Advances in Research

14(6): 1-5, 2018; Article no.AIR.40268
ISSN: 2348-0394, NLM ID: 101666096

Ergonomics Assessment of Pedal Operated Maize Dehuskar-Sheller for Male Agricultural Workers

M. K. Choudhary[1*], C. M. Pareek[1], S. S. Meena[2] and A. K. Mehta[2]

[1]Department of Agricultural and Food Engineering, IIT Kharagpur, India.
[2]Department of Farm Machinery and Power Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author MKC designed and conducted the study, performed the statistical analysis and managed the literature searches. Author CMP wrote the first draft of the manuscript. Authors SSM and AKM managed the experimental process and finalized the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AIR/2018/40268
Editor(s):
(1) Paola Deligios, Department of Agriculture, University of Sassari, Italy.
(2) Md. Rezaul Karim, Assistant Professor, Department of Agricultural Extension, Hajee Mohammad Danesh Science and Technology University, Bangladesh.
Reviewers:
(1) Abdulwahed M. Aboukarima, Agricultural Engineering Research Institute, Egypt.
(2) Sesan Peter Ayodeji, Federal University of Technology, Nigeria.
(3) A. Ashok Kumar, Acharya N. G. Ranga Agricultural University, India.
(4) Jagvir Dixit, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/24561

Original Research Article

Received 22nd February 2018
Accepted 4th May 2018
Published 10th May 2018

ABSTRACT

The pedal-operated maize dehuskar-sheller was ergonomically evaluated with ten male agricultural operators to assess the physiological costs of operation. The Heart Rate, Oxygen Consumption Rate and energy expenditure rate were used for assessment of physiological cost for the operation of the pedal operated maize dehuskar sheller. The Heart Rate and Oxygen Consumption Rate were measured with Computerized Ambulatory Metabolic Measurement System K4b^2. The energy expenditure rate was calculated based on the Oxygen Consumption Rate during the operation. The mean working heart rate, mean working Oxygen Consumption Rate and mean working energy expenditure rate of all subjects during the operation of maize dehusker sheller were found to be 139 (± 22.01) beats/min, 1.40 (± 0.20) l/min and 6.83 (±1.07) kcal/min, respectively. Based on energy expenditure rate, the operation of pedal operated maize dehusker sheller was found under 'Heavy' work category.

**Corresponding author: E-mail: mukeshkchoudhary1992@gmail.com;*

Keywords: Ergonomic assessment; Maize Dehuskar-Sheller; physiological cost.

1. INTRODUCTION

Maize (*Zea mays*) was originated in central Mexico about 7000 years ago from a wild grass, and Native Americans transformed maize into a more promising source of food [1]. Together with rice and wheat, maize provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries [2]. It is estimated that during 2016-17, the total world area covered under maize cultivation was 185.90 million hectares with a production of about 1075.49 million metric tons [3]. It is the third largest produced and consumed food crop, after rice and wheat in India. India is the sixth largest producer of maize in the world and contributed about 2 percent to the global maize production [4].

Maize dehusking denotes the process of removing the husk from maize cob, and in shelling operation, the maize kernels are to be separated from the cobs. Traditionally, the dehusking is done manually and shelling is performed by beating the dehusked cobs with sticks or by pressing with fingers [5,6]. These methods are more susceptible to grain damage and also deteriorate the quality of grains. The dehusking and shelling of maize cobs with traditional practice is very tedious, time-consuming and labor-intensive task. The energy consumption for the only shelling of maize cob was 16.49 percent of total operational energy used in the rainfed cultivation of maize crop in India [7]. The output regarding dehusking maize cobs traditionally (by hand) are reported to be 30 kg/h and shelling efficiency with manually shelling (beating wooden stick) is reported to be 80% with 8.3 per cent grain damage [5]. To mechanise this activity a pedal operated maize dehusker sheller was developed at MPUAT, Udaipur. The main components of the machine were saddle for pedalling, power transmission system, a threshing cylinder with beaters, concave, drum cover, flywheel, feeding trough and transportation wheels. Two persons were required for operating the machine; one for pedalling the machine sitting on the saddle, while other for feeding the maize cobs in the hopper and collecting the maize kernels from outlet. As the women workers involved in Indian agriculture are not accustomed with cycling due to wearing of loose cloth (Sarhi), [8,9]. Hence the pedal operated men workers generally operate maize dehuskar-sheller.

The use of pedal operated maize dehusher sheller can reduce the drudgery of work and increase the output capacity. But before the adoption of any machine, the physiological cost evaluation of agricultural workers during the operation is necessary to test the suitability of that machine. Because whenever the energy expenditure of operator is exceeded during operation it will induce the considerable amount of fatigue and finally lower down the working efficiency of operator. The lack of ergonomical consideration will resulted in poor performance of man-machine system. On the other hand, the application of ergonomic principles in design and operation of the agricultural equipment's will help in enhancing the output efficiency and also safe guarding the workers' health. The performance of any machine especially manually operated ones could be considerably improved if ergonomic aspects are taken into consideration [10]. Hence, there is a strong need of ergonomical assessment of pedal operated maize dehuskar-sheller. This study provides a rational basis for recommendation of operational methods to reduce the drudgery, increase the comfort and safety, and enhance the working efficiency of operators.

Keeping above points in mind, the study was undertaken with the objective of ergonomics assessment of pedal operated maize dehuskar-sheller to find out its suitability for male agricultural workers in terms of physiological cost.

2. MATERIALS AND METHODS

The ergonomical assessment of pedal operated maize dehuskar-sheller was conducted with Male Agricultural operators of the farm of Maharana Pratap University of Agriculture and Technology, Udaipur, India as shown Fig. 1. The detail specification of the thresher is given in Table 1.

Table 1. Technical specifications of Pedal Operated Maize Dehusker Sheller

S. no.	Specifications	Dimension
1	Saddle height, mm	806
2	Crank Length, mm	180
3	Height of pedal at its lowest position, mm	76
4	Diameter of Flywheel, mm	500
5	Diameter of drum, mm	170
6	Length of peg, mm	40

2.1 Subject Selection

Ten male agricultural workers were randomly selected from the age group of 20-40 yrs. for the study as the highest strength level is attained in this age range [11]. All selected workers were physically fit and free from any illness. Before starting the experiment, age, height, weight and blood pressure of each subject were measured at farm. The maximum heart rate [12] and body mass index [13] of the selected subjects were calculated using the equations 1 and 2.

$$HR_{max} = 220 - \text{age (years)} \quad (1)$$

$$Body\ mass\ index\ (BMI) = \frac{weight,\ kg}{(height)^2, m^2} \quad (2)$$

Table 2. Physical characteristics of the selected subjects

Particulars	Range	Mean± S.D
Age, Years	20-38	29.2±7.52
Weight, kg	44-52	47.8±2.53
Height, cm	154-168	161.3±4.40
BMI, kg/m^2	16.76-21.64	18.41±1.46
Av. Predicted HR_{max}, beats/min	182-200	190.8±7.52

2.2 Measurement of HR, OCR, and EER

All the trials were conducted between 10 am to 2 pm at agricultural farm of MPUAT, Udaipur in the month of December 2014. The ambient temperature and relative humidity during experiments period were 21 ± 0.56 0°C and 52 ± 4.3% respectively. The subjects were instructed to have a light breakfast before they reported at the farm. It was ensured that the subjects had a good sleep at night and were free from any intoxicants. Before starting the actual trails, all the workers were trained on how to operate the pedal operated maize dehuskar-sheller. The selected subjects were put for the operation of Maize dehusker sheller and their Heart Rate (HR) and Oxygen Consumption Rate (OCR) were recorded with K4b^2 (computerized Ambulatory Metabolic Measurement System). Before starting the experiment, the subjects were allowed to take rest for 10 minutes, and their heart rate data were recorded. After that, the subject was asked to start pedalling work on the pedal operated maize dehusker sheller until they are tired. The pedalling speed was maintained at 50 rpm as it is the optimum pedalling rate for an Indian agricultural worker for daylong pedalling work [14]. The recorded data was transferred to computer for further analysis. All the readings were then averaged out for 1 min. by software. The data recorded at resting level and from 6th to 15th min. of operation were used for computing the physiological parameters of the subjects. The resting data were used to compute the average resting HR and average resting OCR of all subjects. The average HR and OCR values from 6th to 15th min. of operation were used as working HR and working OCR [15] as it is considered that the heart rate gets stable after 5 to 6 minute of the work. The Energy Expenditure Rate (EER), corresponding to the resting and working HR and OCR values, was calculated by equation 3.

EER= OCR × 20.88 (20.88 kJ/l is calorific value of oxygen) (3)

When the subjects were completely exhausted, they were asked to stop pedalling and allowed to rest so that all the physiological parameters regained to their resting level. The increase in heart rate (ΔHR), also known as work pulse, was worked out from the difference in working HR and resting HR. Similarly the increase in Oxygen Consumption Rate (ΔOCR) and energy expenditure rate (ΔEER) were computed. The same procedure was repeated for all the subjects.

The operation of maize dehusker sheller was categorized based on the energy consumption during this operation as shown in Table 3 [16].

Table 3. Classification of different jobs based on physiological response of workers

Grading	Physiological response		
	Heart rate, beats/min	Oxygen uptake, lit/min	Energy expenditure kcal/min
Very light	<75	<0.35	<1.75
Light	75-100	0.35-0.70	1.75-3.5
Moderately heavy	110-125	0.70-1.05	3.5-5.25
Heavy	125-150	1.05-1.40	5.25-7.00
Very heavy	150-175	1.40-1.75	7.00-8.75
Extremely heavy	> 175	> 1.75	> 8.75

Fig. 1. Operational view of Pedal Operated Maize Dehusker Sheller

3. RESULTS AND DISCUSSION

The ergonomical assessment of pedal operated maize dehuskar-sheller was conducted with Male Agricultural operators and their HR and OCR were measured using $K4b^2$. The EER was calculated using the equation 3. The resting HR for selected subjects was varied from 74 to 87 and working HR was varied from 103 to 172 beats/min. The mean resting HR, mean working HR, and mean work pulse (ΔHR) of all subjects during the operation of maize dehusker sheller were found 82 (±4.38) beats/min, 139 (±22.01) beats/min and 57 (±21.36) beats/min, respectively. The resting OCR for selected subjects was varied from 0.128 l/min to 0.185 l/min and working OCR was varied from 1.01 l/min to 1.61 l/min. The mean resting OCR, mean working OCR and mean ΔOCR of all subjects were found 0.15 (±0.02) l/min, 1.40 (±0.20) l/min and 1.25 (±0.20) l/min, respectively. The resting EER for selected subjects was varied from 0.59 to 0.87 kcal/min and working EER was varied from 4.78 to 7.97 kcal/min. The mean resting EER, mean working EER and mean ΔEER of all subjects were found 0.721 (±0.11) kcal/min, 6.83 (±1.07) kcal/min and 6.10 (±1.04) kcal/min, respectively. The mean working heart rate (WHR) was in close agreement with the values reported by Nag et al. [17] for pedal threshing operations.The variation in heart rate among the selected subjects with same machine and under same working environment is due the difference in their age, height and weight. From the results it was observed that the mean working HR of all subjects for pedal operated maize dehusker sheller was more than the acceptable limit of heart rate for Indian worker on 8 h work day, i.e. 110 beats/min [18]. Thus the physiological workload of pedal operated maize dehusker sheller was not within the limit of continuous performance. So it was suggested that the pedal operated maize dehusker sheller should not be operated continuously for 8 hours without frequent rest-pauses. For continuous operation with the equipment, two male workers may be engaged in shifts. The operation of pedal operated maize dehusker sheller was found under Heavy Work category on the basis of energy expenditure rate. Thus, normal rest pauses should be provided to the workers for day long operation.

4. CONCLUSION

An ergonomic evaluation of pedal operated maize dehuskar-sheller was carried out with ten male agricultural operators to assess the physiological costs of operation. The mean working heart rate and work pulse of selected subjects were found to be 139 (±22.01) beats/min and 57 (±21.36) beats/min, respectively. The higher values of the mean working heart rate and work pulse rate suggested the need of frequent rest-pauses to the workers for day long operation. The mean working Oxygen Consumption Rate of selected subjects during the operation of maize dehusker sheller was found to be 1.40 (±0.20) l/min. The mean working energy expenditure rate was found to be 6.83 (±1.07) kcal/min. Thus the operation of pedal operated maize dehusker sheller categorized as heavy work on the basis of energy expenditure rate. So it was suggested to engage two male workers in shifts for continuous operation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ranum P, Pen˜a-Rosas JP, Garcia-Casal MN. Global maize production, utilization, and consumption. Annals of the New York Academy of Science. 2014;1312:105–112.
2. Shiferaw B, Prasanna B, Hellin J, Banziger M. Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. Food Security. 2011;3:307–327.
3. World Agricultural Production - USDA Foreign Agricultural Service; 2018. Available:https://apps.fas.usda.gov/psdonline/circulars/production.pdf
4. Kumar R, Srinivas K, Sivaramane N. Assessment of the maize situation, outlook and investment opportunities in India. Country Report – Regional Assessment Asia (MAIZE-CRP), National Academy of Agricultural Research Management, Hyderabad, India; 2013.
5. Mudgal VD, Jain NK, Bordia JS, Seth P. Research digest (1992-97) Udaipur Centre. AICRP on PHT, CTAE, Udaipur. 1998;17-18,26-32.
6. Singh SP. Status of maize threshing in India. Agricultural Mechanization in Asia, Africa & Latin America. 2011;42(3):21-28.
7. De Dipankar. Energy use in crop production systems in India. Book No. CIAE/2005/2. Central Institute of Agricultural Engineering, Bhopal; 2005.
8. Anonymous. Empowerment of farm women in agriculture. Final Report of Misson Mode NATP-20. College of Home Science, MPUAT, Udaipur. 2005;63.
9. Singh SP. Ergonomical evaluation of manually-operated cleaner-graders, fertilizer broadcaster, seed drills and Ridger with farm women. Final Report Project No. 496. NRCWA (Bhopal Sub-Centre), CIAE, Bhopal. 2005;31.
10. Gite LP. Ergonomics in Indian agriculture – A review. Paper Presented in the International Workshop on Human and Draught Animal Powered Crop Protection Held at Harare; Jan. 19-22; 1993.
11. Glickman EL, Collinsworth TA, Leigh M. Exercise testing and prescription in the enhancement of physiologic and overall well-being in the older adult. Forum on Public Policy: A Journal of the Oxford Round Table. 2006;1-21. Available:https://pdfs.semanticscholar.org/68e4/9ec87ef4413a63f4c2d99e732af341109922.pdf
12. Fox SM, Haskell WL. The exercise stress test: Needs for standardization. In: Eliakim M, Neufeld HN, Editors. Cardiology: Current Topics and Progress. New York: Academic Press. 1970;149–54.
13. Madden D. Body Mass Index and the measurement of obesity. HEDG Working Paper 06/11. The University of York; 2006. Available:https://www.york.ac.uk/media/economics/documents/herc/wp/06_11.pdf
14. Tiwari PS, Gite LP, Pandey MM, Shrivastav AK. Pedal power for occupational activities: Effect of power output and pedaling rate on physiological responses. Internat. J. Industrial Ergonomics. 2011;41:261-267.
15. Tiwari PS, Gite LP. Physiological responses during operation of a rotary power tiller. Biosystems Engineering. 2002;82:161–168.
16. Sen RN. Tentative classification of strains in different types of jobs according to the physiological responses of young Indian workers in comfortable climates. ICMR Report, Indian Council of Medical Research, New Delhi; 1969.
17. Nag PK, Sebastian NC, Mavlankar MG. Occupational workload of Indian agricultural workers. Ergonomics. 1980; 23(2):91-102.
18. Saha PN, Datta SR, Banerjee PK, Narayane GG. An acceptable workload for Indian workers. Ergonomics. 1979;22: 1059-1071.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/24561