Development and Ergonomic Assessment of Manually Operated Modified Linseed Crop Thresher

ABSTRACT:

Manually operated modified linseed crop thresher was developed from ergonomics considerations. Anthropometric data were taken in selected age subjects 25-40 years for male workers. Anthropometric data regarding body dimensions were obtained for male workers from SHUATS, Prayagraj. During the methods of threshing operation (thresher and traditional method) the working heart rate was recorded with proper technique and oxygen consumption rate, energy expenditure rate and body parts discomfort scoring was obtained. The heart rate, oxygen consumption, energy expenditure rate and BPDS were obtained in the mean value 115.19 beats/min, 0.63 l/min, 9.59 kJ/min and 44.93 for thresher operating whereas 127.56 beats/min, 0.77 l/min, 11.56 kJ/min and 55.43 for traditional method operating.

Keywords: linseed crop thresher, crop, traditional methods, Ergonomics, Hear rate, Oxygen consumption, energy expenditure rate and BPDS

INTRODUCTION

Introduction Linseed (Linum usitatissimum) is a plant of the family Linacease that belongs to the genus Linum. Jawas and Alsi are the native names for it. Linseed is regarded as the most important commercial yarn crops. Linseed crop is the threshing involves manual beating and animal trampling of harvesting plants. The prime moving force of Indian economy is an agriculture. It is also true that around 70% of our total population is dependent on agricultural related occupations. Nearly 86% of Indian farmers are small and marginal with average land holdings in the country being less than 1.1 hectare (Anonymous. 2020). These small farmers do need mechanized tools for easing their workload with highest level of efficiency but most of them are not in a position to buy and operate it as of cost constraints.

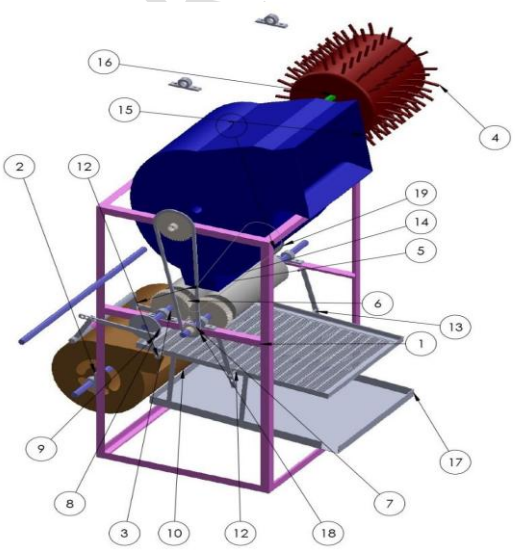
The traditional method for threshing linseed involves trampling the crop with bullocks or tractors, or beating it with sticks or over stones. Additionally, the crop can be beaten by beating it with sticks or over stones. After that, the flaxseeds are winnowed with the assistance of a stationary cleaning machine that is operated by hand. After removing the capsule from the plant, the following stage in the threshing process is to separate seeds from capsule, followed by cleaning the seed to remove any remaining capsule. Szarszunow *et al*. (1998) came to the conclusion that the core reasons for linseed seed losses are bad threshing and damage caused by the threshing process.

The Greek terms ERGO (which means work) and NOMOS are the roots of the word ERGONOMICS (means rules of laws). The clinical have a look at the link between an individual and his or her working environment is known as ergonomics, also other name as human engineering, human factors, or human ergology. The scientific field of ergonomics focuses on understanding how people interact with

one another, and the scientific design profession uses theory, concepts, data, and methods to generate and improve work systems that involve machines or jobs with people as vital parts. Because human labour was not regarded as an important component of man-machine system, even the most appropriate and well-designed machine could not perform as intended. Tamilselvi and Krishnan (2016) completed the take a look at on the ergonomic testing of agricultural sprayers considering human activity. The ergonomical assessment included measuring the subjects' heart rates, oxygen consumption rates, energy expenditure rates, and levels of discomfort experienced due to various frame components. From a physiological standpoint, the energy cost and cardiac price of work are what determine the task demand or work load, which in turn determines the demands placed on the aerobic-respiratory system and heart rate (Awasthi et. al., 2019). Anthropometric measures vary considerably with factors such as gender, race and age. Considerable difference has been found in Indian and Western anthropometric data (Wibneh et. al., 2020). Drudgery caused by bad posture is expressed in terms of postural pain experienced by the worker. In agricultural operations, it has been discovered that muscular pain of the body is relatively more important than heart rate and oxygen consumption rate as limiting factors. For the evaluation of body ache, a number of individual rating scales have been developed, but visual analogue pain scales are the ones most frequently used (Premkumari et al. 2018).

MATERIALS AND METHODS

The test setup become deliberate for a development and ergonomic assessment of manually operated modified linseed crop thresher. The SOLIDWORKS drawing of a linseed crop thresher changed into generated. The modified linseed crop thresher was created on the Farm Machinery & Power Engineering workshop at VIAET, SHUATS Prayagraj. The modified linseed crop thresher has a manually operated drive that rotates the threshing cylinder. The crop is held by hand and put on top of the threshing cylinder. Then, the handle is used to turn the threshing cylinder.



ITEM NO.	COMPONENT	QTY.
1	FRAME	1
2	BEARING	8
3	SHAFT1	4
4	CYLINDER	1
5	NYLON ROLLER	2
6	SPUR GEAR	2
7	CHAIN WHEEL 44	4
8	RECIPROCATING SYSTEM	1
9	SQUARE	1
10	BLOWER	1
12	SIEVE	1
12	SQUARE 111 mm	2
13	SQUARE	2
14	SHAFT	1
15	HOPPER	1
16	HANDLE	1
17	COLLECTOR	1
18	CHAIN -2	1
19	CHAIN-1	1

Fig.1. SOLIDWORKS drawing of development of modified linseed crop thresher

Selection of age subjects

When conducting experiments for the determination of studying ergonomics, the selection of subjects is a very important role. The subject that is chosen should be physically and medically capable of participating in the experiments. It was ensured that subjects were of a certain age group, physically fit, free of illness, and willing to participate in the experiments. Ageing has an effect on maximum aerobic capacity, heart rate, force strength, and force cross-sectional area. For this study, different age subjects were chosen from the available workforce, ranging from 25-40 years for male workers (Gite and Singh, 1997). For male workers, all anthropometric data measurements are taken, including height, human weight, and other body parameters of various ages. After that, they were permitted to carry out the thresher operation using the aforementioned thresher.

The first step is to calculate each age subject's body mass index after learning their human weight and height. In order to evaluate their state of health, both their body surface area (BSA) and body mass index (BMI) were determined.

$$BMI\ \left(\frac{kg}{\mathrm{m}^2}\right) = \frac{Weight\ (kg)}{(Height, cm)^2}$$

$$= \mathrm{BSA}\ (\mathrm{m}^2)\ = \sqrt{\frac{Height\ (cm) \times Weight\ (kg)}{3600}}$$

Testing of during working at methods of threshing

The Tests during the threshing operation were of two types (thresher and traditional method). Testing was done in the agriculture farm with manually operated modified linseed crop thresher. There were 5 kg sample of crop and selected age subjects (25-40 years) of worker to do the experiment. And after that thresher operation was done. During the threshing operation working heart rate was recorded with proper technique and oxygen consumption, energy expenditure rate and body parts discomfort scoring was obtained. To evaluate the thresher each five kg of the crop were threshed by beating on the hard surface by each age subjects of workers. Traditional method of threshing of linseed crop (beating) was evaluated for the comparison with the thresher.

Fig.2. Thresging of linseed crop by thresher

Fig.3. Thresging of linseed crop by traditional method

The Various study parameters of physiological and postural Response of the worker is given in Table 1.

Table.1: Various study parameters of physiological and postural Response of the worker

S. No.	Independent parameters	Description	Dependent parameters
1	Age subjects (years)	25-40 years	1. Heart rate (b/min) 2. Oxygen consumption rate (l/min) 3. Energy expenditure rate (kJ/min) 4. Body part discomfort score
2	Methods of threshing	Thresher	
		Traditional method (beating)	

Heart rate (HR)

First of all, stable heart rate measured using pulse oximeter in resting condition of different age subjects for 8-10 min before operating linseed crop thresher. Each trial was conducted for a duration of 15-20 minutes of continuous methods of threshing. The working HR from 15-20 minute of continuous operation of selected male workers of different age subjects during the methods of threshing by the thresher and also traditional method with the help of pulse oximeter and poler heart rate monitor due to reason of stabilization of working heartbeats of operation. The average data of working HR of continuous operation of male workers of different age subjects during methods of threshing operation. For time of the workday, the average heart rate for each subject was used as a representative value.

Oxygen consumption rate (OCR)

The OCR was computed by using the following equation given by Singh *et. al.,* 2008.

$$OCR = 0.0114 \times HR - 0.68$$

Where,

- OCR is the oxygen consumption rate in (l/min)

Energy expenditure rate (EER)

The EER was computed by using the following equation given by Varghese *et. al.,* (1994).

$$EER = 0.159 \times HR - 8.72$$

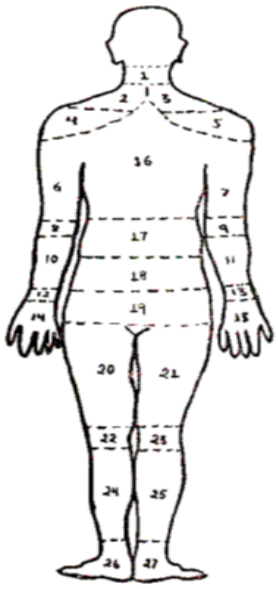
Where,

- Energy expenditure rate (EER) in (kJ/min.)

Body parts discomfort score (BPDS)

The Corlett and Bishop (1976) technique was applied to measure localised discomfort. Using this process, the subject's body is split into 27 areas. To avoid a subject marking on one body region only, each body region was given a unique number. The subject will be requested to mention to all body parts with discomfort, staring with the maximum painful, the next painful in downward order till no further zones are denoted. The number of each portion of body that are identified, from the mark of discomfort to the absence of discomfort, represents the quantity of pain levels. The maximum quantity of intensity phases of pain experienced under different treatments will be obtained. For each of the six levels of pain in a farm operation, a case of the outcome is provided below the table. The subjects are requested to indicate what type of sensation is contributing to the discomfort. The BPDS rating scale provides this information. Suppose it was found out that, the maximum was six categories for the agriculture operations. According to this, the intensity assigned by different subjects might vary. For example, one subject might assign six rankings and the intensity would vary from 6 to 1 for that particular subject. Whereas, if other subjects have assigned 5 rankings, then the intensity would vary from 6 to (6/5=1.2) in an arithmetic order. The sum of each subject's individual body parts scores is the subject's overall body parts score.

The mean value of all subjects would be used to calculate the overall BPDS. The score for each category is obtained by multiplying the quantity of parts by the rating. The BPDS is the total of the individual scores of each ranking. The procedure will be repeated for all the operations and all the subjects and the average values will be obtained.



1: Neck
2: Clavicle left
3: Clavicle right
4: Left shoulder
5: Right shoulder
6: Left arm
7: Right arm
8. Left elbow
9: Right elbow
10: Left forearm
11: Right forearm
12: Left wrist
13: Right wrist
14: Left palm
15: Right palm
16: Upper back
17: Mid back
18: Lower back
19: Buttocks
20: Lift thigh
21: Right thigh
22: Left knee
23: Right knee
24: Left leg
25: Right leg
26: Left foot
27: Right foot

Fig.4. Area for evaluation of discomfort of body parts

RESULTS AND DISCUSSION

Age subjects' (years) anthropometric data for male workers

Male agricultural workers' height, weight, body mass index (BMI), and body surface area (BSA) were all measured to find out their anthropometric data. Table.2 shows the detail of selected age subjects ranging from 25 to 40 years for male workers. Anthropometric data for age subjects were presented in table .3.

Table 2: Detail of selected age subjects (years) for male workers

S.I No.	Age subjects (years)	Height (cm)	Weight (kg)	BMI (kg/m2)	BSA (m2)
1	25	171.2	71.5	24.39	1.843
2	30	166.4	65.2	22.24	1.709
3	35	161.8	67.3	22.96	1.739
4	40	169.6	74.8	25.52	1.813

Table 3: Age subjects' (years) anthropometric data for male workers

S. I. No.	Dimension	Max.	Min.	Mean	SD	CV (%)	5th Percentile	95th Percentile
1	Weight, kg	74.8	65.2	69.7	4.292	6.158	65.515	74.305
2	stature	171.2	161.8	167.25	4.145	2.478	162.490	170.96
3	Arm reach from the wall	82.3	73.6	77.1	3.750	4.863	73.870	81.52
4	Standing eye height	165.3	156.8	161.125	3.738	2.320	157.205	164.94
5	Sitting height	81.7	74.1	77.675	3.229	4.158	74.445	81.22
6	Sitting eye height	74.2	67.3	70.575	2.989	4.236	67.585	73.81
7	Popliteal height	44.5	41.2	42.925	1.389	3.236	41.410	44.335

8	Knee height	53.5	47.6	50.475	2.520	4.992	47.885	53.17
9	Elbow height	108.7	102.2	105.45	2.706	2.566	102.590	108.31
10	Shoulder height	141.4	135.6	138.075	2.594	1.879	135.735	141.01
11	Head length	21.3	16.8	18.875	1.877	9.943	17.025	20.97
12	Hand length	19.1	16.5	17.925	1.132	6.318	16.665	19.01
13	Foot length	24.3	22.6	23.35	0.794	3.399	22.630	24.21
14	Grip diameter, outside	8.64	8.35	8.523333	0.153	1.796	8.373	8.634

Except for weight in kilograms (kg), all body measurements are in centimeters (cm).

Effect of selected age subjects on heart rate of workers during working at methods of threshing

The working heart rate of selected age subjects (25-40 years) was presented in fig. 5.

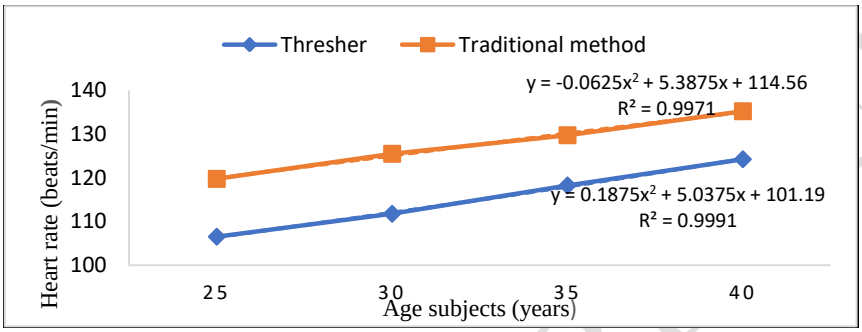


Fig.5. Relationship between heart rate and selected age subjects at methods of threshing (thresher and traditional method)

The result of heart rate increased from 106.5 to 124.25 beats/min and 119.75 to 135.25 beats/min as the age subjects increased varied from 25-40 years for threshing methods. Mean value of the working heart rate was found 115.18 beats/min during threshing operation with the thresher method and 127.56 beats/min during threshing operation with the traditional method (beating). During working the traditional method hand strength was used and force was applied continuously. The polynomial trends were observed to best equation in establish the relation between HR and selected age subjects at threshing methods in thresher and traditional method. The value of coefficient of determinant (R^2) was considered which was more with polynomial trends. Similar results of HR on selected different age subjects and methods of threshing have been reported by Rajaram et al., 2011.

Effect of selected age subjects on oxygen consumption rate of workers during working at methods of threshing

The oxygen consumption rate of selected age subjects (25-40 years) was presented in fig. 6.

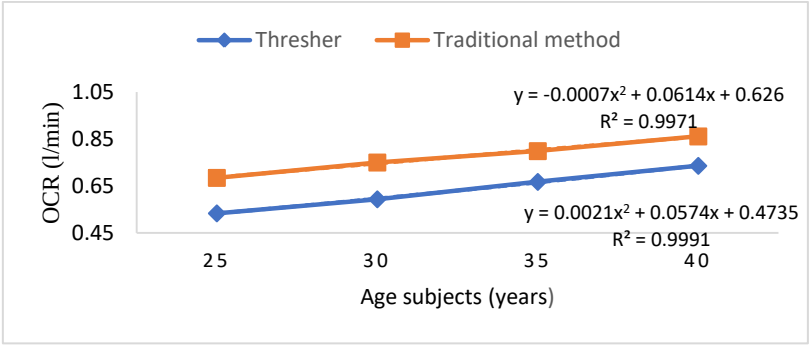


Fig.6. Relationship between OCR and selected age subjects at methods of threshing (thresher and traditional method)

The estimated value of OCR increased from 0.53 to 0.74 l/min. in thresher and 0.69 to 0.86 l/min. in traditional method as the age subjects increased from 25-40 years. The mean value of OCR was found 0.63 l/min during threshing operation with the thresher method and 0.77 l/min during threshing operation with the traditional method (beating). The more value of coefficient of determinant (R^2) obtained for polynomial trends. The polynomial trends gave equation to establish relationship between OCR and selected age subjects at threshing methods in thresher and traditional method. Similar results of OCR on selected different age subjects and threshing operation have been reported by Singh *et. al.,* (2008).

Effect of selected age subjects on energy expenditure rate of workers during working at methods of threshing

The energy expenditure rate of selected age subjects (25-40 years) was presented in fig.7.

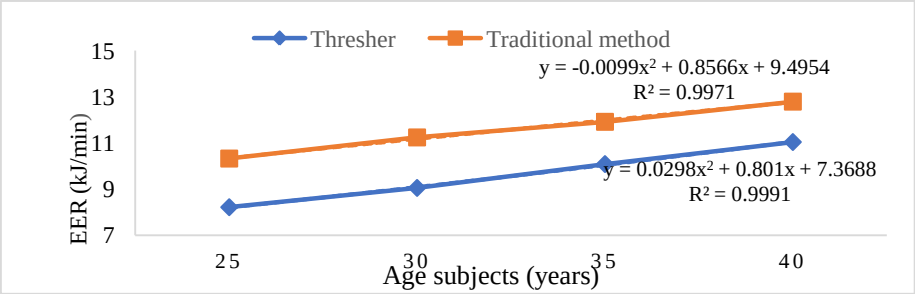


Fig.7. Relationship between EER and selected age subjects at methods of threshing (thresher and traditional method)

The estimated value of EER increased from 8.21 to 11.04 kJ/min. in thresher and 10.32 to 12.78 kJ/min in traditional method as the selected age subjects increased from 25-40 years. The mean value of EER was found 9.59 kJ/min during methods of thresher with the thresher and 11.56 kJ/min during methods of threshing with the traditional method (beating). The more value of coefficient of determinant (R^2) obtained for polynomial trends. The polynomial trends gave equation to establish relationship between EER and selected age subjects at threshing methods in thresher and traditional method. Similar results of EER on selected different age subjects and threshing operation have been reported by Varghese et. al., (1994).

Effect of selected age subjects on body parts discomfort score of workers during working at methods of threshing

The body parts discomfort score of selected age subjects (25-40 years) was presented in fig.8.

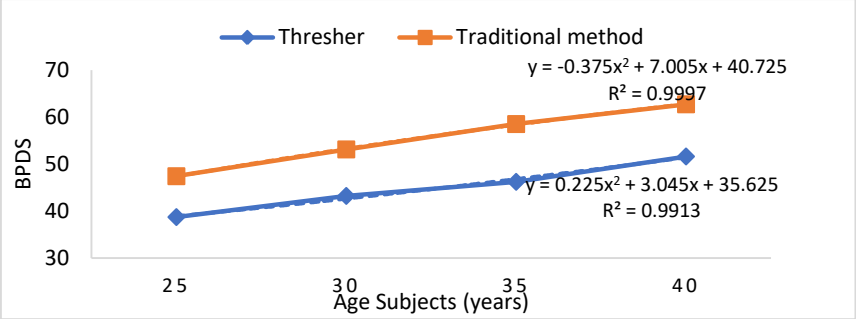


Fig.8. Relationship between BPDS and selected age subjects at methods of threshing (thresher and traditional method)

The value of BPDS increased from 38.7 to 51.6 in thresher and 47.4 to 62.7 in traditional method as the selected age subjects increased from 25-40 years. The mean value of BPDS was found 44.93 during threshing operation with the thresher method and 55.43 during threshing operation with the traditional method (beating). The more value of coefficient of determinant (R^2) obtained for polynomial trends. The polynomial trends gave equation to establish relationship between BPDS and selected age subjects at methods of threshing in thresher and traditional method.

CONCLUSION

The physiological parameter heart rate was obtained in the range of 106.5 to 124.25 beats/min in thresher and 119.75 to 135.25 beats/min in traditional method. Along with the age subjects, the heart rate was also increasing in these methods of threshing. The oxygen consumption rate was obtained value in the range of 0.53-0.74 l/min in thresher and 0.69-0.86 l/min in traditional method (beating). Along with the age subjects, the OCR was also increasing in these methods of threshing. The energy consumption rate was obtained value as from 8.21-11.04 kJ/min in case of thresher and 10.32-12.78 kJ/min in case of traditional method. Along with the age subjects, the EER was also increasing in these methods of threshing. The body parts discomfort score was obtained value as from 38.7-51.6 in case of thresher and 47.4-62.7 in the case of traditional method. Along with the age subjects, the BPDS was also increasing in these methods of threshing.

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