Chapter

A Review of Ergonomic Evaluation of Occupational Hazard of Indian Agriculture Farm and Allied Activities

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Abstract

Women in India are the major workforce in agriculture and perform almost all the agricultural activities. Women constitute 25.51% of the total work force in the country. The rural women play a vital role in agriculture and other agro based processing activities. They spent more time on post-harvest activities than those pre-harvest activities. Environmental and occupational health issues among agricultural workers expressed high levels of concern about working in hot weather, agricultural injuries, pesticides, awkward posture and drudgery prone activities. User Eco-friendly tools can increase the working efficiency and reduce the working load health hazards on farm activities during agricultural activities.

Keywords: Agriculture Activities, musculoskeletal Problem, drudgery, health, work Load, women Participation, postural discomfort

1. Introduction

Women comprise approximately 25.51% of the total work force in India as per [1], of which approximately 18.5% and 24.9% are agricultural labourers and cultivators respectively while 47.5% work in household and other important agriculture-aiding fields. Women fulfill many crucial roles in the farming sectors, all the way from being general farmers to farming-entrepreneurs [2]. It was observed that more than 75 per cent women are involved in activities like winnowing, weeding, grading, threshing and cleaning of field farm operations [3]. If women were to be given the same opportunities in utilizing resources as men, the UN Food and Agriculture Organization estimates a rise in yields by up to 30%, which could have a chain effect by which a rise in total agricultural output by 4% is predicted along with reduction of the general hunger in population by 12–17%, which is about 100 million people [4]. The participation of farm women in agricultural activities suffer both by nature wise and extent wise by multiple of things including, local dimension in nature of labor, socio-economic strata of the farm families, ancestral family customs, change in nature of activities thanks to mechanization, introduction of your time and labour saving implements and ever changing nature of agro-climatic conditions [5].

Ergonomics is a multidisciplinary science that activities to make a better fit between the work and the worker to ensure their healthiness and well-being. It emphasizes on designing and arranging things so that workers can use them easily and safely. The International Ergonomics Association [6] defined ergonomics as a science that deals with understanding the interaction between humans and other elements of a socio-technical system. Using ergonomics in agriculture helps in reducing and removing the risks involved in work, machines, vehicles and the work environment which includes tools and materials, method of work, ambient conditions, physical environment and organization of work. Ergonomics and sustainable agriculture should go hand in hand with each other. Women contribute in overall farm production--average contribution--is estimated to be in the range of 60 to 65 percent of the total labour and in certain areas, the same contribution is even higher in percentages. Unfortunately even today, agriculture related activities rank as one of the most hazardous activities as it relies mostly on manual labour and people working in the fields of agriculture are exposed to a multiple varieties of hazards that are extremely damaging to their physical condition and well-being. People from rural communities and background often lack orientation and knowledge on the health related issues that they face. Farmwomen consider pain as a traditional part of work or let us say their *Karma* and seek medical assistance when the condition becomes ruthless or disabling. This same issue carries over to preventive measures designed to reduce the incidence of musculoskeletal injuries or other hazardous work exposures [7]. It was reported by [8] that the share of women labour force in agricultural operations is expected to be 55 percent by 2025 A.D. They participate in several farm operations putting many hours of productive manual labor daily. It is duly reported [9] that women contribute to plentiful responsibilities to undertake extensive range of duties both in the home and outside but their partaking is considered insignificant by the social order. They are at length involved in a variety of farm operations like transplanting, weeding, harvesting, processing, marketing and selling of food grains, fruits and vegetables etc. These activities not only require substantial time and energy but also are the sources of tremendous amount of drudgery. Drudgery, which is largely, envisaged as physical and mental damage, anguish, repetitiveness and hardship that are experienced by farmwomen while performing these farm operations. The drudgery prone situations lead to an assortment of health and mechanical hazards, which creates physical exhaustion fatigue and low productivity.

2. Methodology

The objective of seeking for recent articles related to ergonomic evaluation of occupational hazard of Indian agriculture farm and allied activities the common search engines of Google Scholar, Scopus PubMed and Science Direct were used. Once we were identifying a study, we made a methodical survey within the web site of the journal during which the study was published with the intention of detecting further studies. All the co-authors discussed on the content of the chosen papers and a few of them were excluded, because they did not meet a minimum of one among the inclusion criteria described below. Evaluating the methodology of the selected studies is a key step in carrying out and interpreting systematic literature reviews related to objective of study. Moreover, the literatures, reports and documents associated with this study are reviewed because the references to testify the knowledge we obtained and selected up.

While collecting the data; particular attention was given to the selection of respondent on physical fitness and prevalence of any serious health hazard. The

anthropometer and weighing balance were used to measure the physical characteristics like height and weight. The grading of health status of women was done based on Body Mass Index. The BMI scores were interpreted as per the classification given by [10]. Stopwatch was used for recording the time determined for the farm women. The heart rate was recorded by using the heart rate monitor sphygmomanometer (Digital), based on the heart rate records, the following parameters were calculated. The results were statistically analyzed using test of significance (t- test at 5% level of probability) and simple regression (r) by the method proposed by [11]. For calculation of Energy Expenditure Rate from heart rate [12]. The cardiac cost of work is the total number of heart beats spent about the resting level in order to perform the work, The cardiac cost of revitalization is the total number of heart beats above the resting level occurring at the termination of work and return to the pre activity state [13].

1. Average heart rate during rest and work. Measured by (Digital) sphygmomanometer.

2. The energy expenditure per minute was estimated from the heart rate with the help of formula Energy expenditure (kJ/min) = (0.0114 x WHR – 0.68) 20.93

3. ΔHR (beats/min) = Average working heart rate – average heart rate during rest

4. Output (Kg/h) = yield/average time

5. Physiological cost reduction (%) = T^1 (ΔHR/Output) – T^2 (ΔHR/Output) x 100/ T^1

6. Cardiac cost reduction (%) = (CCW T^1- CCW T^2) x 100/ CCW T^1

The prevalence of musculoskeletal problems among agricultural workers were found using Psychophysical techniques developed by [14] 'Body Map' technique was used to determine musculoskeletal problems and Body Part Discomfort Score (BPDS) and Visual Analogue Discomfort (VAD) scale was used to assess Overall Discomfort Score (ODR) of the respondents while performing different agricultural activities. Taken as a whole, the Visual Analogue Discomfort (VAD) Scale was also employed to determine this discomfort score, which ranges from 0 to 10 for determining the level of discomfort with 10 being the highest level of while 0 indicating none. This tool emphasizes discomfort and not necessarily the pain felt. Since this method follows a ten-point scale, it is also more suitable for Indian workers due to ease of understanding. Discomfort Rating Scale 0: No discomfort 1–3: Light discomfort <3–5: Moderate discomfort <5–7: More than moderate discomfort <7–9: High discomfort <9–10: Extreme discomfort.

3. Extent of participation of women in agriculture farm and allied activities

Nature and extent of the involvement of women folk vary significantly from one region to another and even within a region. They take part largely in as many as 11 family operations out of total 17. While ploughing remains much male-dominated, women heavily involve themselves in activities like sowing/transplanting (86%), weeding (84%), storage of grains (78%), land preparation (72%), cleaning seeds for sowing (70%), gap filling (68%), manure and fertilizer application (68%),

harvesting (64%), threshing and winnowing (62%) and rat control practices (58%) [15]. For the period of peak season of agriculture especially during harvesting time, women of farm families labor on an average seven to eight hours a day in the field. This is besides their everyday duties of cooking, fetching water, cleaning etc. [16]. Women are most active in areas like fertilizing, sowing, grain cleaning, drying, etc. Women also partake in almost all aspects of animal husbandry from collecting fodder and feeding the animals to collecting milk and disposing dunk [17].

4. Ergonomic evaluation of agriculture farm and allied activities

Relationship between Anthropometric measurements of women and work efficiency in an Indian context, ergonomic point of view, average age was found 33.39 ± 7.57 years, height 154.94 ± 3.61 cm and weight 51.33 ± 4.06 kg respectively. The mean Body Mass Index (BMI) was calculated using standard formula Weight in kilograms/ (Height in meters)^2 it was 21.39 ± 1.42 which meant that they were in the normal category during groundnut shelling for energy expenditure during the shelling by decorticator calculated 9.31 kJ/min in traditional practices, while by improved practice it was 18.94 kJ/min [18]. Anthropometric parameters studied by [19] female workers of different ages to assess the work methods and postural demands during work performance to enhance the operability, safety, convenience and comfort while performing domestic and occupational tasks [20]. The study showed that Vo2 max of the chosen women folk range from 16.1 to 64.8 ml/min with a mean value of 39.89 ml/min. and half of the respondents (50%) had very good physical fitness in the range of 41–45 ml/min. According to [21], the range of average heart rate lies between 153 and 180 beats/min. Nevertheless, the amount considered as a fair amount of work when considering a large sample of cardiac responses was below 130beats/min. The rates however ranged at 153.3/min for water-lifting and 140.3/min for pedal-threshing. Relatively, the increase in uptake of oxygen to workload ranged at 5–7% per 10 beats/min increase, with oxygen-pulse ratio being at various levels 43:120, 55:130, 61:140, and 74:150 [21]. The authors go on to say that stationing the oxygen intake, 120–132 beats/min can be achieved which signifies an average workload. Overall, energy expended throughout the day amongst people working in agriculture ranged (in MJ) between 10.3 to 11.7, of this number, 5.6 to 6.6 MJ (or between 53 and 56%) was used in a work day. The time-weighted average of the entire day comes to 7.2–8.1 kg/min. This implies that the comparatively, the load amounted only to around 20.22% of maximum oxygen uptake. However, if only the energy spent in a working day is considered, the time-weighted average was between 10.9–14.6 kg/min or 30–40% of maximum oxygen uptake.

4.1 Physiological parameters and energy expenditure

Generally, pulse is employed as an ergonomic measure to gauge the physiological or functional demands of labor on the individual workers [22]. The physiological point of view, the work demand or workload refers to the stress placed on the cardio-respiratory system and is decided by the energy cost and cardiac cost of work [23]. [18] reported physiological cost of work and energy expenditure in terms of heart rate were observed to be lower while performing selected activities with groundnut decorticator when compared to the traditional practice. The average cardiac cost of labor was decreased by 83.00 per cent with the utilization of groundnut decorticator. The work output was also found higher with the improved technology [24]. The study revealed that physiological stress output recorded by improved serrated sickle was average of 51.03 m^2/h as compared to local serrated

sickle by which 37.52 m^2/h area was harvested. During harvesting with local sickle, the average ΔHR was 33.93 beats/min and energy expenditure was 12.33 kJ/s while by improved serrated sickle, it was recorded as 17.46 beats/min and 8.40 kJ/s. The average cardiac cost of work (CCW) was 55.41 beats/m^2 local sickle while 20.51 beats/m2 by improved serrated sickle. Therefore, the serrated sickle costs 35% less worker/unit of output and is 36.63% more efficient [25]. The study revealed that weeding through twin wheel hoe has proved efficient on time and output as compared with traditional Khurpi. The percentage change in average working heart rate was increased 18.88% with the use of twin wheel hoe. The output capacity was higher using twin wheel hoe (241.67 m^2/ hr) as compared to only (70.84 m^2/hr) with Khurpi; improved technologies have significantly higher work output than the traditional technology. It means that work output was near about thrice, as compared to traditional implement so working by twin wheel hoe is recommended. While performing weeding activity, average ΔHR was 10.00 beats/ min. While use of twin wheel hoe it was recorded as 27.00 beats/ min. The cardiac cost of worker was 8.00 beats/ m^2 while uses of twin wheel hoe it was 7.00 beats/ m^2. It is an accountable for energy expenditure during weeding in soybean crop and calculated energy expenditure was 7.27 kJ/min. Traditional practices, while by twin wheel hoe, it was recorded as 11.38 kJ/min and increases efficiency 247.45%.

4.2 Drudgery among rural women

Drudgery is usually conceived as physical and psychological strain, fatigue and monotony, hardship, experienced by humans. Drudgery of farm women is a crucial aspect that has attracted wide attention of researchers. If measured by the extensiveness and intensiveness of their involvement, farm women shoulder much more burden than man [26] does. Many of such activities are drudgery susceptible to varying degree. Even women suffer from different health problems, which adversely affect their working efficiency and family welfare. Women have shorter time to rest than men and environmental degradation is increasing women's work-load [27]. [28] also reported from Madhya Pradesh, India, participation of women in agriculture, India and developing countries are engaged in most of the farming and home related activities besides their exclusive involvement in domestic chores, women do the extremely tedious, time and labour intensive works. Generally, Indian women feel more work for a long time without rest and perform many roles in society and family. This drudgery or fatigue results in feeling tired, sleepiness, physical or mental stress, exhaustion and pain in body parts. So it are often said that each one the farm women suffer from the drudgery while performing various activities. [29] reported that women working in agriculture usually have to make do with archaic tools or a lack of proper tools at all which can also be unsafe, hazardous and unhealthy.

4.3 Physiological and psycho-physiological stress

While the mean average of heart rate when resting stationary remained at around 77–81 bpm, while working in the kitchen it ranged around 84–110 bpm while sitting down and 101–130 bpm while working standing up. In the kitchen, grinding turned out to be the most fatiguing work while vegetable-cutting was the friendliest for bpm [19]. Physiological stress on women while harvesting wheat activity averaged their heart rate to be around 121.5 b/min., which increased further up to 126.7 b/min. by the evening. Energy spent was also found to be 15.5 kJ/min, which further increased up to 12.3 kJ/min during evening hours [30]. It can be safely concluded that factors like bad state of workplace and lacking access to better

tools contribute towards discomfort in both healthy and unhealthy individuals. These factors also greatly impact body posture, which alters the psychological functions of a private and produces many sorts of musculoskeletal problems. Agriculture work is expected to cause muscular-skeletal problems in developing countries [31].

4.4 Postural stress and Muscular-skeletal disorders in farm women

Muscular-skeletal disorder is observed to cause occupational ill-health as a leading factor. A bad posture is often cited as a factor causing the disorder in workplaces with prominent physical labour. The cervical spine, head and shoulders, elbow and wrist joint are all the parts, which can be related in the problems of efficiency, design, and discomfort. Muscular-skeletal issues are defined as damages to one's muscles, joints, tendons, or nerves, which can be an outcome of the many physical work-related factors. Early symptoms are pain, swelling, numbness, tingling, and loss of strength and range of motion. If one does not swift, the posture to the correct one it can cause acute and chronic issues. Acute problems are severe pain, excessive circulatory stress, and fatigue which could lead to higher chances of accidents and decreased productivity. Agriculture is generally recognized as the nation's most hazardous industry that displays high rates of musculoskeletal disorders with evidence to suggest that ergonomic risk factors are involved [32]. Chronic effects may produce many injuries and disorders in the musculoskeletal units, which may result in permanent or partial disability of the affected parts depending on the degree of stress and its duration [33]. The percentage deviation in the cervical region comes to1.7percentage to 7.3% among women belonging to 21–30 years. and 31–40 years of age groups while drawing water. In the lumber region the deviation was to the extent of 10and 8.9% leading to several musculoskeletal problems both in cervical and lumbar region [34]. [30] Stated that during the harvesting of wheat, women have to work in squatting posture from morning until evening. As they harvest wheat in this inconvenient position for long duration, there are high incidences of severe low back pain and pain in knees reported by these women [35]. Found that these issues were most frequently perceived in moderate to severe capacity as pain in shoulders, upper back, arms, and lower back while performing the work of threshing. Body Part Discomfort Score (BPDS) of both men and women in agriculture revealed that it was felt most severely in weeding, then in land preparation, followed by threshing, harvesting, irrigation and use of chemicals. On average, the Overall Discomfort Rating scores indicated that all the activities were in the range of 'high discomfort' both for men and women except irrigation where it was within the range of 'moderate discomfort' and therefore the ODR of females just in case of plant protection activity was within the range of 'light discomfort' [36]. Reported Indian farm women using of improved twin-wheel hoe for weeding in soybean crop reduce drudgery with muscular stress and fatigue. The focus of the demonstration was to vary the attitude, skill and knowledge towards recommended practices within the work. Farmwomen adopted the improved technique as it had increased the efficiency to work, reduce the drudgery and helped in avoiding bending or squatting posture. It lessened the exertion and fatigue to make the farmwomen conformable. [37] also revealed that massive number of workers suffered from low back trouble (93.3%), neck trouble (86.6%), wrist trouble (80%) and shoulder trouble (75%) due to the strenuous postures adopted while performing post harvesting jobs. [38] revealed that majority (33%) of the respondents performed the activities of planting/sowing, hand weeding, cutting/plucking, sorting and cleaning in bending, sitting or squatting postures. Mean many intensity of pain felt by respondents in several body parts different body parts revealed that respondents

felt very mild (score-1) to very severe pain (score-5) in various body parts thanks to working in awkward postures for long durations. Hand weeding and cleaning of vegetables were rated as very demanding (mean score- 4.6); and planting/sowing, hand weeding and cleaning activities were very exhausting (mean score- 4.7, 4.6 and 4.8 respectively). Respondents adopted very difficult posture while planting/sowing; hand weeding, cutting/plucking and cleaning (mean score- 4.7, 4.6, 4.7 and 4.8 respectively). Planting/sowing and cutting/plucking were very painful activities (mean score 4.6); cutting/plucking was perceived as very heavy activity (mean score 4.6).

[39] concluded that both proper standing and bent posture were used by most farm-women while carrying out various activities like cutting (89%), threshing (37%) storage (45%), and Sun drying of grains (56%) respectively. While sowing (57%) and preparing land for threshing (74%), both squatting and bending posture had to be used while only bending posture was used or uprooting of seedlings (95%) and transplanting (96%). Most women used sitting posture for winnowing (92%), sieving (95%) and cleaning (96%). According to [40], women experienced severe to very severe pain in shoulder, upper arm, low back wrist/hands and knees while topdressing fertilizers using the traditional method instead of improved modern ones. The girls using modern methods to when fertilizing the farms showed a significant decline in experiencing pain (91.42%). Therefore most women experience moderate severe to severe pain in neck, shoulder, lower back, upper leg, calf muscles, wrist and ankle while working in agriculture.

4.5 Improved techniques and technologies on drudgery of women

Women in agriculture point to the fact that women are generally employed in the operations, which are either not mechanized or least mechanized and involve a lot of drudgery [41]. According to [42] the average physical cost of labour was less using the chaff cutter, sickle, Bhindi Plucker, seed treatment drum, weeder and groundnut stripper. Using Shovel, paddy thresher and wheelbarrow technologies, there was observed an increase in labour cost compared to old techniques. Work output saw rose with these modern methods except in the case of chaff cutter and seed treatment drum. Women generally had a positive response to using these methods as well. [18] reported use of groundnut decorticator reduced drudgery 84.26 per cent and it also saves time by 96.00 per cent in comparison to traditional practice. [43] study on drudgery reducing farm implements operated by women liked improved sickle and tubular maize cob sheller were carried results revealed that, 75% perceived the sickle as profitable (78.33%), compatible (76.77%), triable (75%) and observable (73.33%). Regarding the utilization of tubular maize cob sheller, 61.67% perceived the unit as profitable, compatible (73.33%), neither simple nor complex (58.33%), triable (66.67%) and observable (58.33%). Both sickle and tubular maize cob sheller were most feasible by majority of the farm women. Improved farm equipment that are women friendly are better in every respect in harvesting the crop. [44] Reported use of Naveen sickle, is best than the local sickle. It cover more area in given time, minimizes the drudgery and therefore the perceived exertion was low. It saves time and money expenditure on labour. It is very easy to handle and body problems are less.

As per [45], women participated most heavily in works such as seed treatment, transplantation, raising nursery, weeding, pruning, grain storage, manual harvesting, picking of vegetables, collection of animal dung and its transportation to fields. The knowledge level of participants about drudgery reducing implements

was almost nil. After being trained, the women showed a 74.6% increase in level of knowledge about drudgery reduction. Saving time thus also lead them to make time to resting and take care of households. [46] reported hexagonal tubular maize Sheller saves almost half the time and increases working efficiency 30.25 per cent and reduces 70.60 per cent drudgery of farm women over traditional practice. It is also seen that maize sheller saves time by 23.78% as compared to traditional practice. [47] another study on hexagonal tubular maize sheller increased working efficiency 79.24 per cent and reduces 87.94 per cent drudgery of farm women over traditional practice. The cleaning efficiency was also increased 6.6% while using hexagonal tubular maize sheller. [25] revealed that drudgery was reduced 70. 21% when twin wheel hoe is used in weeding, it also reduce physiological cost, 21.42%, saves time 71.20% compared to traditional practice (Khurpi) while weeding in soybean crop.

4.6 Perception of Workload of agriculture activities

Physiological cost of operation is influenced by the health of operators, nutrition, basal rate and energy expended while working which will be indirectly measured by measuring oxygen consumption and pulse. Generally, person's subjective experience of a specific workload or rate of labor is more closely associated with pulse than to oxygen consumption during the performance of labor. Therefore, several research workers [48–52] have used pulse for assessment of physiological workload of the workers. [22] Indicated that farm women perceived significantly lowered exertion while performing the chosen farm activities with the improved tools compared to the utilization of traditional tools. According to this study [53], the impact of drudgery on women is that many respondents suffer from heavy physical strain and physical stress due to work overload i.e. 88.34 percent and 98.34 percent in Tarai and hill area. In addition, fewer respondents have the problem related with incidence of miscarriage i.e. 10 and 12 percent in Tarai and hill.

4.7 Perceived health hazards problems faced by farm workers

Occupational hazard constitutes a serious source of morbidity and mortality among all workers [54]. The occupational hazard could also be mainly thanks to two reasons i.e. the utilization of harmful chemicals in farming and biomechanical and posture demand of their health [55]. [56] also observed that farm women worked constantly in awkward postures during different agricultural activities then they suffered from discomfort in various parts of their body. [57] reported for occupational hazard among farm women were majority 65.00 per cent reported injury while harvesting followed by 33.33 per cent while weeding and 25.00 per cent while cleaning land. Joint problem was reported by 89.16 per cent farm women in wrist, 88.33 per cent in knee, back bone and shoulder, 75.00 per cent in neck and 73.33 per cent in elbow. Majority of farm women reported physical problems like body pain (95.83 per cent), tiredness (92.50 per cent) and physical stress (90.83 per cent) while transplanting. Farm women also reported impact of disease of the skin during farm activities i.e. heat stroke (84.16 per cent), heat prostration (68.33 per cent) and mycosis and allergy (23.33 per cent). [46] reported hexagonal tubular maize sheller shows easy in operation no muscle strain, low cardiac cost, less energy expenditure while using traditional practice. [25] revealed that Twin wheel hoe was user friendly tool can help to reduce the environmental an occupational health hazards of farm activity and also improved the work efficiency of workers during agriculture activities.

5. Conclusions

In this chapter, we shed light on farm women engaged in more time on post-harvest activities than those pre-harvest activities. Environmental and occupational health issues among agricultural workers expressed high levels of concern about working in warm weather, agricultural injuries, pesticides, awkward posture and drudgery prone activities. Improved drudgery agriculture tools saves time and money spend on labour, minimizes body muscular problems and it is very easy to handle. The probabilities of the injury are eliminated and it is safe to use thanks to its better construction and low cost effecting harvesting tool. This advanced technology might be adopted by the farm women. We still have an extended thanks to make a secure agricultural environment more efforts are needed for getting to availability of eco-friendly tools to finish users and thus, more emphasis on focusing ergonomists, agriculture experts, tool designers and organizations concerned with occupational health hazards.

Conflict of interest

The authors declare no conflict of interest.

Author statement

All authors read, reviewed, agree and approved the final manuscript.

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