Synopsis of the Thesis

ASSESSMENT OF WORK RELATED HEALTH HAZARDS OF VEGETABLE CULTIVATORS AND ERGONOMIC DESIGNING OF HAND TOOLS

By

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Introduction:

India is an agricultural-based country and agriculture plays an important role in the economic development of the country. A large number of people of different districts of West Bengal state are engaged in agriculture throughout the year. Apart from cereal production (rice, wheat, etc.) agricultural labourers are engaged in different types of vegetable cultivation. In the present investigation potato and ground nut cultivation was taken into consideration.

Potato cultivation is one of the important vegetable cultivation in India. Both male and female workers are involved in this job and expend a great extent of their physiological cost. There are different tasks in potato cultivation, which are performed in different phase viz., planting of seeds, tunneling in the potato field and harvesting of potato. The potato cultivation tasks are repetitive in nature and those are carried out mainly by manual efforts. Most of the tasks of potato cultivation performed by the cultivators are monotonous, strenuous, physiologically demanding as well as time-consuming. They have to face many job related health problems during work. In different phases of potato cultivation tasks different patterns of work are performed. Some of the activities are dominated by static muscular contractions and some other tasks involve repeated dynamic activities. Due to adopting different inappropriate postures whilst performing different potato cultivation tasks, workers are exposed to postural stress and may suffer work related musculoskeletal disorders (WRMSD) in different parts of the body. They may therefore be considered to be suitable for ergonomics intervention.

The farmers were found to use different types of conventional hand tools, viz., plough, yoke, spade, hoe, bucket etc., for performing the different tasks of potato cultivation. An important hand tools, small spade which is frequently use in potato cultivation for tunnelling operation as a part of field preparation. The design of small

spade varied from region to region. The existing small spade is designed without considering the human factors. The workers are compelled to adopt different inappropriate postures during working with this conventional hand tool. As a result they have to face different job related health problems.

The groundnut cultivation is done in different parts of India including the West Bengal state. There are different steps of groundnut cultivation. In the present study ergonomics study has been performed on one of the selected task of groundnut cultivation - the separation of groundnut pods from the plant root after harvesting. The groundnut cultivators required to separate the ground nut from the root of the plant manually by the fingers. This may leads to WRMSD in different segments of the body especially in hand-arm systems during plucking the nut. Ergonomic intervention is required in this field.

In the present investigation different human factors involved in the potato cultivation tasks have been studied. Efforts have been made to evaluate the nutritional status, work related MSDs, work-rest pattern, postural pattern, postural stress, physiological stress of the workers. Attempts had been made to redesign the small spade, one of the most important tools frequently used by the potato cultivators. Efforts had been made to design of a new hand tool, named as nut plucking tool, for separating ground nut from the root of the plant considering the ergonomic principles.

Aim and Objectives:

The main aim of the present investigation was the evaluation the occupational stresses of the cultivators engaged in different tasks of potato cultivation job and their relationship with physiological response and nutritional status. Another aim was ergonomic evaluation and redesigning of hand tools used in potato and groundnut cultivation from the viewpoint of ergonomics.

The followings are the objectives of the present investigation:

a) Evaluation of work related musculoskeletal disorders (MSDs) of potato cultivators

b) Evaluation of postural and physiological stress of potato cultivators

c) Ergonomic design of hand tools (small spade and ground nut plucking tool).

Methodology:

The present investigation was carried out on vegetable cultivators only. This study was conducted in 692 participants of whom 353 were male and 339 were female (age range of 18–60 years), selected from different villages of Midnapore (East and West), Bankura and Howrah districts of West Bengal state, India.

The socioeconomic status of workers was evaluated by modified Kuppuswami scale. Anthropometric measurements were taken from the subjects following standard technique and appropriate landmarks. Nutritional status of the participants was evaluated by 24-h recall as well as by the anthropometric method. Blood pressure and hemoglobin status were measured using standard protocols.

Occupational health problems of the participants related to the potato cultivation tasks were evaluated by modified Nordic Musculoskeletal Questionnaire method and perceived discomfort rating in different segments of the body. The work-rest patterns of potato cultivators were determined by directly observing their work as well as by taking interview of the workers. The postural pattern of the workers during performing their jobs was studied by the direct observation method employing video-photography. Working postures were evaluated by standard posture analysis tools, viz., OWAS, REBA, RULA, and QEC. The physiological stress was evaluated by working heart rate, Cardiovascular Stress Index (CSI) and blood lactate during performing different potato cultivation tasks.

For the designing the hand tools some systematic steps were followed. At first, the problems of the conventional tools were evaluated by the subjective assessment as well as by some objective measurements. After identifying the drawbacks of existing tools, design

concepts were developed to overcome the problems. According to the design concept some prototype models were made. The prototypes were tested by the psychophysical test like paired comparison test. Design of the tools was made by considering the anthropometric dimension of the users and the results of the paired comparison test. The effectiveness and acceptability of the modified design of the tools were evaluated. The tests include subjective assessment, discomfort feeling, heart rate and body joint angles.

Results and Discussions:

The result of the socioeconomic status of the cultivators was revealed that the majority of them were belonging to upper lower socioeconomic category (male: 79.61%; female: 87.32%).

From the results of nutritional status it was noted that about 42.71% male and 51.76% female were undernourished. The workers had low hemoglobin concentration and the prevalence of anaemia was 46.62% in males and 66.87% in females, which was more than the global prevalence. Most of the participants were normotensive (male: 67.61%; female: 76%). However, a notable percentage had hypertension (male: 21.86%; female: 15.27%), although the prevalence of hypotension was low (male: 10.53%; female: 8.73%).

It was revealed that the prevalence of MSDs was very high among the workers of both sexes. The lower back problem was highly prevalent (male: 93.25%; female: 92.26%) among the workers which was followed by the problems in upper back (male: 63.8%; female: 65.16%), waist (male: 60.12%; female: 57.42%), shoulder (male: 47.24%; female: 61.94%), hip (male: 44.17%; female: 55.48%) and elbow (male: 46.63%; female: 50.57%). The results indicated that the prevalence of MSDs was comparatively higher in tunnelling task compared to potato harvesting and seed planting operations. However, lower back problem was extremely prevalent in all types of tasks of potato cultivation. It has been noted that the female workers were more likely to have musculoskeletal

pain/discomfort compared to the male cultivators. The prevalence of MSDs also exhibited variation in the participants having different work experience.

The work-rest pattern showed that the total working hours was approximately 9 hours including rest pauses. From the results of postural pattern it was revealed that the predominant posture of different potato cultivation tasks were forward bending and squat sitting posture. From different posture analysis methods it was noted that the postures adopted by the workers had risk levels from 'medium' to 'very high' in different tasks of potato cultivation.

The average working heart rate was 105.33±10.77 beats/min in male and 109.97±9.94 beats/min in female and it was found that they were working at about 55% and 58% of their age-predicted maximum heart rate in male and female respectively. Among the different tasks of potato cultivation, the highest mean working heart rate was noted in tunnelling operation compared to potato harvesting and seed planting tasks. According to the classification of physical work in terms of heart rate the seed planting and potato harvesting tasks were considered as the moderate work. But tunnelling task was belonging to the heavy work category. Those workers involved in tunnelling task had a significantly higher Cardiovascular Stress Index (CSI) than that of the potato harvesting and seed planting workers. According to CSI classification, all the tasks of potato cultivation have been classified as stressful category except planting of seed in male. The higher working blood lactate level was noted in tunnelling operation (male: 3.77±0.83 mM/lit; female: 5.20±1.37 mM/lit) compared to seed planting (male: 2.54±0.3 mM/lit; female: 3.22±0.63 mM/lit) and potato harvesting tasks (male: 2.93±0.38 mM/lit; female: 3.33±1.14 mM/lit). In tunnelling operation the blood lactate level of female workers was higher than the point of onset of blood lactate accumulation (OBLA) (4.0 mM/l).

A set of hand dimensions was measured from both male and female participants to make an anthropometric database of the cultivators and those hand dimensions were used for redesigning of hand tools (spade and ground nut plucking tool) which are used in different tasks of vegetable cultivation. Fourteen hand dimensions have been identified which were considered useful for agricultural hand tool design and the measurements were taken from the participants and their percentile values were computed for male and female workers separately as well as for combined population also.

In potato cultivation, the workers are required to use a small spade for tunnelling operation. Such spade is smaller in size than the conventional standard spade. The small spade were made with conventional idea without due consideration of human factors. There were some drawbacks in the design of the small spade from the view point ergonomics. For example, the main problem of this small spade was that the handle length of the spade was short. Therefore, the workers were required to bend too much for a long time while performing tunnelling operation with this tool, which might cause biomechanical stress in different body joints and might produce different segmental pain. The workers reported pain/discomfort at different body segments, viz., lower back, upper back, finger, palm, wrist, etc., i.e., an overall discomfort was prevalent in the hand. Secondly, during summer and hot humid conditions, excessive sweating created problem of gripping the handle.

An attempt has been made to redesign the small spade considering the human factors. Different existing small spade were evaluated and their merits and demerits were identified. A modified design was made by considering several factors. The diameter of the handle of the redesigned small spade was 3.0 cm. The diameter of the handle was made considering 5^{th} percentile value of the hand grip diameter of the users which might be helpful for the proper griping of the handle. The length of the handle of the spade was

increased to about 72.5 cm from that of existing length. Such change might improve the postures of the workers when performing the spade operation. The angle between the blade and handle was increased to about 50^{o} from that of existing models. Such changes in angle might improve the biodynamic parameter of the body (e.g. body joint angles). The length and width of the blade were also increased from that of existing one for improving the surface area of the blade. The weight of the redesigned small spade was 2.0 kg. The weight of the spade was decreased from that of the existing spade. Each of the design criteria were selected by psychophysical analysis of the users employing paired comparison test. To ensure a good grip a rubber pad was pasted on the handle. The final design was settled after a lot of trials and consultations with workers. The redesigned small spade became more comfortable in handling than the existing spade. The prevalence of pain / discomfort in different segments of the body became lowered during use of the redesigned small spade than that of existing spade. The physiological strain of workers was decreased while working with the redesigned spade. There was an increase in productivity by about 11% in male and by about 9% in female workers respectively. The cost of the redesigned small spade was a little higher than existing spade. On the other hand, redesigned small spade lowered the risk of injury among workers and provides better worker comfort.

In addition to the small spade another hand tool was designed which could be used for a specific task in groundnut cultivation. The hand tool was named as groundnut plucking tool, which could be used for detaching groundnut pods from the root of the plant. In usual practice the workers were used to separate the groundnut pods from the root of the plant manually by the fingers. The workers reported discomfort/pain in different body segments, especially in the hands and arms. A large number of workers (89% of male and 92% of female) reported MSDs in finger and more than 75% of male and 80% of

female reported problems in the palm and wrist. Besides this, about 66% of male and 71% of female workers were found to have problem in the elbow joint. A nut plucking hand tool was proposed instead of manual plucking. The tool was designed by considering the human factors. The final design was settled after a lot of trials and consultations with workers. In case of designing of nut plucking tool, main emphasis was given on hand–handle interface and plucking interface. A handle was attached to the main body of the tool and to ensure a good grip a rubber pad was wrapped on the handle. The handle dimension was settled on the basis of percentile values of relevant hand dimensions and other dimensions were fixed by the results of the paired comparison test. For separating the nuts from the plant, sharp finger like projections was made in front edge of the tool. The newly designed nut plucking tool was better than that of conventional system (manual) from the view point of productivity and safety. The prevalence of pain/discomfort in different segments of the body was lower during use of the nut plucking tool than the conventional system. The physiological strain of workers was decreased while working with newly designed nut plucking tool and there was a significant increase in productivity.

Conclusion:

It was concluded that the potato cultivators had a number of musculoskeletal disorders in different segments of the body. The lower back problem was highly prevalent among the workers and it was followed by upper back, waist, shoulder, hip and elbow. The higher prevalence of work related MSDs at different body segments of the agricultural workers might be related to their postural pattern, repetitive movements as well as longer duration of exposure in awkward posture. The predominant posture of different potato cultivation tasks were forward bending and squat sitting posture. Adopting these two awkward postures during performing the tasks might be one of the possible causes of back

pain among the workers. The female workers were more prone to have MSDs than that of male workers. The female cultivators had to perform household chores including cooking in addition to the occupational work (agricultural activities), the cumulative effects of which might result a higher degree of musculoskeletal problems in comparison to male workers. The WRMSD can be reduced if the workers adopt appropriate posture, as far as practicable, during performing their jobs and follow the rules of manual material handling. The forward bend posture is a very strenuous posture. In case of tunneling task, the workers were spending more than 80% of total work time in forward bending posture. The problems will be reduced if the forward bend posture can be avoided. This may be achieved by using redesigned hand tool (small speed). The workers are required to use a small spade for tunneling operation. The length of the handle of the spade and the angle between the blade and handle were suggested to increase from the existing length. Such change may improve the postures of the workers when performing the spade operation. The musculoskeletal disorders and postural stress could be reduced by modifying the work-rest cycle. In the present study it was observed that the workers took a long duration rest (food break) for about 2½ hours. It may be more helpful if the longer continuous rest period is reduced and more number of short breaks is provided within work shift. According to their work load and energy requirement the 30-minute work and 5 minutes rest will be preferable for long durational potato cultivation jobs. Training and awareness programme are required for educating the workers about the appropriate posture for different tasks and about bad effects of inappropriate posture. Two important hand tools, viz., redesigned small spade for tunnelling operators and newly designed ground nut plucking tools for groundnut cultivators were very simple and low cost. They would be able to improve the productivity and would reduce some of health hazards of the workers. The workers should be encouraged to use the modified tools.

There are further scopes of future studies. The redesigned small spade and newly designed ground nut plucking tools were evaluated for a short period of time. They should be tested for a long time and on a large number of subjects. Efforts may be made for identifying the merits and demerits of the redesigned tools after a long-term use. Further modifications can be incorporated, if required. Efforts may also be made to redesign other tools used by the cultivators. Efforts should also be made to devise new equipment for the workers so that their postural stress could be minimized.