International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; SP6: 694-697

Naveendra Kumar Patel
Department of farm machinery & power engineering
Shuats, Prayagraj, Uttar Pradesh, India

Vivekanand Singh
Department of farm machinery & power engineering
Shuats, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Naveendra Kumar Patel
Department of farm machinery & power engineering
Shuats, Prayagraj, Uttar Pradesh, India

(Special Issue -6)
3rd National Conference
On
PROMOTING & REINVIGORATING AGRI-HORTI, TECHNOLOGICAL INNOVATIONS [PRAGATI-2019]
(14-15 December, 2019)

Ergonomic evaluation of hand operated linseed thresher

Naveendra Kumar Patel and Vivekanand Singh

Abstract
A study was conducted on the ergonomic evaluation of hand operated linseed thresher. Anthropometric data of age group operators of (20-23, 24-27, 28-31 and 32-35 years) were determined. Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score of age groups were determined during working on linseed thresher at different weight sample of linseed. Anthropometric data of stature, arm length, standing eye height, knee height, elbow height and body mass index were determined for different age groups. Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score were increasing when age groups increased at weight sample (1.0, 1.5 & 2.0 kg). Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score of 20-23 yrs age groups were found minimum and varied from 90-106 b/min, 0.34-0.52 l/min, 7.08-11.03 kJ/min and 20.16-25.58 respectively on working. Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score of 32-35 yrs age groups were found maximum and varied from 120-135 b/min, 0.68-0.84 l/min, 14.23-17.67 kJ/min and 44.82-58.07 respectively during working operators on linseed thresher at different weight samples.

Keywords: Linseed crop, hand operated linseed thresher, Heart rate, Energy expenditure, Oxygen consumption and Body part discomfort score.

1. Introduction
Linseed (*Linum usitatissimum* L.) is considered as one of the most important economic yarn crops. The major linseed production countries are Kazakhstan, Russia, Canada, China, India, and USA. India is 5th rank among the linseed producing countries during 2017. In India, the major linseed growing states are Madhya Pradesh, Maharashtra, Uttar Pradesh, Bihar, Rajasthan etc. Madhya Pradesh and Uttar Pradesh together contribute to the national linseed production to the extent of about 70 percent (www.factfish linseed production).
Agriculture has an important place in Indian economy and the main work force in it is human power. Population dynamics of Indian agricultural worker and it was estimated that by 2050, total population 1323 million and the population of agricultural worker will be about 202 million of which 121million will be the female workers and 81million male workers (*Source: vision* 2050 document of CIAE, Bhopal).
Ergonomics is the scientific study of relationship between man-machine and working environment. The ergonomics is the scientific discipline mainly concerned with understanding of the interaction of humans, and the scientific design profession that applies theory, principles, data and methods to design and improve the work system involving machine or job with human as an integral system. Agricultural operations are very labor intensive in India. Farming operation includes working with biological and mechanical systems and farmer has to work in adverse climatic conditions, poor infrastructure, limited implements and machines in ergonomically unsuitable postures.

Physiological cost of operation is influenced by the health of operators, nutrition, basal metabolic rate and energy expended while working that can be indirectly measured by measuring oxygen consumption and heart rate. In general, person's subjective experience of a particular workload or rate of work is more closely related to heart rate than to oxygen consumption during the performance of work (Christensen, 1962). Selection of subject (workers) plays an important role whenever we are conducting an ergonomic study. The subjects are required to be medically fit and represent real user population in operation of the selected machinery. The selection is made on the basis of gender, age, height and weight. In India, generally male subjects are selected for conducting ergonomic studies on agricultural machinery.

The aim of the study was the determination of anthropometric parameters of the operators and also to evaluate the physiological and postural discomfort parameters of different ages of operators at different weight sample of linseed. Keeping in view the above facts, this study was undertaken with the following objectives:

1. To determine the anthropometric parameters of the operators.
2. To evaluate the physiological and postural parameters of age groups operators on linseed thresher.

2. Materials and Methods

The ergonomic evaluation of hand operated linseed thresher was conducted with male agricultural workers of the farm of SHUATS, PRAYAGRAJ, (U.P), and INDIA. Hand operated linseed thresher is fabricate in the farm machinery workshop. The detail specification of the thresher is given Table 2.1.

Table 2.1: Specification of linseed thresher

S. No.	Particulars	Specifications
1	Overall dimensions L×W×H (mm)	500×300×1000
2	Power transmission unit	Hand operated, Chain
I	Drive type	Chain and sprocket
A	No. of Chain & No. of sprocket	1 & 3
B	Sprocket dia. (mm)	70
C	No. of teeth on sprocket	18
II	Blower dia. (mm)	280
3	Crop feeding device	Chute type
I	Method of feeding	Manual, Hold on method
II	Feeding height above ground, (mm)	920
III	Size of opening, (mm)	460 × 390
4	Threshing cylinder	Nylon roller
I	Size of nylon roller, (mm)	300×130
5	Concave Type	Open type concave
I	Size of open concave (mm)	380 × 280
6	Blower	Blade type

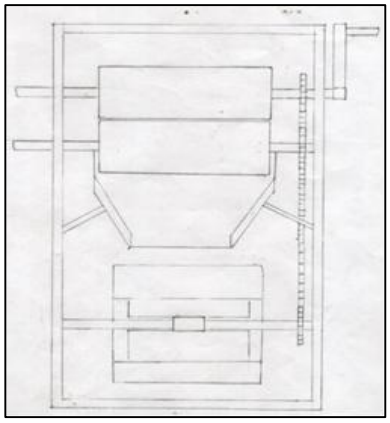

Fig 2.1: Front view of linseed thresher

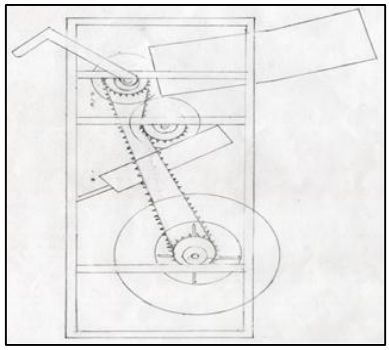

Fig 2.2: Side view of linseed thresher

2.1 Selection of age subjects

Sixteen male agricultural workers from SHUATS, Prayagraj in India were selected age subject for study. Selection of subject plays an important role whenever we are conducting an ergonomic study. In India, generally male subjects are selected for conducting ergonomic studies on agricultural machinery. For this study, different age subjects were selected from the available workforce of different age varied from 20-35 yrs as given in table 2.2.

Table 2.2: Detail of selected different age subjects

S.I. No.	Age group (years)	Height (cm)	Weight (kg)	BMI
1	20 – 23	166	65	23.59
2	24 – 27	170	62	21.45
3	28 –31	172	73	24.68
4	32 – 35	164	70	26.02

BMI = Weight (kg) / [Height (m)] ^{2}

2.2 Determination of variables

- Independent Variable
- Different age groups = 20 - 23, 24 - 27, 28 - 31 and 32 – 35 yrs
- Weight sample of linseed = 1.0, 1.5 and 2.0 kg (three replications R_1, R_2 & R_3)
- Dependent Variable

1. Heart rate (b/min)
2. Oxygen consumption rate (l/min) OCR = 0.0114 × HR – 0.68 (Singh *et al*. 2008) [15]
3. Energy expenditure rate (kJ/min) EER = 20.86 × OCR (Nag *et al*. 1979) [13]
4. Body part discomfort score (BPDS)

To measure localized discomfort, Corlett and Bishop (1976) [5] technique was used. In this method, the body of subject is divided into 27 regions. Each body region was numbered differently to avoid a subject marking on body region only. If the maximum number of intensity levels of pain experienced for the experiment was five categories, first category (body parts experiencing maximum pain) was given rating of 5 and for second category (body parts experiencing next maximum pain) rating was given as 4 and so on, for the fifth category (body parts experiencing least pain) rating was allotted as one. The number of categories of pain experienced by different subjects might vary. The body part discomfort score of each subject was the rating multiplied by the number of body parts corresponding to each category. The total body part score for a subject was the sum of all individual scores of the body parts assigned by the subjects. The body part discomfort score of all the subjects was added and averaged to get mean score.

The same procedure was repeated for all the experiments the overall BPDS would be the average value of all the subjects.

3. Results and Discussion

3.1 Anthropometric data of selected age subjects

Anthropometric data of selected subjects were measuring to the integrated composite anthropometer in complete resting condition. Four subjects were selected from agricultural engineering farms of different age groups. It is presented in Table 3.1.

Table 3.1: Anthropometric data of age (year) subjects for male workers

S.I No.	Anthropometric data	Dimension (cm)			
		20 - 23	24 - 27	28 – 31	32 – 35
1	Stature	166 ± 3.16	170 ± 3.16	172 ± 3.16	164 ± 3.16
2	Arm length	66 ± 2.55	64 ± 2.55	59 ± 2.55	63 ± 2.55
3	Arm span	164 ± 2.12	159 ± 2.12	164 ± 2.12	161 ± 2.12
4	Standing eye height	159 ± 2.06	158 ± 2.06	154 ± 2.06	155 ± 2.06
5	Sitting height	85 ± 1.3	82 ± 1.3	85 ± 1.3	83 ± 1.3
6	Sitting eye height	75 ± 1.22	72 ± 1.22	75 ± 1.22	74 ± 1.22
7	Popliteal height	42 ± 0.71	43 ± 0.71	43 ± 0.71	44 ± 0.71
8	Knee height	51 ± 1.12	52 ± 1.12	50 ± 1.12	49 ± 1.12
9	Pelvic height	90 ± 1.48	93 ± 1.48	89 ± 1.48	91 ± 1.48
10	Elbow height	109 ± 1.87	106 ± 1.87	104 ± 1.87	105 ± 1.87
11	Shoulder height	136 ± 1.3	139 ± 1.3	138 ± 1.3	136 ± 1.3

Body part dimension ± SD

3.2 Heart rate

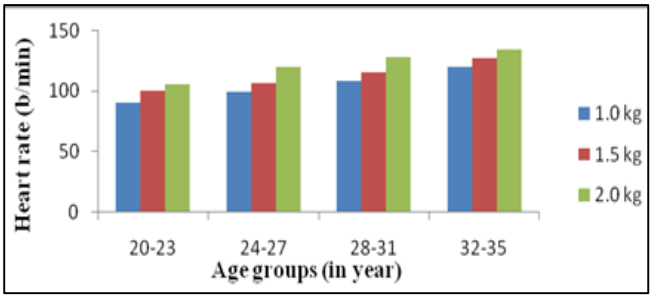

Fig. 3.1: Relationship between age groups and heart rate of workers during working on linseed thresher at different weight sample of linseed

Heart rate of different age groups operators (20-35 yrs) varied from 90 to 135 bpm during operators of linseed thresher at different weight sample (1.0, 1.5 & 2.0 kg). Lowest heart rate was found 90 bpm for the age groups (20-23year) at the lowest level of weight sample and highest heart rate was 135 bpm for the age groups (32-35year) at the higher level of weight sample. The main reason for increased heart rate with age groups found to be irregular design of thresher.

3.3 Oxygen consumption rate (OCR)

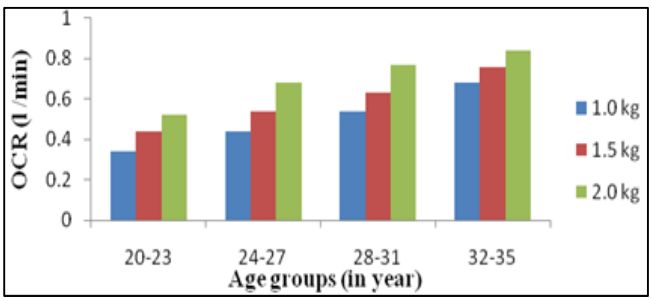

Fig 3.2: Relationship between age groups and OCR of workers during working on linseed thresher at different weight sample of linseed

OCR of different age groups operators (20-35 yrs) varied from 0.34 to 0.84 lit/min during operators of linseed thresher at different weight sample (1.0, 1.5 & 2.0 kg. The main reason for increased OCR with age groups found to be irregular design of thresher.

3.4 Energy expenditure rate (EER)

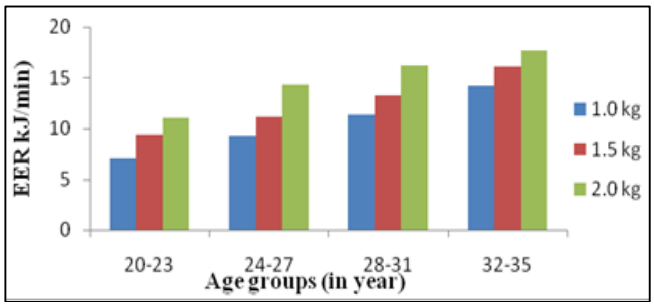

Fig 3.3: Relationship between age groups and EER of workers during working on thresher at different weight sample of linseed

EER of different age groups operators (20-35 yrs) varied from 7.08 to 17.67 kJ/min during operators of linseed thresher at different weight sample (1.0, 1.5 & 2.0 kg). The main reason for increased EER with age groups found to be irregular design of thresher.

3.5 Body part discomfort score (BPDS)

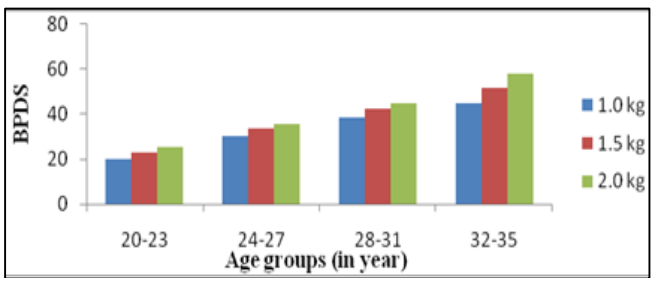

Fig 3.4: Relationship between age groups and BPDS of workers during working on linseed thresher at different weight sample of linseed

BPDS of different age groups operators (20-35 yrs) varied from 20.16 to 58.07 during operators of linseed thresher at different weight sample (1.0, 1.5 & 2.0 kg). The main reason for increased BPDS with age groups found to improve it in all design of thresher.

4. Conclusions

Following conclusions were drawn from the study:

1. Anthropometric data of age (year) subjects for male workers *viz*. stature, arm length, arm span, standing eye height, sitting eye height, popliteal height, knee and pelvic height, elbow height and shoulder height were found out using integrated composite anthropometer and measuring tape.
2. With increasing age groups of subjects, heart rate also increased when during working on linseed thresher at different weight sample.
3. With increasing age groups of subjects, oxygen consumption also increased when during working on linseed thresher at different weight sample.
4. With increasing age groups of subjects, energy expenditure also increased when during working on linseed thresher at different weight sample.
5. With increasing age groups of subjects, body part discomfort score also increased when during working on linseed thresher at different weight sample.

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