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An ergonomic assessment of manually operated chisel weeder at agriculture working field

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Abstract
A study was conducted on an ergonomic assessment of manually operated chisel weeder at agriculture working field (10× 10 m^2. Anthropometric data of age group operators of (25-40 years) were determined. Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score of physiological and postural parameters of age groups were determined during working on chisel weeder at agriculture working field. 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 (1.5, 2.0 & 2.5 kg). Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score of 20-24 yrs age groups were found minimum and varied from 89-108 b/min, 0.32-0.555 l/min, 6.96-11.49 kJ/min and 17.74-21.38 respectively during working. Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score of 35-39yrs age groups were found maximum and varied from 95-130 b/min, 0.40-0.80 l/min, 8.40-16.68 kJ/min and 42.92-53.32 respectively operators on paddy transplanter at different weight samples.

Keywords: chisel weeder, anthropometer, body dimensions, heart rate, energy expenditure, oxygen consumption rate and body part discomfort score

1. Introduction
India is a vast country having agriculture sector as the backbone of its economy. India has total land acquisition of about 329 million hectares out of which 166 million hectares of land is under cultivation (Sahay, 2008). The population of India is more than 123 crore and is increasing day by day at an alarming rate. Hence, it is required to produce more food to meet the needs of growing population. Agriculture plays a vital role in India's economy 54.6% of the population is engaged in agriculture and allied activities (census, 2011). Tilling, cultivating and weeding are the major operations that are usually done in this stage of farming. Among these, weeding is one of the most significant farm operations in crop production and protection system. Weed growth is a major problem for both dry and wet land crops causing a considerable lower crop yield. In northern Karnataka of south India most of the farmers use the traditional tools for the weeding process. The commonly used tools are sickle, hoe, manual/animal driven weeders, manual tiller etc. It requires enormous amount of labour force to perform the work. Manually operated weeder for working field weeding is better than other chemical and traditional tools weeder.
The weeding operation is carried out with indigenous hand tools like 'Khurapi' and spade. Recently many improved hand tools have been introduced for weeding. Straight blade hoes and triangular blade hoes made by black smiths and village artisans are traditionally used. Use of rotary tools e.g. discs and rotating rods is limited.
Ergonomics (also known as Human Engineering, human factors or human Ergology) is the scientific study of relationship between a person and his/her 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.
The following objectives were undertaken as:
1. To determine the anthropometric parameters to reduce drudgery of operators.
2. To evaluate the physiological and postural parameters of age group of operators on chisel weeders.

2. Materials and Methods

In this study, experiment setup was planned for an ergonomic assessment of manually operated chisel weeder. The experimental set up was developed to determine the physiological and postural parameters of the workers of the different age groups operating on chisel weeder at working field area. The experiment was carried out in the farm machinery workshop, SHUATS, Prayagraj. The detail specification of the manual chisel weeder is given table 1.

Table 1: Specification of manual chisel weeder

S. No.	Particulars	Specifications
1	Type of machine	Manual chisel weeder
2	Suitabily of field	Vegetable field
3	Overall dimensions L×W×H (cm)	184×18×95
4	Type	Single row
5	Cutter blade L×W×H (cm)	17.5×3.5×10
6	No. of ground wheel	Two
7	Ground wheel dia.	19.5 cm
8	Rim dia.	4.5 cm
9	No. of tine	Single tine
10	Hub length	18 cm
11	Range for adjustment of depth	5-10 cm (chisel)
12	Weight of weeder	4.5 kg
13	Angle of inclination of handle	45-65 (adjustable according to suitabily human)

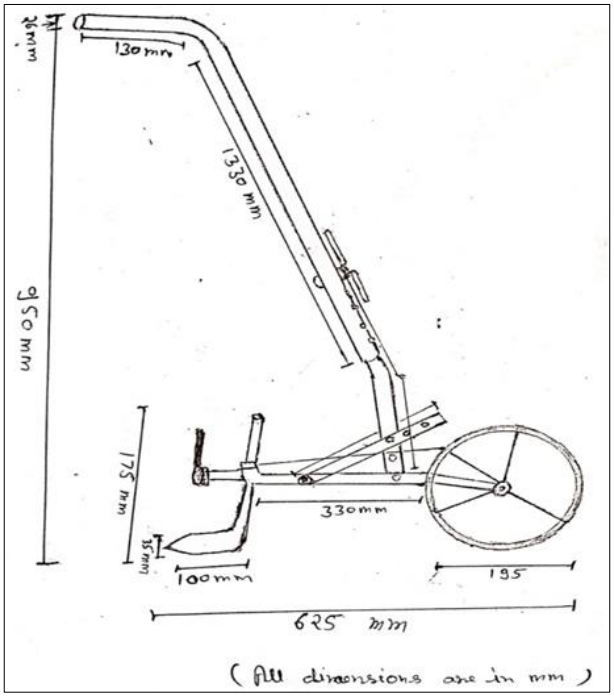

Fig 1: Side view of chisel weeder

Fig 2: Testing of hoe weeder on working field

2.1 Selection of age subjects

It was ensured that subjects were selected from particular age groups, physically fit, not suffering from any illness and had willingness to participate in undertaking experiments. The maximum aerobic capacity, heart rate, muscle strength and muscle cross-sectional area has been affected with ageing (Marsh *et al.*, 1999). For this study, different age subjects were selected from the available workforce of different ages which varied from 25-40 years.

The instruments, equipments and subjects required in the reading session are as follows:

1. Measuring tape (measurement of body dimension)
2. Pulse Oximeter (measuring of heart beat)
3. Weighing scale (measurement of body weight)

Table 2: Detail of selected different age subjects

S.I. No.	Age (years)	Height (cm)	Weight (kg)	BMI
1	25	168	65	23.03
2	30	167	62	20.82
3	35	170	77	21.25
4	40	168	70	27.00

The first step was measured the weight and height of the subjects and determined the body mass index of each of them. Their health was determined by finding the body mass index is formula given

$$BMI = Weight\ (kg) / [Height\ (m)]^2$$

The selected different age of subjects for conducting experiments should be physically fit. There should not be any chronic diseases or illness and handicaps. The selected different age subjects should be physically fit and engaged in physical work, not having any illness, handicap or chronic problem.

2.2 Determination of variables

- Independent Variable

a. Different age year = 25-40 yrs

b. Agriculture Working field = (10 × 10) m^2

- Dependent Variable

1. Heart rate (b/min)
2. Oxygen consumption rate (l/min)
3. Energy expenditure rate (kJ/min)
4. Body part discomfort score

2.2.1. Oxygen consumption rate (OCR)

The HR and OCR were taken as the physiological parameters. The HR and OCR were taken for computational work. The OCR of subject on their measured heart rate was estimated based on general equation as given by Singh *et al*. (2008).

OCR = 0.0114 × HR – 0.68

Where,

- Oxygen consumption rate (OCR) in lit/min
- Heart rate (HR) in beats/min
- The oxygen consumption rate (lit/min) was converted in kJ (1 lit.O_2 = 20.93 kJ).

2.2.2. Energy expenditure rate (EER)

The EER was computed by using the following equation given by Nag *et al*. (1980).

EER = 20.86 OCR (kJ/min

2.2.3 Measurement of body part discomfort score (BPDS)

To measure localized discomfort, Corlett and Bishop (1976) technique was used. In this method, the body of subject is divided into 27 regions.

For example, if one subject has experienced 5 categories, first category (body parts experiencing maximum) rating was allotted as 5 and for second category (body parts experiencing next maximum pain) rating was allotted as 3.75 and so on for the fifth category (body parts experiencing least pain) rating was allotted as 1.25. 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.

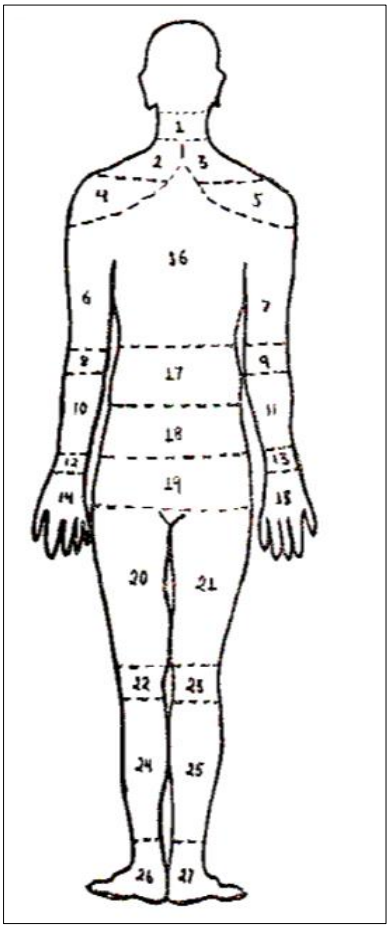

Fig 3: Region for evaluating body part discomfort score

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

3. Result and Discussion

3.1 Anthropometric data of selected age subjects

Anthropometric data of selected subjects were measured using measuring anthropometer in complete resting condition. Four subjects were selected from agricultural engineering farms of different age subjects.

Table 3: Anthropometric data of age (year) subjects for male workers

S.I No.	Particular Dimension	Anthropometric data			
		25 yr	30 yr	35 yr	40 yr
1	Stature(cm)	168	167	170	168
2	Arm length(cm)	73	74	74	75
3	Arm span(cm)	167	179	177	179
4	Standing eye height(cm)	157	155	158	157
5	Sitting height(cm)	85	82	85	83
6	Sitting eye height(cm)	75	72	75	74
7	Popliteal height(cm)	42	43	43	44
8	Knee height(cm)	51	52	50	49
9	Pelvic height(cm)	90	93	89	91
10	Elbow height(cm)	112	108	109	110
11	Shoulder height(cm)	136	142	142	141
12	Weight (kg)	65	62	77	70

3.2 Effect of different age subject on heart rate of workers during working on chisel weeder at agriculture working field

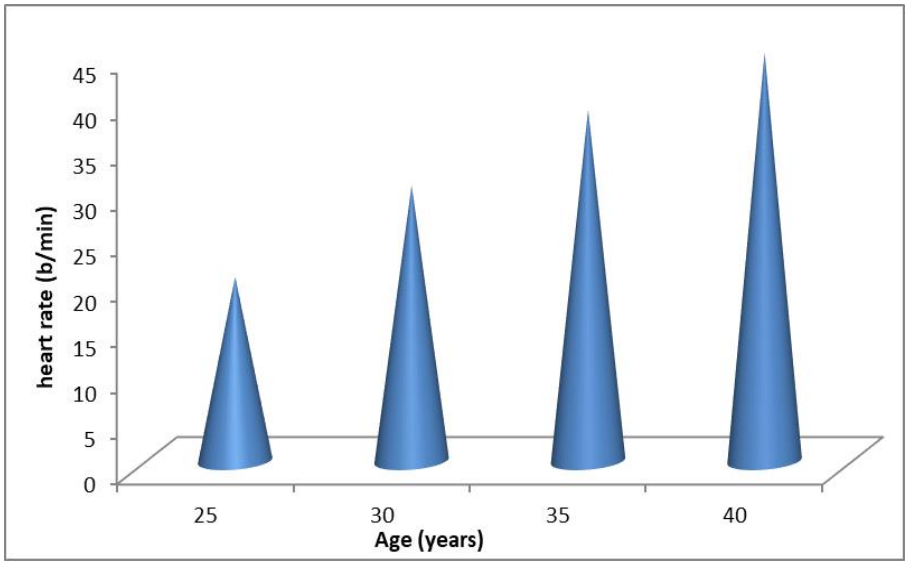

Fig 4: Relationship between age subject and heart rate of workers during on chisel weeder at working field

Maximum heart rate of age subject workers of 40 yrs varied from 125 beats per min during working at agriculture working field. Minimum heart rate of workers of age subject 25 yrs observed from 99 beats per min at same conditions. The results were found to similar with Tiwari *et al.,* (2005).

3.3 Effect of different age subject on oxygen consumption rate of workers during working on chisel weeder at agriculture working field

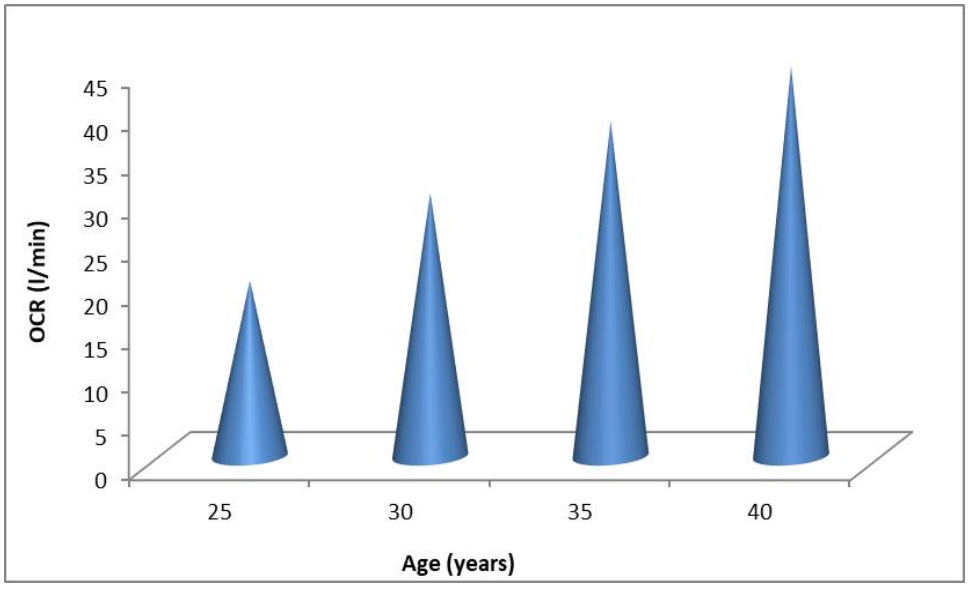

Fig 5: Relationship between age subject and OCR of workers during on chisel weeder at agriculture working field

Maximum OCR of age subject workers of 40 yrs varied from 0.729 l/min during working at agriculture working field. Minimum OCR of workers of age subject 25 yrs observed from 0.425 l/min at same conditions. The results were found to similar with Singh *et al*., (2008).

3.4 Effect of different age subject on energy expenditure rate of workers during working on chisel weeder at agriculture working field

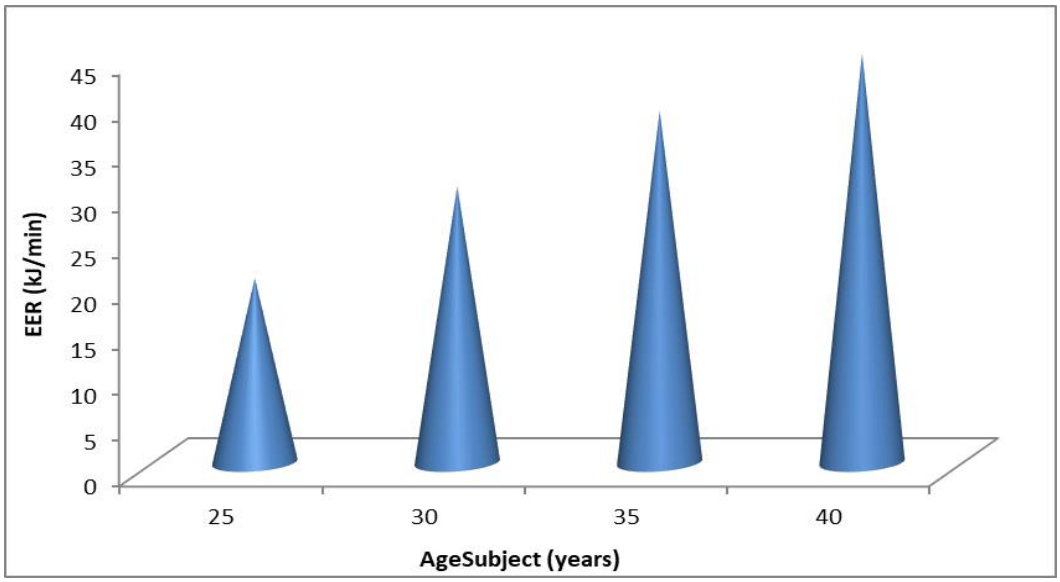

Fig 6: Relationship between age subject and EER of workers during on chisel weeder at agriculture working field

Maximum EER of age subject workers of 40 yrs varied from 15kJ/min during working at agriculture working field. Minimum EER of workers of age subject 25 yrs observed from 9kJ/min at same conditions. The results were found to similar with Nag *et al*. (1980).

3.5 Effect of different age groups on body part discomfort score of workers during working chisel weeder at agriculture working field

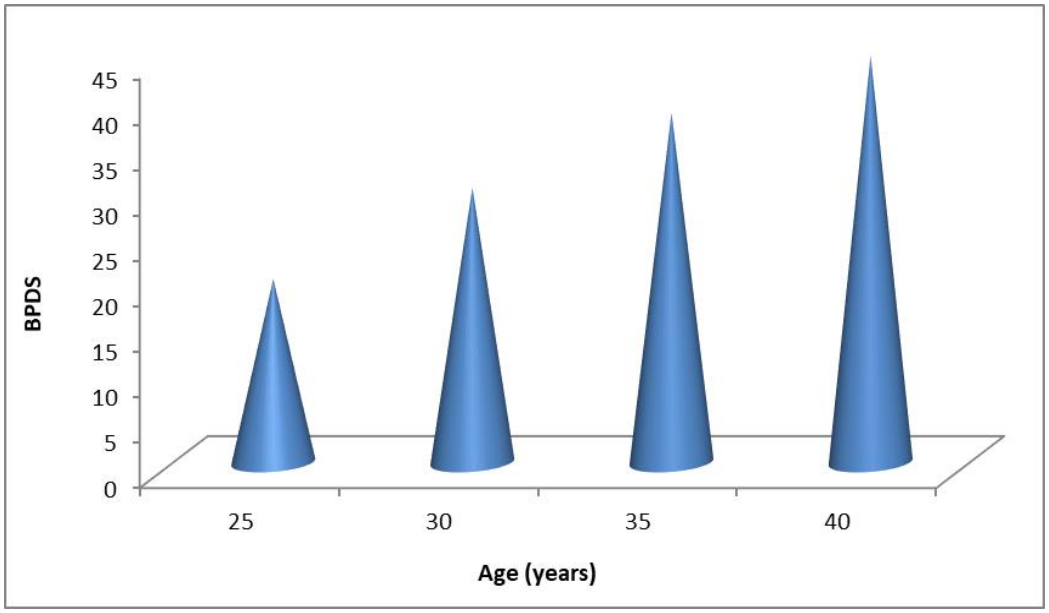

Fig 7: Relationship between age subject and BPDS of workers during on chisel weeder at agriculture working field

Maximum EER of age subject workers of 40 yrs observed from 44.73 during working at agriculture working field. Minimum EER of workers of age subject 25 yrs observed from 20.16 at same conditions. The results were found to similar with Kumar *et al*., (2002).

4. Conclusions

Following conclusions were drawn from the study:

1. Anthropometric data of ages (years) subjects for male workers *viz*. stature, arm length, arm span, standing eye height, sitting eye height, popleal height, knee height, pelvic height, elbow height and shoulder height were found out using anthropometer.
2. With increasing age subjects, heart rate increased on chisel weeder during agriculture working on field.
3. With increasing age subjects, oxygen consumption increased on chisel weeder during agriculture working on field.

4. With increasing age subjects, energy expenditure increased on chisel weeder during agriculture working on field.
5. With increasing age subjects, body part discomfort score increased on chisel weeder during agriculture working on field.

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