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A Comparative Study of Postural Stress for Ergonomically Compatible Design in Selected Manual Weeding Tool

Kumari Chanchala Priya*, J.K. Singh and Adarsh Kumar

Division of Agricultural Engineering, Indian Agricultural Research Institute-IARI, New Delhi, India

**Corresponding author*

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A B S T R A C T

An Experiment was performed to comparative study of forearm postural stress in selected wheel hoe and modified wheel hoe for ergonomically compatible design. Modified tool (handle 35^0 with vertically downward) was evaluated with existing wheel hoe (handle 60^0 with vertically downward) in terms postural stresses, as BPDS, ODS, shoulder elbow and wrist deviations. The BPDS for existing ranges from 33.0 to 35.23 and for modified 27.43 to 31.20. While that of ODS for existing ranges were found 2.21 to 2.70 and for modified 1.60 to 2.08. The wrist deviation for existing wheel hoe were found 40^0, which changed for modified wheel hoe to 5^0 while 98° of elbow extension for modified wheel hoe and that of for existing was 138° of shoulder deviation was found to be $39^0$for existing and that of 10^0 for modified. It was found that the postural parameters such as shoulder deviation, elbow deviation and wrist deviation get reduced by 29.^{0}, 40^0 and 35^0 respectively in modified wheel hoe. The BPDS and ODS reduced by 4.8 and 0.74 score respectively.

Introduction

There are so many tools and equipment involved in agricultural activity from land preparation, sowing, harvesting to storage of agricultural produce. Weeding is an important but equally labour intensive agricultural unit operation. Earlier, weeding was mostly done by hand where lot of energy was expended. In addition to this during these activities operators have to adopt bending and squatting body posture due to which their physiological workload increases and also they face many types of musco-skeletal problems as a result of which the efficiency to work decreases to a great extent. Therefore now tools for mechanical weeding are in use which make its simple and required less energy. Behera and Swain (2005) reported that manually operated weeders have found acceptability due to their low cost.

According to Nag and Dutt (1979), manually operated weeders need human effort to operate. The performance of the weeders as well as the operator vastly depends on the design of the weeders. Therefore the size, design and dimensions of these tools and implements have a great bearing on the size and physical built of users. Therefore

compatibility between two is essential. Efforts are still on to reduce the drudgery in weeding operation (Khogare and Borkar, 2012). The present study was undertaken to make design compatibility for farm workers in the existing wheel hoe and evaluate the modified. Comparative study between modified and existing wheel hoe in terms of postural stress viz. overall discomfort score, body part discomfort score, shoulder, deviation, elbow deviation and wrist deviation has been analysed.

Materials and Methods

Wheel hoe

Wheel hoe is manually operated equipment for weeding and intercultural operations. It consists of wheel assembly, a set of replaceable soil tools and handle assembly. The working depth of the tool can be adjusted through the plate with multiple holes provided in the frame and welded to the tool assembly. The ground wheel is made up of two circular rings. The specifications of wheel hoe used for experiment are as follows: Overall length (mm): 1090

Overall width (mm): 160
Overall height (mm): 1100
Number of tynes: 1
Wheel diameter (mm): 200- 600
Working depth (mm): Up to 60

Modification in wheel hoe

Wheel hoe was modified for most effective posture (close to neutral posture) during operation. In pure vertical orientation of handle the forearm posture comes under neutral posture, because in this forearm and wrist are in anatomically straight alignment. Since we can't make the handle completely vertical (0^0 to the vertical) because it leads to improper grip. As the selected wheel hoe handle set at 60^0 to the vertical was modified to 35^0 with vertical to make the operating hand handle position as possible as close to neutral posture

Selection of subjects

The selected subject should be physically and medically fit for carrying out the experiments (Seidel *et al.,* 1980). For this study; five physically fit subjects were selected from the available workforce belong with 5th and 95th percentile of population. The details of subject selected are given in Table 1.

Measurement of postural parameters

The postural stress assessment of subjects were done while operating wheel hoe during weeding operation in field. The subjective evaluation of discomfort was done by computing body part discomfort score, overall discomfort score, shoulder deviation elbow deviation and wrist deviation.

Measurement of body part discomfort score (BPDS)

Body part discomfort score (BPDS), was measured using Corlett and Bishop (1976) technique. In this technique the subject's body is divided into 27 regions and the subject was asked to indicate the painful regions after completing the work. The subjects were asked to mention all body part with discomfort, and to give ranking as the most painful to the next painful and so on until all painful body parts have been mentioned.

The number of different groups of body parts, which are identified from extreme discomfort to no discomfort, represented the number of intensity levels of pain experienced by the worker. The maximum number of intensity levels of pain experienced for experiment need to be categorized.

Measurement of overall discomfort score (ODS)

The overall discomfort was assessed according to a 5-point psychophysical rating scale (0-no discomfort to 5-extreme discomfort) which is an adoption of Corlett and Bishop (1976) technique. At the end of each experiment subject was asked to indicate their overall discomfort rating on this scale.

The overall discomfort ratings given by each of the five subjects were added and averaged to get the mean rating. The same procedure was repeated for all experiments with all the selected subjects. The five points scale is given as follows:

0-No discomfort

1-Very little discomfort

2-Mild discomfort

3-Great discomfort

4-Extreme discomfort

The number shows the level of discomfort experienced by the subject during experiment.

Measurements of elbow, shoulder and wrist deviation

Shoulder, elbow and wrist deviation were measured through still photographs obtained from videos using software called image measurement. Before starts of experiment markers were pasted on the joint of hand and elbow to distinct critical points of movements. Videos of subjects were taken during the conduction of experiments. The sequential still (snapshot) photographs were obtained from recorded videos by the use of VLC player.

The obtained photographs were acquired in the image measurement software to measure different angles to assess deviations.

Results and Discussion

Comparison of postural parameter of subjects in existing and modified wheel hoe

The performance of wheel hoe was evaluated in the field of sandy loam soil having soil moisture content 9.41 to 11.06 (% db.) and bulk density was 1354.2 kg/m3 to 1506.8 kg /m3. The weeding efficiency of existing wheel hoe was 79.93 which changed to 81.61 after modification. There was no considerable change in weeding efficiency and field capacity.

The body part discomfort score of all the subjects were calculated according to the Corlett and Bishop (1976) technique. The values of BPDS and ODS each individual subjects for both existing and modified wheel hoe furnished in and The BPDS and ODS values using existing and modified tool are depicted in figure 1 and 2 respectively. From the figure it was evident that the BPDS for existing ranges from 33.0 to 35.23 and for modified 27.43 to 31.20.

While that of ODS for existing ranges were found 2.21 to 2.70 and for modified 1.60 to 2.08. The wrist deviation for existing wheel hoe were found 40^0, which changed for modified wheel hoe to 5^0 which were close to the maximal values (38°–40°) found in several other studies (Li *et al.*, 2005; Wigderowitz *et al.*, 2007).

Similarly, it was found that with 98° of elbow deviation present in existing wheel hoe while that of for modified wheel hoe was 138°. In the same way, van Andel *et al.*, (2008) deliberate minimum elbow angle of 85° was used for all functional tasks they studied. Peak values were also similar across studies. In fact the shoulder deviation was found to be $39^0$for existing and that of 10^0 for modified.

Table.1 Details of subject selected

Sr. No.	Subjects	Age (Yrs)	Weight (kg)	Height (cm)	BMI (kg /m^2)
1	A	33	65	165.7	23.67
2	B	36	75	180	23.14
3	C	45	63	165.3	23.05
4	D	31	57	163	21.45
5	E	35	50	165.5	18.25

Fig.1 Body part discomfort score of subjects with existing and modified wheel hoe

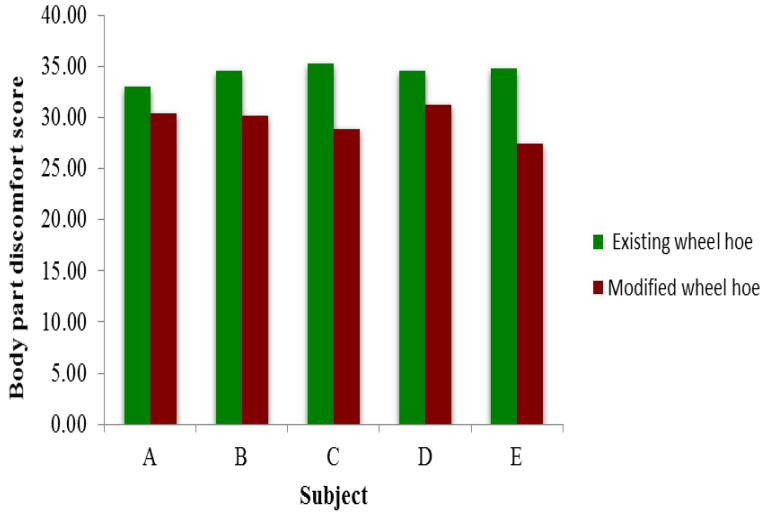


Fig.2 Overall discomfort score of subjects using existing and modified wheel hoe

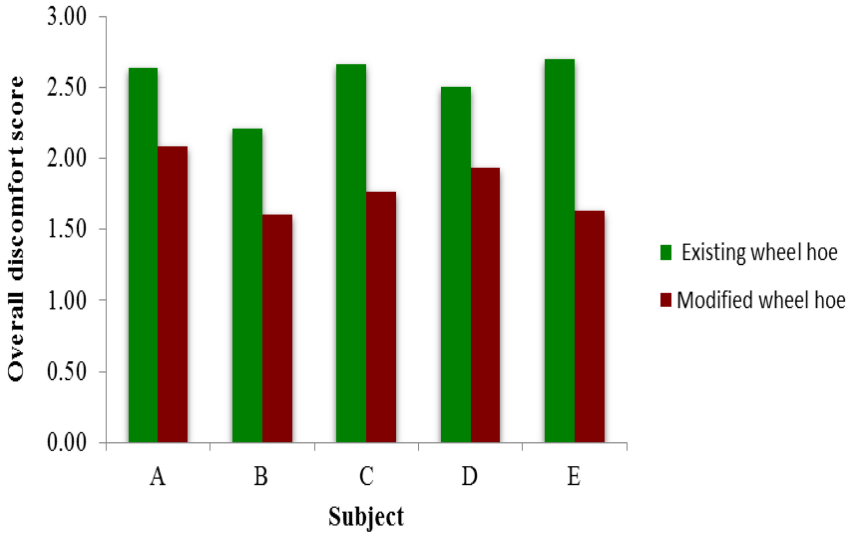
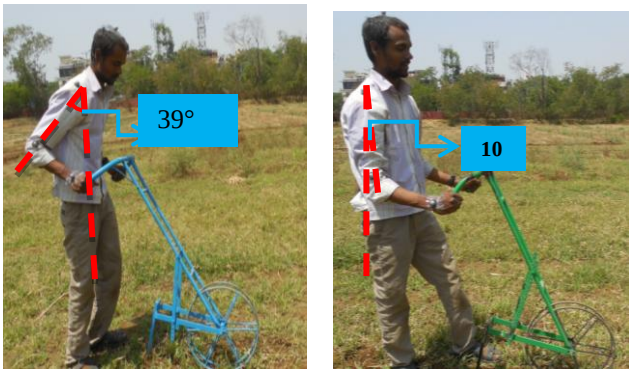
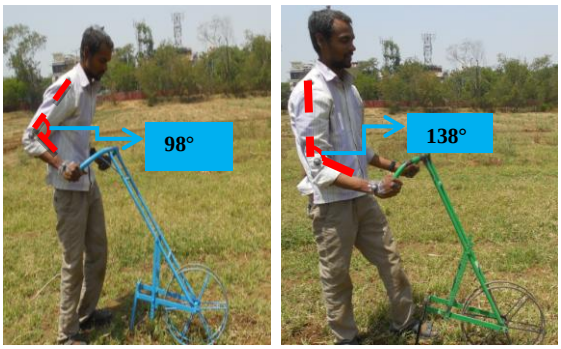


Fig.3 Shoulder deviation



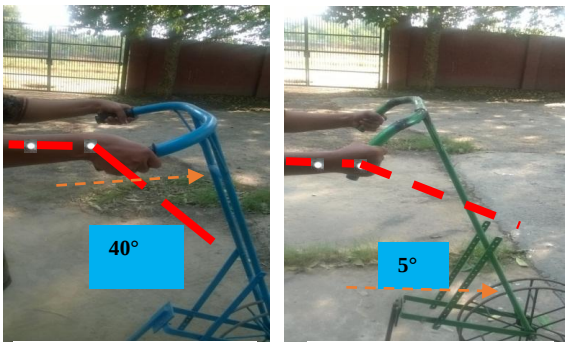
Existing wheel hoe **Modified wheel hoe**

Fig.4 Elbow deviation



Existing wheel hoe **Modified wheel hoe**

Fig.5 Wrist deviation



Existing wheel hoe **Modified wheel hoe**

The shoulder deviation, elbow deviation and wrist deviation for modified wheel hoe were found to be more close to neutral position which is the most comfortable posture.

It was concluded that the postural parameters such as shoulder deviation, elbow deviation and wrist deviation get reduced by 29.0, 400 and 350 respectively in modified wheel hoe. The BPDS and ODS reduced by 4.8 and 0.74 score respectively. Henceforth compliance of such modification in wheel hoe handle can reduce postural stress and the health hazards in weeding operation.

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