The Pharma Innovation Journal 2021; SP-10(11): 2552-2557

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(11): 2552-2557

www.thepharmajournal.com
Received: 07-09-2021
Accepted: 09-10-2021

Swapnali Borah
College of Community Science, Central Agricultural University, Tura, Meghalaya, India

Nilakshi Borah
College of Community Science, Central Agricultural University, Tura, Meghalaya, India

Corresponding Author
Swapnali Borah
College of Community Science, Central Agricultural University, Tura, Meghalaya, India

Ergonomic intervention for reduction of drudgery of women farmer involved in vegetable cultivation

Swapnali Borah and Nilakshi Borah

Abstract
Most of the activity related to vegetable cultivation was very tedious, laborious as well as drudgery prone. Farm women having lots of health related issues as they were used age old agricultural tools which were not suitable for their body as these were meant for man. Some ergonomically suitable tools related to vegetable cultivation were designed/ modified and adopted and given to farm women for testing. The study was conducted among 80 Garo farm women within the age group of 20-50 years who were actively participated in different activities of vegetable cultivation from two villages namely Aminda Rangsagre and Aminda Simsanggre of Gambegre block of West Garo Hills districts of Meghalaya selected by purposive sampling procedure. After analysis of the data results showed that farm women reduces their physiological cost, reduction of pain in different parts of their body and decreases musculoskeletal disorders by using ergonomically designed/modified tools and technologies which can be recommended to farm women involved in vegetable and also other cultivation.

Keywords: vegetable cultivation, musculoskeletal disorders, improved farm tools, occupational health hazards, garo farm women

Introduction

Woman is the backbone of agricultural labor force though worldwide her hard work has mostly been unpaid (Singh *et al*. 2010) [23]. In India, women of rural areas play a significant role in agriculture and other agro based activities (Devi Nirmala G. *et al*. 2019) [11]. The daily work schedule of rural women is very challenging and laborious and they are working every day for 8-9 hours in agriculture and 4 hours in household activities (Borah & Borah 2020) [7]. Women play a significant and key role in production of vegetables (Kumari Anuradha Ranjan & Laxmikant 2015) [18]. Moreover in rural areas of India women are likely to collect firewood from a field, they used it as a main fuel source for cooking (Gupta M. P. 2005) [16]. The women of Meghalaya was not exceptional they also play numerous role in vegetable cultivation as well as their household works. During the whole process of vegetable cultivation their body gets tired and their efficiency reduces. Devi Nirmala G.*et al*. (2019) [11]; Gite and Singh (1997) [15] found that during the farm activities women adopt an unnatural body posture due to which their physiological workload increases and also they face many types of musculoskeletal problems, as a result, the efficiency of women decreases to a greater extent. Since the majority of Indian farmers having small land holdings, they are unable to procure high cost machinery for vegetable cultivation (Kumar *et al*. 2008) [17]. The affordable technologies which can be beneficial over the traditional cultivation practices are the current need of vegetable farming (Bergamo *et al*. 2016) [3].

Vegetable cultivation is one of the most tedious, monotonous and labour intensive activities which is largely done in rural areas of West Garo Hills. They cultivate both rabi and kharif vegetables. Women of West Garo Hills are lack of knowledge in the use of improved technologies and equipments while doing vegetable work. Most of the rural farm women are doing planting/sowing, weeding, harvesting, transporting etc with traditional age old tools. They adopt standing, bending or squatting posture in repetition for long duration which can cause various musculoskeletal disorders. Musculoskeletal disorders (MSDs) can affects the body's joints, muscles, ligaments, tendons and nerves (Borah S. 2015) [5]. Musculoskeletal disorders are one of the important causes of occupational health hazards and disability not only in developing countries but in developed and industrially developed countries (Genaidy *et al*. 1993) [14] too.

The traditional age old tools and technologies considering men's anthropometric, physiological, and ergonomical parameters can increase work load and occupational disorders in spite of decreasing, if it is not user friendly for farm women (Singh *et al*. 2016) [16]. According to Armstrong (1983) [1] improper design and extreme use of hand tools were related with increased incidence of both acute and sub-acute cumulative injury of wrist, hand and fore arm. The designing and modification of ergonomically suitable drudgery reducing tools are need of the rural farm women to overcome the problem to efficiently manage the activity of vegetable cultivation with proper posture and reducing of labour and time. Therefore the study focuses on minimizing drudgery of farm women by doing intervention with developed/modified some improved tools which can be used in the field of vegetable cultivation for reducing drudgery and increasing work efficiency of women farmers.

Materials and Methods

In order to determine the samples for this study, 80 women farmers from two villages namely Aminda Rangsagre and Amida Simsanggre of Gambegre block of West Garo Hills who were involved in vegetable cultivation were selected purposively. This study adopted interview method along with observation for collection of data. Percentage reduction of ergonomic cost with the use of improved tool was calculated.

Heart rate (beats/min) was measured before and after intervention of ergonomic tools and technologies with the help of Polar heart rate monitor, which consisted of one transmitter and one receiver to transmit and received the ECG signals. Transmitter was tied on the chest of the subject and receiver was tied on the wrist and ECG signals were recorded at rest, during the entire period of work and recovery thereafter for a period of 5 minutes.

Measurement of energy expenditure has been in extensive use in work physiology since long (Christensen, 1953; Durin & Passmore 1967; Saha & Banerjee 1976) [9, 12, 20]. Energy expenditure was estimated from average heart rate during rest and during work before and after intervention by using given formula for Indian housewives (Varghese *et al*. 1994) [26].

Energy Expenditure (kj/min) = 0.159 × Average heart rate (beats/min) – 8.72

It is often difficult to measure heart rate in the tasks of very short period. To prevent this difficulty, for assessment of workload, scientists suggested the use of another simple method which provides equally reliable information, that is, subjective perception of exertion and came out with a scale known as “Rating of Perceived Exertion (RPE)”, based on extensive research (Gamberale, 1972; Skinner *et al*. 1973; Arstila *et al*. 1974; Pendolt *et al*. 1977; Borg 1982; Varghese *et al*. 1994) [13, 25, 2, 19, 8, 26]. This scale has been designed as a practical method for rapid appraisal of all occupational work. In this study a modified 5-point scale of perceived exertion by Varghese *et al*. (1994) [26] was used. The grip strength was measured with the help of grip dynamometer before and after intervention. It consists of a handle for handgrip connected with a spring to a pointer on the marked dial. The subject was asked to pull the handle separately with right and left hand before and after the work and the reading given on the dial in kgs was recorded for both the hands. The percent reduction in grip muscular strength (muscular fatigue) was calculated from the formula:

$$\text{Percent reduction in grip muscular strength} = \frac{Sr - Sw}{Sr} \times 100$$

Where, Sr = Strength of muscles during rest (kgs) and Sw = Strength of muscles during work (kgs)

Musculoskeletal disorder during the performance of various activities of vegetable cultivation was recorded from the intensity of the pain in different parts of the body like head, neck, shoulder, upper arm, lower arm, chest, hips, upper back, lower back and knee joints. In order to ascertain the degree of severity of discomfort, a five point rating scale (Varghese *et al*. 1996) [27] was used for measuring severity of body pain (Rating: 1- No pain; 2 – Mild; 3 – Moderate; 4 – Painful; 5 – Very Painful).

Results and Discussion

At the time of collection of data for present study it was observed that farm women of West Garo Hills engaged in vegetable cultivation had been using traditional age old tools like *khurpi*, *dao*, hoe, sickle, spade, pickaxe etc. Women farmers have no knowledge about uses of ergonomically designed women friendly improved tools and technologies in vegetable cultivation. However different activity related to vegetable cultivation was very tedious and painstaking and farmers having musculoskeletal problem. Therefore some ergonomically suitable tools related to vegetable cultivation were designed/ modified and adopted and given to farm women for testing. After analysis of the data showed that farm women reduces their physiological cost, reduction of pain in different parts of their body and decreases musculoskeletal disorders by using following improved tools and technologies.

Improved *Kokcheng:* (Developed by CCS, CAU, Tura)

Rural women of Garo hills use traditional ‘*kokcheng*’ (a locally made bamboo basket) to carry firewood, water pot, fodder, vegetables from farm to home and home to market. The rope of traditional *kokcheng* made with a bark of ‘*omak’* (local name) tree skin which was strong to give support to loaded *kokcheng* but it is very hard and rough to user’s body. Therefore a new and improved *kokcheng* was developed where a new adjustable belt is attached and the new belt is a kind of thickly woven cotton belt with adjustable buckle. Added support is given from two shoulders with padded belt so that weight on head can be decentralized to shoulders of users. One padded head support is also attached which give comfort to head. From Table 1 it can be showed that farm women reduce their drudgery while using improved *kokcheng*. Further analysis of data showed that reduction in heart rate, energy expenditure, and decrease pain in lower back, neck, and head while using improved *kokcheng* during carrying and transporting of vegetables. Improved *kokcheng* which was designed for Garo women of Meghalaya can also be suggested to reduce their drudgery while collecting fodder leaves from hilly forest (Borah S. 2016) [6]. Bhattacharyya *et al*. (2012) [4] also reported that there was a reduction of 9 beats per minutes in case of both average and peak heart rate during weeding in tea fields with an improved tool.

Table 1: Dimension and Impact on Ergonomic Cost of Improved *Kokcheng*

Dimension of improved *Kokcheng*		**Impact on ergonomic cost**	
		Ergonomic Parameters	**Percentage Reduction in Ergonomic Cost while using Improved *Kokcheng***
Height	43 cm	Heart Rate (b/min)	5.59
Diameter (top)	48 cm	Energy Expenditure (Kj/min)	9.75
Width of the adjustable belt	4 cm	Rated Perceived Exertion	27.78
Size of the head support	7.5 x 24 cm	Lower Back Pain	22.68
Size of bottom	18 x 18 cm	Head Pain	19.59
Size of shoulder	7 x 50 cm	Neck Pain	22.45

3.2 Improved Tubular Maize Sheller: (Tested by CCS, CAU, Tura.)

Analysis of the data showed that farm women had been shelling maize manually by using their fingers which was more tedious and time consuming and having pain in fingers, hand, wrist etc. Therefore a hand operated improved tool was developed/modified to increase work efficiency, reduce pain and strain while shelling maize, which is made up of iron pipe with four tapered fins riveted to its inner periphery. This tool is used for big as well as small size corn as it is available in both sizes. Farm women reported that work efficiency is very high by using this tool and efforts are very low and also reduction of hand grip strength in both the hand (Table 2).

Table 2: Dimension and Impact on Ergonomic Cost of Tubular Maize Sheller

Dimension of improved tubular maize sheller		**Impact on ergonomic cost**		
		Ergonomic Parameters	**Percentage Reduction in Ergonomic Cost while using Improved Tubular Maize Sheller**	
			Right Hand	Left Hand
Weight	0.215 kgs	Hand Grip	64.39	88.89
Diameter	16.5 cm	Rated Perceived Exertion	9.75	
Cost Rs. 100/-		Pain in finger	30.2	
		Pain in wrist	14.65	

Similar findings were reported on comparing energy expenditure of farm women while using traditional practices during performing agricultural activities and by using drudgery reducing tools like maize sheller, sickle and hand ridger, their energy expenditure decreased and the outcome increased almost ten folds by using each tool (Singh S. *et al*. 2016) [24].

3.3 Improved Serrated Angled Sickle: (Tested by CCS, CAU, Tura)

Improved Sickle with long serrated blade was used for cutting and harvesting vegetables and fodders. After analysis of data it was found that while using improved sickle improved the hand posture of farm women and thereby reduced stress of the grip muscles at the time of harvesting vegetables and cutting fodders. This improved technology has positive impact on reduction of hand grip strength and increases working efficiency.

Table 3: Dimension and Impact on Ergonomic Cost of Improved Serrated Angled Sickle

Dimension of improved serrated angled sickle		**Impact on ergonomic cost**	
		Ergonomic Parameters	**Percentage Reduction in Ergonomic Cost while using improved Serrated Angled Sickle**
Total Length	35 cm	Heart Rate (b/min)	2.54
Length of the Blade	24 cm	Energy Expenditure (Kj/min)	9.56
Length of the Handle	14 cm	Rated Perceived Exertion	11.11
Material of Blade	Iron	Wrist Pain	34.14
Material of handle	Wooden	Upper Arm Pain	18.39
Cost	Rs.180/-	Lower Arm Pain	13.84

From Table 3 it was also observed that heart rate, energy expenditure, pain in wrist, upper and lower arm were reduced while using improved serrated angled sickle by farm women while doing work. Singh *et al*. in the year 2014 reported that higher working efficiency achieved while doing harvesting with improved serrated sickle. Again D. Sutjann, (2000) [10] has found that the farmers' productivity to be higher by using serrated sickles when compared to non-serrated sickles.

3.4 Improved Spade: (Tested by CCS, CAU, Tura.)

Farm women reported that Spade is a tool used for digging, lifting and moving bulk materials such as soil, coal, gravel, sand etc. Improved spade handle was designed as per the anthropometric measurement of women of West Garo hills involved in vegetable cultivation. Farm women reported that while using improved spade their heart rate, energy expenditure and rated perceived exertion reduced to 6.76, 10.99 and 18 percent respectively (Table 4).

Table 4: Dimension and impact on ergonomic cost of improved spade

Dimension of improved spade		Impact on ergonomic cost	
		Ergonomic Parameters	Percentage Reduction in Ergonomic Cost while using improved Spade
Handle Length	94.5 cm	Heart Rate (b/min)	6.76
Length of the Blade	19 cm	Energy Expenditure (Kj/min)	10.99
Breadth of the Blade	19.5 cm	Rated Perceived Exertion	18
Material of Blade	Iron	Wrist Pain	11.47
Material of handle	Wooden	Lower Back Pain	24.24
Cost	Rs.380/-	Upper Back Pain	24.04

Further analysis of data from Table 4 showed that improved spade could reduce pain in wrist, lower and upper back of farm women. Another study reported that working with improved weeding hoe (spade) brought about significant reduction in pain relating to fingers (16.66%) followed by palms and wrist (14.29%), mid-back (13.04%), neck (12.5%) and upper back (11.54%). Lower back, elbow, lower arms, legs and upper arms also experienced some relief of pain. (Bhattacharyya N. *et al*. 2012) [4].

3.5 Improved Angular *Khurpi*: (Tested by CCS, CAU, Tura.)
After analysis data it was found that farm women used improve angular *khurpi* to handle soil, manure, and levelling soil surface for small area. This short tool with a flat blade used for digging soil and weeding in vegetable farms and garden also.

Table 5: Dimension and Impact on Ergonomic Cost of Improved Angular *Khurpi*

Dimension of improved angular khurpi		Impact on ergonomic cost	
		Ergonomic Parameters	Percentage Reduction in Ergonomic Cost while using improved Angular Khurpi
Total Length	33 cm	Heart Rate (b/min)	3.33
Length of the Blade	24 cm	Energy Expenditure (Kj/min)	9.72
Length of the Handle	14.5 cm	Rated Perceived Exertion	19.56
Material of Blade	Iron	Wrist Pain	10.27
Material of handle	Wooden	Upper Arm Pain	11.00
Cost	Rs.99/-	Lower Arm Pain	29.68

Farm women reported that improved *khurpi* having angular handle is comfortable to use and reduce stress in grip muscle. From table 5 it can be concluded that heart rate and energy expenditure reduces by using this improved tool. Farm women also reported that they experienced reduction of pain and strain in wrist, lower and upper arm. Another study conducted by Sandhu P. *et al*. in the year 2001 on elderly people in Punjab and found that improved technologies were effective enough to reduce the both heart rate and energy expenditure of elderly people to a considerable extent for performing the selected household activities.

3.6 Improved Sitting Pick Axe: (Tested by CCS, CAU, Tura.)
At the time of collection of data we have seen that rural women of Garo hills are using a primitive type of pick axe mainly used for breaking up hard surface like dry hardened earth. A new sitting pick axe was selected and tested through rural farm women. The rubber grip was attached in handle for comfortable power grip of women farmer. Adopted pick axe was one side pointed blade and other side flat blade which can be used for breaking rocks, digging hardened surface easily. Data analysis showed that Improved sitting pick axe reduces their heart rate, energy expenditure, rated perceived exertion wrist pain as well as lower and upper arm (Table 6).

Table 6: Dimension and Impact on Ergonomic Cost of Improved Sitting Pick Axe

Dimension of improved sitting pick axe		Impact on ergonomic cost	
		Ergonomic Parameters	Percentage Reduction in Ergonomic Cost while using improved Sitting Pick Axe
Total Length	30.5cm	Heart Rate (b/min)	2.56
Length of Pointed blade	12cm	Energy Expenditure (Kj/min)	9.40
Length of Flat blade	11cm	Rated Perceived Exertion	23.91
Material of Blade & Handle	Iron	Wrist Pain	26.66
Material of grip handle	Rubber	Lower Arm Pain	28.83
Cost	Rs.175/-	Upper Arm Pain	29.33

3.7 Improved Standing Rake: (Tested by CCS, CAU, Tura.)
Standing rake is a broom like tool for outside use to collect dry leaves, hay, and grass etc. removing dead grass for loosening the soil. Improved rake was tested and used by women farmers which were involved in vegetable cultivation. Use of Improved Standing Rake reduces grip fatigue and pain in upper and lower back as it has long and comfortable grip handles so that farm women can work without bending their back. Table 7 shows that while testing this tool there was a reduction of energy expenditure, heart rate, rated perceived exertion, lowering pain in wrist, upper and lower back of farm women.

Table 7: Dimension and Impact on Ergonomic Cost of Improved Standing Rake

Dimension of improved standing rake		Impact on ergonomic cost	
		Ergonomic Parameters	Percentage Reduction in Ergonomic Cost while using improved Standing Rake
Total Length	107.5 cm	Heart Rate (b/min)	7.56
Length of the Blade	14.5 cm	Energy Expenditure (Kj/min)	8.77
Breadth of blade	19.5 cm	Rated Perceived Exertion	26.19
Length of the Grip Handle	14 cm	Wrist Pain	9.67
Material of Blade & handle	Iron	Upper Back Pain	24.88
Material of grip handle	Plastic	Lower Back Pain	20.51
Cost	Rs.210/-	-	-

3.8 Improved Standing Pick Axe: (Tested by CCS, CAU, Tura)

Standing pick axe mainly used for breaking of hard surface like concrete and rocks or dry hardened earth while standing. It is women user friendly tool with a comfortable grip handle. Adopted pick axe was one side pointed blade and other side flat blade which can be used for breaking rocks, digging hardened surface easily. After analysis of the data it can be showed that farm women reduces their heart rate, energy expenditure as well as decreases pain in upper and lower back of their body while using this type of improved tool (Table 8). G. Nirmala Devi *et al*. In the 2019 [11] revealed that the women suffered from pain and discomfort more in lower back, upper back and feet due to manual transplanting method, however, the pain was reduced when the activity was performed with improved easy transplanted in standing position.

Table 8: Dimension and Impact on Ergonomic Cost of Improved Standing Pick Axe

Dimension of improved standing pick axe		Impact on ergonomic cost	
		Ergonomic Parameters	Percentage Reduction in Ergonomic Cost while using improved Standing Pick Axe
Total Length	122 cm	Heart Rate (b/min)	10.37
Length of the Blade	11 cm	Energy Expenditure (Kj/min)	10.51
Length of the Grip Handle	8.5 cm	Rated Perceived Exertion	28.57
Material of Blade & handle	Iron	Wrist Pain	35.71
Material of grip handle	Plastic	Upper Back Pain	30.07
Cost	Rs.280/-	Lower Back Pain	12.22

Conclusion

Vegetable cultivation was more tedious, painstaking as well as drudgery prone for farm women in West Garo Hills of Meghalaya. Farm women perform various tasks in a traditional way due to lack of efficient knowledge about improved tools and technologies meant for women and also lacking of knowledge of required skill regarding cultivation. In order to secure health, safety and well being thus improving the quality of work life and achieving productivity, it is necessary that tool and technologies must be designed ergonomically which will be suitable for farm women and also awareness of it required among farm women. Use of improved tools and technologies it corrects work posture and reduces physiological cost, pain in different parts of body of the farmers. Therefore it can be concluded that ergonomically designed improved tools and technologies can be used to reduce pain, discomfort, perceived exertion and physiological cost like heart rate and energy expenditure of farm women involved in cultivation and allied activities.

Acknowledgement

This is a part of the project of AICRP-Home Science (FRM component), funded by CIWA, ICAR, Bhubaneswar.

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