption was measured using Benedict- Roth Recording Spirometer and the heart rate using polar heart rate monitor. By using the data on heart rate and oxygen consumption rate, calibration chart were prepared for each subject.

**Selection of Brush cutters**

Two models namely two stroke model brush cutter and four stroke model brush cutter were

selected for the study which was frequently used in the study area (Table 1). The trials were also conducted by using different types of cutting attachments namely nylon wire, two way blade and three way blade in each brush cutter ( Fig.1).

**Ergonomic evaluation of selected brush cutters**

All the five subjects were equally trained in the operation of the two models of brush cutters. The trials were conducted two times a day, at different time intervals i.e., before 9 am and after 11 am in order to find out the changes in energy expended and heart rate due to environmental condition. The heart rate was measured and recorded using heart rate monitor for the entire work period. Each trial



Fig.1. Types of cutter heads used for the study

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**Table 2. Scale for Overall Discomfort Rating, Overall Fear Rating and Overall Difficulty Rating.**

Level	Overall Discomfort Rating	Overall Fear Rating	Overall Difficulty Rating
0	No discomfort	Completely secure and no fear	Very easy
1			
2		Secure and meager fear	Easy
3	Light discomfort		
4		Moderately secure and less fear	Less difficulty
5	Moderate discomfort		
6		Slightly secure and moderate fear	Difficult to operate
7	More than moderate		
8		Insecure and more fear	Very difficult
9	Very uncomfortable		
10	Extreme discomfort	Extreme fear	Extremely difficult

was carried out for 30 minutes of duration and same procedure was repeated to replicate the trials for all the selected subjects. From the values of heart rate (HR) observed during the trials, the corresponding values of oxygen consumption rate ( $VO_2$ ) of the subjects were predicted from the calibration chart of the subjects. The energy cost of operation of the selected brush cutters were computed by multiplying the oxygen consumed by the subject during the trial period with the calorific value of oxygen as 20.88  $kJ l^{-1}$  (Nag *et al*, 1980) for all the subjects.

### Acceptable workload (AWL)

The acceptable workload (AWL) for Indian workers is reported as a work consuming 35 per cent of  $VO_2$  max (Saha *et al*, 1979). To ascertain whether the selected operations were within the acceptable workload (AWL), maximum oxygen consumption rate ( $VO_2$  max) was estimated using the data on the heart rate-oxygen consumption rate relationship. Each subject's maximum heart rate was estimated by the following relationship (Bridger, 1995).

Maximum heart rate ( $beats\ min^{-1}$ ) =  $200 - 0.65 \times$   
Age in years

### Overall discomfort rating (ODR)

For the assessment of overall discomfort rating a 10 - point psychophysical rating scale (0 - no discomfort, 10 - extreme discomfort) was used which is an adoption of Corlett and Bishop (1976) technique. A scale of 70 cm length was fabricated having 0 to 10 digits marked on it equidistantly. A moveable pointer was provided to indicate the rating. At the ends of each trial subjects were asked to indicate their overall discomfort rating on the scale. The overall discomfort ratings given by each of the five female subjects were added and averaged to get the mean rating.

For the assessment of Overall fear rating, a 10 - point psychophysical rating scale (0 -no fear, 10 -extreme fear) was used. For the assessment of difficulty in operation, a 10 - point psychophysical rating scale (0 - no difficulty, 10 - extremely difficulty) was used. The scale for overall discomfort rating, overall fear rating and overall difficulty rating are given in Table 2.

### Body part discomfort score (BPDS)

To measure localized discomfort, Corlett and Bishop (1976) technique was used. The subject's

body was divided into 27 regions and the subject was asked to mention all body parts with discomfort, starting with the worst, the second worst and so on until all parts have been mentioned. The total body part score for a subject was the sum of all individual scores of the body parts assigned by the subject. The body discomfort score of the subjects were added and averaged to get mean score.

## RESULTS AND DISCUSSION

### Calibration Chart

A calibration chart was prepared with heart rate as the abscissa and the oxygen uptake as the ordinate for the selected five subjects. The calibration chart is presented in Fig 2. It is observed that the relationship between the heart rate and oxygen consumption of the subjects was found to be linear for all the subjects, which is in close agreement with the results reported by Kroemer and Grandjean (2000).

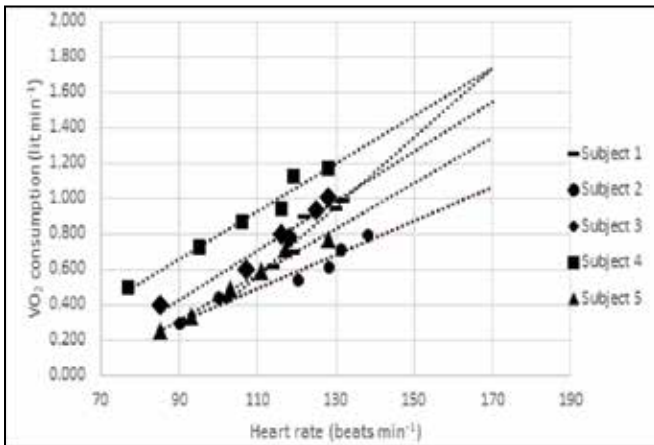


Fig. 2. Relationship between oxygen uptake and heart rate

### Energy expenditure of operation

The data collected were analyzed statistically as 2x3 factorial experiments. IBM SPSS 24.0 statistical software was used to analyze the data. Multivariate test with POST-HOC (BUTKEY) analysis was used to compare the significant differences among mean of the treatments at 5 per cent level of probability and relationship between subgroups of sampled data. The mean heart rate and energy expenditure of selected brush cutter models is furnished in Table

3. There was significant difference in heart rate and energy expenditure in the operation of different models of brush cutters. Minimum heart rate was observed in four stroke model brush cutter with a value of 146 beats min<sup>-1</sup>. The energy expended was more in operating two stroke model of brush cutter with a value of 27.25 kJ min<sup>-1</sup>.

Table 3. Mean heart rate and energy expenditure of selected brush cutters

Sr. No.	Brush cutter	Average heart rate (beats min <sup>-1</sup> )	Energy expenditure (kJ min <sup>-1</sup> )
1	Four stroke model	146 <sup>a</sup>	25.65 <sup>a</sup>
2	Two stroke model	156 <sup>b</sup>	27.25 <sup>b</sup>

(In column, mean values followed by the same letter do not differ significantly at P=0.05 according to Post hoc tests)

Energy expenditure was recorded significantly higher in operating the brush cutters after 11 am than before 9 am operation in a day. It may be attributed to the effect of environment on the subject since the heart rate integrates the total stress on the body and responds more quickly to changes in work demand and indicates more readily the quick changes in body function due to changes in work environment.

### Heart rate as influenced by type of cutting mechanism

The effects of types of blades on mean heart rate of selected brush cutter models for female operators are furnished in Table 4. A significant increase in heart rate was noticed while operating different cutter heads in the order of nylon wire, two blade cutter head and three blade cutter head for both models. The heart rate was maximum with a value of 165 beats min<sup>-1</sup> while operating the two stroke model with three blade cutter attachment. The minimum heart rate was noticed in four stroke model with nylon wire operation. For nylon type heads, since it is flexible, the vibration due to working of head would not transmitted to the hands.

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**Table 4. Heart rate as influenced by type of cutting mechanism.**

Brush cutter	Cutter head	Average heart rate (beats min <sup>-1</sup> )
Four stroke model	Nylon wire	138 <sup>a</sup>
	Two blade type	144 <sup>b</sup>
	Three blade type	155 <sup>d</sup>
Two stroke model	Nylon wire	147 <sup>c</sup>
	Two blade type	156 <sup>e</sup>
	Three blade type	165 <sup>f</sup>

*(In column, mean values followed by the same letter do not differ significantly at P=0.05 according to Post hoc tests)*

While operating brush cutters, vibrations created at the engine and the cutter head, are transmitted to the body through the hands to the human body. The operators are exposed to large vibration from handle since the engine is generally attached to the brush cutter directly. Hence a vibration reducing aid for brush cutter should be fabricated to reduce vibration transmitted to the hands of the women operator. A supporting wheel may be fabricated and fitted in the brush cutter for transmitting a part of the vibration produced by the cutter head to the ground. It also works as an extra support. Hence reduces the discomfort of women operator due to weight of machine.

### Acceptable work load

The oxygen consumption in terms of VO<sub>2</sub> max was minimum while operating four stroke model with nylon head with a value of 69.87 per cent and maximum for operating two stroke model with three blade cutter head (94.57 per cent). It is observed that all the values were much higher than that of the AWL limits of 35 per cent indicating that selected operations could not be operated continuously for 8 hours without frequent rest-pauses.

### Postural discomfort

The mean overall discomfort scores, body part discomfort score, overall fear rating and overall difficulty rating was assessed during operation of two models of brush cutters for female operators. The

maximum discomfort is experienced by the subjects in the operation of two stroke model with three blade attachment and it is scaled as uncomfortable. Lowest ODR value was observed in four stroke model with nylon wire operation.

Body part discomfort score was minimum with a value of 43.00 for the operation of four stroke model with nylon head, while it was maximum with a value of 51.29 for the operation of two stroke model with three blade cutter head. This is further confirmative of earlier result arrived that the four stroke model brush cutter was more easy to operate than two stroke model.

The fear score was varied from 3.5 with a rating (>Secure and meager fear) for the operation of four stroke model with nylon head to a value of 8.0 with a rating “Insecure and more fear” for the operation of two stroke model with three blade cutter head. The overall difficulty of operation score was 3.1 with a rating (>Easy) for the operation of four stroke model with nylon head, while it was maximum with a value of 8.0 (Very difficult) for the operation of two stroke model with three blade cutter head. The result showed that operation of two stroke model brush cutter was found difficult to operate compared with four stroke model.

## CONCLUSION

A brush cutter is a portable machine with a cutting attachment mounted on a shaft, usually

more than 1 m long. Brush cutter uses a rapidly spinning plastic line or a metal knife to break off or cut the unwanted plants. Depending on the engine size, location, type, shaft design or handle shape design, there are several variations of brush cutters. A study was undertaken to evaluate the existing two stroke and four stroke models of brush cutters with different cutting mechanism on the ergonomic basis for women operators. Minimum heart rate and energy expenditure was observed in four stroke model brush cutter than two stroke model. A significant increase in heart rate was noticed while operating different cutter heads in the order of nylon wire, two blade cutter head and three blade cutter head for both models. The body part discomfort score value was maximum in the operation of two stroke model with three blade attachment, where as it was minimum in the operation of four stroke model with nylon head. The operation of four stroke and two stroke models with nylon wire were safer for operation. The energy expenditure was lowest in four stroke model with nylon wire operation.

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