Review of Literature

CHAPTER II

REVIEW OF LITERATURE

This chapter presents the literature relevant to the topic, which helps the investigator to give a clear and better picture of what has been done and what needs to be done. Therefore it helps the investigator in bridging the research gap. In order to make the presentation meaningful, it is divided in to following sub headings

2.1. Organic Farming
2.2. Participation of Woman in various Agricultural activities
2.3. Anthropometric Measurements
2.4. Physiological cost of work in terms of:
   - Heart rate
   - Energy Expenditure
   - Postural stress
   - Muscular stress
2.5. Ergonomics assessment of Agricultural Technologies/ tools
2.6. Body discomfort/ occupational health hazards experiences by woman Farmers

2.1 Organic Farming

Practicing Organic agriculture is managing the agro-ecosystem as an autonomous system, based on the primary production capacity of the soil under the local condition. Organic refers to the agricultural systems used to produce food and fiber. Organic farming systems do not use toxic chemical pesticides or fertilizers. Instead, they are based on the development of biological diversity and the maintenance and replenishment of soil fertility. Organic foods are minimally processed to maintain the integrity of the food without artificial ingredients, preservation, or irradiation. Organic farming describes two major aspects of alternative agriculture:

1. The substitution of manures and other organic matter for inorganic fertilizers.
2. The use of biological pest control instead of chemical pest control.

Organic farming is the pathway the leads use to live in harmony with nature. Organic farming is the key to a sound development and a sustainable environment. It minimizes environmental pollution and the use of non-renewable natural resources. It conserves soil fertility and soil erosion through implementation of appropriate conservation principles. Several reasons have been emphasized for the need of organic farming, like limited land holdings poor socio-economic condition of farmers, rise in input cost etc. The broadest view shows two major reasons viz, population and environment, emphasized the ultimate need for eco friendly technologies.

Organic farming is a production system, which avoids or largely excludes the use of inorganic fertilizers, pesticides, growth regulators and livestock feed-additives. To the maximum extent feasible, organic farming system rely on crop rotations, crop residues, animal manures, legumes, green manures, off farm organic wastes and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests.

Long-term use of chemicals fertilizers has resulted in declining crop productivity and depletion of soil fertility in intensive rice-wheat cropping. Use of organic manures like sesbania green manure and recycling of farm manures on the other hand show promise in sustaining high crop productivity and soil fertility. Sesbania green manure alone but with P.K. and Zn application, appears capable of production and sustaining rice yield about 6-7 tons per hectare. Numerous long-term studies show that imbalance caused by chemical fertilizers is not noticed with organic manure additions. The yield decline in crops due to nutrient imbalance under intensive cropping have been found to be averted by FYM (Farm Yard Manure) additions over NPK (Nitrogen, Phosphorus, Potassium), (Nambiar and Ghosh, 1984; Morris and Meelu, 1985)

Henning et al (1990) report that there is evidence that credit agencies are reluctant to finance organic farmers largely because of their small size vis-a-vis the size of credit agencies regular clients and because of the agency's poor understanding of how organic farming system work.

According to Lampkin (1990) organic farming is production systems, which avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators, live stocks feed activities. Organic farming systems rely on crop rotation, crop residues, animal manures, legumes, green manures, off farm organic wastes and aspects of biological pest control to maintain soil productivity, to supply plant nutrients, to control insects weeds and other pests.

A self-sustaining system of agriculture like organic farming may offer solution to many sustainability problems affliciting Indian agriculture today. By following chemical based energy intensive agriculture, India could achieve self-sufficiency in food production but decline in crop productivity, emergence of new nutrient disorders diversity, susceptibility to new pest and pathogens, human health hazards etc., altogether, have created a spectre of unstainability. In Punjab, the shift to commercialised inputs (exotic seeds, water, pesticides and other chemical etc.) as a mode of augmenting agriculture productivity had resulted in peasant pauperization, ecological degradation and increasing centralization. (Shiva, 1991).

According to Modgal (1995) organic farming is more efficient than conventional agriculture. Conventional agriculture would always be more energy intensive than biological agriculture. Biological agriculture as a potential agriculture for the future depends largely upon its ability to produce enough food to feed the world. If an extensive research effort is applied to biological agriculture development, it may have enormous potential for food production while remaining an environmentally benign system with relatively low energy and resource requirements. Numerous long-term studies have shown that imbalance caused by chemical fertilizers is not noticed with organic manure additions. China has reached its present stage of agriculture development thought the recycling of organic wastes which account for two-third of its soil nutrient supply. Long term soil fertility management studies at Pantnagar have also clearly revealed that addition of farm yard manure at the rate 5 tons per hectare or sesbania green manure to rice, over and above the recommend dose of NPK applied to rice and wheat in the sequence, produced an additional yield of 5 to 10 quintals per hectare of both of these crops which was attributed to improved micro-nutrient supply to crops, and better soil environment. If human society had to endure, not just for another century but also for thousands of years, we need to learn a way of life that can be sustained. Efficient technologies producing little harmful waste are the need of the hour. We must learn to rely on renewable resources. The contamination of surface and ground water occur though excessive inorganic fertilizer application. The contamination of food by pesticides leads to poisonous effect on human beings. The "Green Effect" or the heating of earth is also caused by the large-scale modern agriculture. All these factors have brought the mankind on the brink of ecological disaster. Another certainty is that during our lifetime, vast and unforeseeable changes will take place. What is also certain is that burgeoning human population. Learning was to better treat our mother earth and not to rival nature but to cooperate with it and live in harmony, have been emphasized.

According to Singh and Singh (1995) tribal agriculture before contact with civilization was the true form of organic agriculture. After contact with different agencies their agriculture practices have changed considerably however, many examples are still found where a limited land is used for crop production on a sustainable basis with environmental protection. One such type of cultivation is practiced by Angami Nagas. Angami is one out of the fourteen major tribes of Nagaland, which inhabits Kochima district. Here farmers have comparatively smaller land areas with them on steep slopes to feed the village population throughout the year. To get the supply of food, to maintain fertility of soil and to save land from erosion, farmers grow older trees (Alnus nepalensis) across the slopes. Cultural practices for field crops get timely supply of nutrients giving regular food supply and trees grow without affecting the main crop and give a supply of timber and fuel wood. Angamis in this system do not need to use any fertilizer or manufactured chemical and their practices are centuries old giving them a regular food supply, maintain fertility of the fields and protect soil, which otherwise is very much vulnerable to erosion. The case study may be treated as an example of organic farming ensuring food supply in difficult field situation.

According to Chander (1996) some of the hindrances to promotion of organic agriculture in developing countries are lack of documentation or organic farming packages of practices, poorly equipped extension personnel on sustainable organic agriculture practices, lack of governmental support, near absence of organic certification agencies within the countries, poor market infrastructure for organic products, poor products consumer awareness of organic farming and marketing practices, lack of education and training facilities an organic farming.

By recycling of all the available organic wastes, China has been able to grow crops on sustainable basis for decades with no micronutrient problem and has provided hygienic health environment to her people (FAO 1977). Recycling of organic wastes on agriculture is amazingly on massive scale. To the Chinese, there is nothing like wastes; waste is only a misplaced resource, which can become a valuable material for another product (FAO 1977). This way of looking upon waste is one of the guiding principles of China's traditional concepts of the multipurpose use of resources and the recovery and re-use of waste material. Since liberation, the country has been aiming at transforming waste into wealth and the protection of social and physical environment and thus of human health. It is also viewed as essential for social development by changing the traditional division of labour and the specialization of work. Every manurial resource is carefully collected, conserved and used on the land so eventually helping to maintain soil productivity in a system of intensive cultivation and acting as a buffer against shortage of mineral fertilizer.

Table 2.1: Rates of Organic Manures commonly Used in China (FAO, 1977)

CROP	RATE (t/ha)
Rice I Crop	60-70
Rice II Crop	60-70
Wheat	75-100
Maize	75-90
Soyabean	30-45
Cotton	70-75
Sugarcane (1st Crop)	75-135
Sugarcane (Ratoon)	75-135 + mud @ 65 t/ ha

According to IFOAM India (1996) conventional farming as a system depends upon the inputs of artificial fertilizers or chemicals and pesticides or in other words it is not in conformity with basic standards of organic production.

According to WHO estimate there is about one million poisoning due to pesticides yearly with about 20,000 deaths and about 80 percent of poisoning occur in developing countries, though they account for less than 25 percent of pesticides used (Watts and Macfarlane, 1997).

A fields experiment was conducted By Chithra (2000) for two seasons; to study the direct and residual effect of various organic wastes on the nutrient availability and yield of rice under Thamirabarani river basin. The treatment were FYM, composed coir pith, composed sugarcane trash, raw sugarcane trash, green leaf manure (GLM) with different levels of fertilizers viz., 0, 50, 75 and 100 kg/ ha. Cropping sequence followed was direct crop of rice in kharif and residual crop in rabi season. All the treatment significantly increases the yield of rice followed by residual crop over control. The treatment green leaf manure plus 50 kg N/ha was the best for increasing the yields of both direct and residual crop of rice. The organic wastes viz, GLM, pressured and composted coirpith increased the status of available N, P and K of soil respectively.

A field experiment was conducted By Appauu and Saravanan (2001) to study the effect of organic manure application on soil physical prosperities at the harvest of the sorghum crop and its residual effect on the succeeding crop of soybean. The residual effect was studied in combination with tillage treatment is, that the addition of organic manures to the first crop especially poultry manure and farm yard manure increased the yield besides improving the physical properties of soil and organic carbon status. The residual effect of organic manures was well pronounced in soybean yield. Though the improvement in soil physical properties as influenced by different organic manures did not significantly vary among themselves, the physical fertility increased marked over control. Disc ploughing and stubble management without irrigation enhanced the total porosity and hydraulic conductivity of the soil significantly.

According to Sharma (2001) the high cost of certification is a problem of organic farming of the developing countries. Few developing countries have certification agencies with in their borders and even when sufficient resources are available to pay for certification, farmers often lack the information to find credible inspector.

Singh (2001) reported that the factors that have contributed to the lack of development of organic market in India include low awareness about the perils of chemically farmed products, high prices of organic products, lack of consumer confidence in organic food standards and erratic supply.

2.2 Participation of Women in Various Agriculture Activities

Women in rural India play a major role in shaping the country's economy through their active participation in agriculture. At present, the women work force in agriculture and allied sectors is estimated at about 61 million which amounts to about 30% of the total rural workers in the country. (Gite, 2002) They participate in different crop production and food processing operations including storage, packing, transport and marketing. Most of the work related to management of cattle and other farm animals is done by women besides burden of household management. Studies have shown that the Indian women work for about 14-16 hours a day to carry out the most arduous activities on farm and at home. Though modernization of agriculture is taking place at a rapid pace jobs attend by women more or less remained the same.

The rural women are usually employed in arduous field operations like sowing behind plough, transplanting, weeding, inter-culture, harvesting, threshing and agro-processing. The activities in agro-processing involve cleaning / grading, drying, parboiling, milling, grinding, decortication and storage. Women workers are also preferred in commercial agriculture like tea, coffee, tobacco and plantation crops. Bidi making, jute retting, lac cultivation, processing and lac products preparation, cotton picking, sugarcane cleaning, threshing, spices picking, cleaning and processing are also largely performed by women. For some of these operations, hand tools and equipment are available. Other operations are carried out by women workers using their hands/feet.

Chaudhary and Sharma (1961) conducted a study in Kanjhawala block of Delhi territory and found that women participated in manuring, weeding, hoeing, harvesting, threshing, and sugarcane production along with men folk. As compared to joint families, the female in the nuclear families made maximum contribution of workday to the agricultural production activities. The study further revealed that proportion of the female labour in agriculture was greater than that of males.

Singh (1968) studied the participation of rural women in agricultural operations in the NES block of Jabalpur and revealed that a comparatively large proportion of women participated in seed storage, winnowing, harvesting and care of animals. It was observed that women belonging to the middle age group having frequent urban contacts and with formal education, coming from lower castes and possessing small land-holding participated in agricultural operations in larger proportion than others. Social participation did not affect participation in agricultural operations.

Boserup (1970) discussed as to what happens to women, as socially and economically productive members of society, when a nation begins to modernize its agricultural and urban life. Her analysis of farming system in Africa (and of a few systems in Asia and Latin America) indicated that development frequently causes a decline in the productivity and status of women. Man have come to monopolise new agricultural methods and use them for cash crops while women who have not been encouraged to go to school or given the chance for agriculture course or extension service, continue to use traditional method for food crops.

A field survey done by Badran (1972) ın Egypt indicated that 44 percent of adult rural females were involved in production, which was approximately half the proportion of rural males. Rural housewife frequently undertakes fieldwork, food processing, animal husbandry, cutting, weeding and carrying of fertilizer.

In a study on the role of women in agricultural operations Devdas et al (1972) reported that women participated in sowing, harvesting, threshing, transplanting, seedlings, storing the grains, winnowing, preparing seed – beds, picking the cotton pads, shelling the pads, threshing, searing the birds, caring for cattle, milking and application of fertilizers.

Abbott (1975) observed that in Kenya women have traditionally done most of the subsistence farming and today they continue to do the subsistence farming as well as carrying the burden of most of the cash cropping including care of cows, a job formerly the exclusive domain of men. Women are primary farm managers and farm labourers in rural Kenya, not the men.

Chakravarty (1975) conducted a study in same villages of Rohtak district of Haryana and revealed that an active farm women spend 8 to 9 hours on the farm during the peak agricultural season, 3 to 4 hours of taking care of the cattle and 3 to 4 hours in other household chares. They participated in most of the agricultural operations like sowing of seeds, transplanting, weeding, harvesting, preparation of compost and manure pits, application of manures and storage of seeds and food grains.

Chatterjee (1975) found that in the operations like sowing, irrigation, transplantation etc., male labourers were generally employed, and the harvesting and post-harvesting operations offered the greatest employment opportunities to all the casual male, female, and child labourers in Bihar.

Okla and Makey (1975) used survey data from an old cocoa growing area, to compare the position of men and women in agricultural sector and pinpointed the importance of women between 25-44 years in the total populations, in the labour-force and in agricultural occupation; it was observed that women are more likely to assist on farms than to own them.

Kabir et. al. (1976) analyzed that women in Bangladesh undertake seed preservation and storage, vegetable and fruit sowing, poultry raising livestock care, food processing, food preservation, household manufacture and fuel gathering.

Verma (1978) reported that women's main means of production is their own body, and their hands for performing most of the agriculture operations like sowing, transplanting, weeding, harvesting, threshing and winnowing.

Chaney et. al. (1981) argued that women are playing important role in crop production, storage, processing and off farm activities but their access to land agricultural extension and non-agricultural employment continues to be limited.

Dhillon (1981) while studying the changing role of rural women in Ludhiana district of Punjab found that women's work in the household registered little change. Their contribution to agriculture was declining, as they were unable to cope with the technological advancement. They continued doing certain monotonous chores of farm work associated with harvesting and processing of food grains.

Jately (1981) analyzed the impact of planned social change and modernization on women in a study of the most developed village of one of the progressive districts of western Uttar Pradesh. She observed that women are increasingly participating in modern agriculture for reducing costs. Increasing wealth has led to an expansion in livestock and since women are responsible for caring cattle, this lead to an increase in their work load. Increasing commercialization of agriculture and dairying has led to concentration income in the hands of men.

Saikai and Gogai (1981) reported that number of female workers in Assam villages is higher than the census estimate and the type of jobs done by women are uprooting of seedlings, transplanting, harvesting and threshing of paddy besides their day-to-day household work.

Spencer (1981) on the basis of series of detailed surveys of both farm and non farm household in Siera Leone, indicated that women play an important role in agriculture and contribute at least 40 percent of the total labour input it was observed that agricultural development projects which stress mechanization tend to have an adverse effect on the female work load as they increase the amount of land available for planting, weeding and harvesting which are the women's primary function in agriculture.

Agrawal (1983) revealed that in rice system women supply on an average 70- 80 percent of labour for transplanting, 70-85 percent for weeding, over 60 percent for harvesting. They do all the husking and have important roles in seed selection and storage.

Mukhopadhyay (1984) on the basis of studies in six West Bengal villages, reported overall labour force participation rates of 84 percent for men and 10 percent for women. The main agricultural activities absorbing female labour were transplanting, weeding, and processing storage and supervision.

The study revealed that although female participation in traditionally defined economic activities was low, women's total hours of work including work within the household were marginally higher than for men.

All India Co-ordinate Research project in Home-science (1985) studied the time disposition pattern of rural women in three districts of Haryana and revealed that on an average a rural home maker spent 15 hours 46 minutes per day in various household activities including animal care. Regarding participation of rural women in farm related activities it was found that planting activities viz. raising of nursery, ploughing, tilling and sowing were male jobs while crop care activities viz, weeding, hoeing, pruning etc., were mainly performed by females alone in Jind and Hisar District, where as, in Ambala these were male jobs. Irrigation, fertilizer application and plant protection were male dominant jobs while there was joint involvement of both male and females in harvesting and post –harvesting activities.

Srivastava (1985) conducted a study on drudgery faced by women farmers in various agriculture activities. Findings of the study showed that women in agriculture involved in repetitive and monotonous jobs. They performed transplanting of paddy for long hours in a standing cum bending posture. Tools used for harvesting was traditional sickle. Winnowing was another monotonous and time-consuming operation, which was, performed by women farmers.

Another interesting study entitles "Women in agriculture" was conducted by Gandhi (1986). The findings showed that activities such as transplanting of crops and harvesting were women dominated activities.

Pandey at al (1986) examined the crop-wise as well as operation-wise participation of women in agriculture in Hisar District and indicated that cotton, paddy, wheat and rabi fodder were the major crops to absorb the female labour. The female labour was more employed for operations such as weeding and hoeing, harvesting picking, threshing and winnowing. Size of operational holding and percentage of cash crop to the total cropped area were positively and significantly related with the rural women's employment.

Kaur (1988) in Haryana reported that women spent maximum time in harvesting in both the seasons (141. 15 hours in kahrif and 100.18 hours in Rabi Season) on weeding (109.07 hours) threshing (37.64 hours), post harvesting activities (36.22 hours) in kharif season and weeding (44.02 hours) threshing (54.61 hours) and post harvesting activities (38.17 hours) in rabi season.

Sen (1986) conducted a study with the objectives of studying the participation of women in agriculture in India. The findings showed that women farmers were mainly occupied in transplanting, weeding harvesting and post harvest operations.

An attempt was made by Sinha and Verma (1988) to identify the drudgery index of some major agriculture operations performed by women farmers finding of the study revealed that pesticide dusting was considered to be highest drudgery prone activity followed by harvesting, carrying load on head, spade work in field, irrigating, seeding by khurpi, weeding by kasola, transplanting, sowing behind plough. It was also found that drudgery load of women was more than that of man in wheat and paddy crops because women spend more hours than men, and women oriented tasks were monotonous and repetitive.

Sikka and Swaroop (1990) studied in involvement of women in farm and non-farm activities. Females contributed 22.60 percent time in cattle management, 45.00 percent time to farm activities like weeding hoeing and harvesting. The per day utilization in farm activities showed that on an average female spent 3 –10 hours.

According to Grover and Verma (1993) in animal husbandry the maximum time spent by the women is in fodder collection, feed preparation, while in farm activities their maximum time was spent in harvesting, threshing and storage activities.

Sumal (1993) observed that women generally work more than fifteen hours a day attending to the agriculture system like collection of fuel. Fodder and water as well as weeding and animal husbandry.

These findings with slight variation have been supported by Verma and Malik (1984); Munjal (1984), Kaur (1988), Ahuja(1984), Sharma (1977) women belonged to low socio-economic status spent maximum time in farm related activities, Devi (1986).

AICRP (2001) reported that women are vital and productive workers in the Indian economy. Nearly 84 percent of all economically active women in India are engaged in agricultural and allied activities. Agriculture employs four fifth of all economically active women; they constitute one third of the agriculture labour force and 48 percents of self employed farmers. There are 75 million women against 15 million men in dairying and those engaged in animal husbandry, accounts for 20 millions as data has suggested that increasing numbers of adult women in India are not simply "Housewives" but are in fact "farmers". Thus work-role profile of Indian farm women is that they put in 14 to 18 hours of manual work daily on farming operation livestock raising, collection and carrying fodder, fuel and drinking water from distant places. They use conventional tools, which have little efficiency and face drudgery while working in the field or in the home.

Women play a major role in decision-making process in traditional agriculture, but they are virtually not recognized as producers within their own right. At present, the women work force in agriculture and allied sectors is estimated at about 61 million, which amounts to about 30% of the total rural workers in the country. They participate in different crop production and food processing operations including storage, packing, transport and marketing. Women do most of the work related to management of cattle and to the farm animals. They also carry the burden of household work and management studies have shown that the Indian women work for about 14 –1 6 hours a day to carry out the most arduous activities on farm and at home. Though modernization of agriculture is taking place at a rapid pace, jobs attended by women more or less remained the same (Singh and Gite 2001).

According to Sharma (2004), the world around is primarily the women who manage home and perform productive activities. And the innumerable productive activities carried out by women within the household sector are of critical importance for society's survival, growth and development. Since women's contribution in economic development is vital, there is need of proportionate increase of her involvement in decision process, because the success of any production and progress depends upon the plans made and decision taken. Women's active involvement in decisions making is considered essential for rapid economic development of the country.

The current global attempt on the relationship between women's position and participation in the process of management has so far tended to suggest that majority of women in developing countries remain isolated from economic decisions. Rural women share abundant responsibilities and perform a wide spectrum of duties at home and farm. But in spite of discharging all these duties her involvement in decision process is low.

Women are an integral and crucial part of agricultural system, but they do not have access to new technology that could save them from tremendous amount of time and backbreaking labour. The amount of farm work falling into women's hand has therefore increased. They constitute the back bone of the Himalayan economic system as hill agriculture is absolutely depending on them. The time has over come when we have realize the importance of experimental design and ergonomic practices in agriculture system. Need is to undertake efforts in this direction.

According to Vats (2004) hill women have to perform a large number of duties in running a family, attending to domestic animals and extending a helping hand in various farm operations. Present study attempts to highlight the role preferences in agricultural and household activities in hilly areas. Study indicate that dairying, fuel and fodder collection, sowing, weeding hoeing, harvesting and grain storage are the most preferred works of women. Preparation of land, fertilizer application, irrigation, plant protection measures and marketing are the area where they are not much involved.

Anthropmetric Measurements

Bone, muscle and other minute detailed dimensions of the anatomy are mostly referred to for medical and other necessities. But even while designing products for human use, the external body dimensions are of important and the anthropometry has to be considered. While designing individual items or products. One has to take into consideration the dimensions of the product / items, their layout pattern in a given space, the ease of reach, their use, etc. to match with the anthropometry of the users.

Anthropometry is the subject which deals with the measurements of the human external body dimensions in static and dynamic conditions. These include measurements of body parts, their strength, speed and their ranges of motion. (Chakrabarti, 1997).

Age, Sex, race, geographical regions, even different occupations all influence human body dimensions. Accurate dimensions of clothing and personal equipment used by persons, e.g. headgear, footwear, spectacles lifesaving and support equipment would be of great value because human functional dimensions and the range of movements possible demand that appropriate allowances should be made when specific designs are developed. From time to time, anthropometric data are generated from amongst various populations in different countries and are used as ready reference on Indian design practice.

These studies are related to definition of anthropometric measurements. Croney (1980) and Phesant (1982) have expressed that the design of the work place needs to be based on the anthropometry of the users. The anthropometric characteristics of any population are dependent variables. The authors have commented on the effects of such variables on body measurements. Therefore it is important to emphasize the differences between designing for a specific group and for the general population.

According to the third National Health and Nutrition Examination survey (NHANES III, 1988 – 94) collected data to identify differences in various physical body measurements between occupation group (Us Department of Health and Human Services (DHHS) 1996a). The study utilized these body measurements to investigate anthropometric difference among occupational subgroups. The description and definition of body measurements analyzed are listed in table 2.2.(Cited in Hsiao et. Al., 2002)

Table 2.2: Description and Definitions of Body Measurements (US DHHS 1996)

Description	Definition
Stature (cm)	Distance from the bottom of the feet (heels together and toes angled at 90°C) to the top of the head (positioned in Frankert horizontal plane) with the hair compresses, as measured by a fixed stadiometer with a vertical backboard with the subject standing upright, feet flat and heels, bullocks, scapula and back of head contacting vertical board
Weight (kg)	Body weight of the subject wearing only underwear and paper examination gown as measured by an electronic load cell scale.
Sitting height (cm)	Measurement from the buttocks to the top of the head (placed in Frankfort plane) with the hair compressed, as measured by a fixed stadiometer with the subject sitting upright on a box.
Upper arm length (cm)	Distance from the upper most edge of the posterior border of acromion process of the right scapula to the tip of the olecranon process of the elbow as measured by a metal tape placed down the middle line of the posterior of the arm.
Bi–acromial breadth (cm)	Distance as measured with a sliding caliper between the lateral borders of the acromial processes.
Bi–iliac breadth (cm)	Distance as measured with a sliding caliper between the lateral borders of the acromial processes
Elbow breadth (cm)	Distance as measured with a sliding caliper between the epicondyles of the humerus.
Wrist breadth (cm)	Distance as measured with a sliding caliper between the most prominent aspects of the styloid processes of the ulna and radius.
Arm Circumference (cm)	Circumference of the arm as measured by a metal tape placed at the midpoint of the upper arm length.
Waist Circumference (cm)	Circumference of the waist as measured by a metal tape placed in the horizontal plane at the upper most lateral border of the right ileum.
Buttock Circumference (cm)	Circumference as measured by a metal tape placed in the horizontal plane at the maximum protuberance of the buttocks.
Thigh Circumference (cm)	Circumference of the thigh as measured by a metal tape placed in the horizontal plane at the midpoint of the upper leg length.
Upper Leg length (cm)	Measurement from the inguinal crease of the anterior superior iliac spine to the proximal patella, as measured by a metal tape extended along the anterior midline of the thigh

Source: Hasio et.al.(2002)Anthropometric difference among occupational group.Ergonomic, Vol 45(2)136-152

These studies are related to methodology of anthropometry

Grediczka (1977) listed various ways of formulating. The anthropometric data for the use of designers.

They are:

1) Typical measurements of the static human body.
2) The ranges of movement presented within 2 or 3 planes.
3) Pictorial form representation of anthropometric data of the operator and the dimension of device together.
4) Direct recommendations without a picture of man.
5) Information on the spatial parameters of the operator without the figure of a man beside a machine.

Further, the author has opined that placing controls outside the maximum reach of the operator necessitates the performance of task with a difficult movement and in a strained working position.

Although there is no systematic procedure for translating static anthropometric data into dynamic measurements, Kroemer (1983) has set some rules of thumb which are as follows:
Heights (stature, eye, shoulder lip): reduce by 3 percent.
Elbow height: no change, or increase by up to 5 percent if elevated at work.
Knee or popliteal height, sitting: no change except with high – heel shoes.
Forward and lateral reaches: - decrease by 30 percent for convenience, increase by 20 percent for extensive shoulder and truck motions.

According to Chakrobarti (1997) The relevant anthropometric supports along with the intended user's behavioral pattern, should be seen together while designing. To make an article of the correct size, to create a system of multiple units and a work space, or to design an article for a single individual's need, the individuals own dimensional requirements may be of direct importance. But for mass production and use, proper percentile selections of the anthropometric data should be made and adequate allowance should be considered.

Support of anthropometric data (collected from the specific population groups) to design specific articles, e.g., product, equipment, furniture, machine tools, etc should be looked into. Dimensions of equipment of work accessories and work spaces should be considered while designing, in order to achieve effective accommodation layout and for enabling easy handling of equipment of moving within and around the space provided. The final outcome of any man-made article for human use with a definite form, shape and size required to perform a particular task may be termed as a product.

A product should ensure the basic principles of:
Human compatibility thorugh:

- A product user friendly relationship.
- An anthropometric and behavioural match between the user and the product.
- Ease of handling.
- Ease of decoding of messages
- Proper semantic applications; and

Product reliability and safety through:

- Designing the overall form, shape, size of the product and layout of the parts for operational ease.
- Removing unnecessary bad parts
- Guarding unsafe things
- Warning about probable hazards while using the same and training by specific instructions on how to use the system efficiently.

These studies are highlighted on research studies on anthropometric measurements.

In western countries a large amount of anthropometric data is available for reference. The anthropometric data assembled and maintained by the Aerospace Medical French Laboratories, Payton, Ohio is the largest and most comprehensive single repository of raw anthropometric data in the world. However, it does not contain any data on the Indian (Asian) population. The number of anthropometric surveys carried out in the country is very small and the dimensions included were specific to the requirements. Sen (1964), Sen et al (1977) and Gupta et al (1983) pointed out that there was considerable difference between the anthropometric data on Indian and Western people. Therefore, it is necessary to have data on Indian workers to assist in proper equipment design.(table:2.3)

Table 2.3: Various Anthropometric Surveys carried out in India.

Sr. No.	Survey	Total number of Subject	Occupational Distribution	Age range (Years)	Number of Body measurement reported	Subject regional distribution
1	Sengupta and Sen (1964)	499	Male Textile Worker	19 – 60	31	Maharashtra – 370 U.P. – 90 (North India) South India – 39
2	Sen (1964)	40	Adult Male workers	18 – 44	11	Bombay (West India)
3	Pandey (1970)	75	Agricultural workers	16 – 55	11	East and South India
4	Guman Singh (1972)	100	Agricultural workers.	18 – 70	33	Orissa (East India)

Table 2.3 Cont...

Table 2.3 Cont…

5 .	Sen et al (1977)	192	102 – Agricultural workers. 42 – Load Handling workers. 48 – Industrial workers	15 - 40	29	East India
6	Gupta et al (1983)	40	Farm machine. Tractor operators.	21 - 58	7	Punjab (North India)

Source: Gite and Yadav (1989) Anthropometric survey for agricultural machinery design. Applied Ergonomics, vol-20.

In an study conducted by Gupta(1968), entire sample (500 women student, Baroda) was grouped into various body size on the basis of height. The average ranges of body measurement for each height group is as follows:

Table: 2.4 Anthropometric Measurement for each Height Group (Gupta, 1968)

Body Measurement (in Cm)	Short (N = 60)	Medium (N = 353)	Tall (N = 87)
Height	142.5 - 146.8	148.5 – 155.7	160.6 – 164.2
Bust	73.4 – 93.8	71.6 –94.5	67.3 – 94.6
Waist	58.5 – 75.8	56.1 – 84.5	56.0 – 67.8
Hip	78.5 – 100.5	79.8 – 118.0	79.0 – 104.2

The lack of comprehensive anthropometric data for designers in the western world is documented from the finding of lewin (1969) it has revealed that the men had significantly higher means than the women throughout, with the differences varying between 0.7 and 1.6 SOS. Correlation and regression analysis indicated highly significant positive correlations with no sex difference i.e., r > 0.90, between stature and other body dimensions.

Significant positive correlation with values between 0.60 and 0.90 were found for height of shoulder, elbow and kneed joint on standing and height of shoulder and elbow as well as the distance tibial tuberosity in sitting. The women have a significantly higher positive correlation for the relationship between shoulder height standing and height. The correlation for women was $r = 0.67$ and $t = 2.8$.

Stoudt (1981) concluded from his study that body méasurements vary as a function of age, sex, and for different ethnic populations. In connecion to age he said stature and related dimensions (length and heights) generally increase until the late teens or early adulthood, and decline form early to middle adulthood into old age.

Difference between black and white was also observed. The discrepancy was that the blacks tend to have longer legs and shorter torso than white, so the degree of overlap of black and white for stature compared to the overlap for crotch height.

Several other studies by Ayoub (1982) and Sanders (1977) said that occupational differences can result from a host of factors including imposed height and / or weight restrictions, amount of physical activity involved in work and self selection on the part of applicants for practical or sociological reasons. Ayoub (1982) found that underground coal miners had larger circumferences (torso, arms, legs) than did military personnel but died not differ significantly in terms of linear dimensions.

Hanspal's data (1985) revealed the height of the person at 5^{th}, 50^{th} and 95^{th} percentile and values were found to be 150 Cm, 154.2 Cm and 160 Cm, respectively. The readings of elbow heights were 88.6 Cm, 94.4 Cm and 100.0 Cm for 5^{th}, 50^{th} and 95^{th} percentile respectively in standing posture.

Fernandizt et al (1989) reported that an anthropometric survey was conducted on Korean female workers in the garment industry. The data was collected part of the subject to modify workstations that utilized equipment from other countries. Thirty three body dimensions were taken from a sample of 101 workers in the age range 18 – 28 years. The anthropometric measurements were presented and compared with those of the Western and Japanese female. The result indicated that the body dimension of the Korean female are different from those of both the Western and the Japanese female. The ratio of the sitting height to standing height for the Korean female is closer to that of the Western female than it is the Japanese female

According to Gite and Yadav (1989), in Indian Agriculture, hand tools, animal drawn equipment and tractor / power operated machinery are extensively used for various operations. These equipments are either operated or controlled by human workers. Use of anthropometric data can help in the proper design of equipment for better efficiency and more human comfort. Earlier anthropometric surveys carried out in the country were very few and inadequate for use in farm machinery design. Therefore, 52 body dimensions necessary for the design of these equipments were identified and a sample study was conducted on 39 farm workers. The collected anthropometric data were analyzed to calculate mean, range, standard deviation and 5th, 50th and 95th percentile values. Through some examples an effort is made here to illustrate the use of the data in the design of farm equipment. It has now been proposed that extensive surveys should be carried out in different regions of the country to generate the necessary data useful in farm machinery design.

By Gite and Singh (1997), anthropometric data includes data on various body dimensions of workers. Seventy-nine body dimensions have been identified. For finding out the workload of women farmers it is necessary to study their anthropometric data. Some anthropometric data on Indian female workers are given in table 2.4.

Table 2.5: Anthropometric Data on Indian Female Workers.

Body Dimensions	Nag and Chatterjee	Nag et al (1987)	Verghese (1993)	Oberoi et al (1996)	Vatsa (1996)
No. of Subject	8 0	-	120.0	200.0	100.0
Weight (Kg.)	41.2	45.0	-	-	44.5
Stature	149.4	149.8	158.2	157.8	148.3
Chest circumference	-	72.9	-	-	-
Bideltoid breadth	-	35.8	-	-	-
Silting height	-	78.1	78.1	83.1	78.9

Source – Gite and Singh (1997) Ergonomics in agricultural and allied activities in India, CIAE, Bhopal.

AICRP (2000) reported that when dibbling activity was performed average height of the farm women in two selected age groups viz. 25 – 30 and 35 – 45 years ranged between 138 – 160 Cm, average weight from 34 – 62 kg, VO_2 (max) score ranged from 25.44 – 49.60 (lit/min). All the younger women were in the good category of aerobic capacity, whereas older women were in average and low average category respectively. It was observed that age was negatively correlated with VO_2(max) tend to decrease. Beside this 47.00 percent women were found in ectomorphic category indicating poor developed body, 24.00 percent in mesamorphic (average) and 5.00 percent in endomorphic (good). Results showed that 47.50 percent of farm women were having high average physical fitness index score, 26.00 percent in below average and only 2.0 percent had very good score on physical fitness index.

Varghese, et. al., (2000) studied 120 urban homemakers with the age range of 21-50 years. Several dimensions were studied.

Table 2.6: Anthropometric Measurements : (Varghese et. al., 2000)

Body Dimension	Mean	S.D.	5th Percentile	95th Percentile
• Weight	55.1	9.7	39.5	70.9
• Stature	153.2	5.7	143.5	162.6
• Eye height	142.1	5.3	133 1	150.9
• Waist height	92.5	4.0	85.4	99.7
• Elbow height	96.1	3.9	89.4	102.8
• Sitting height	78.1	3.7	71.3	84.0
• Sitting eye height	67.4	3.7	60.5	73.9
• Popliteal height	37.2	3.2	32.0	42.1

Body weights were measured in kg their dimensions were measured in cm. Thus, from the over all review few guidelines can be drawn for the anthropometric dimensions.

1. Anthropometric characteristics of any population depend on the biological, social and demographic variables.
2. Anthropometric measurements are important for designing equipments, work space and work place layout.
3. The design should usually be conceived to accommodate the population in between 5th and 95th percentile, keeping the 50th as mid value, so as to cover most of the population.
4. "To avoid reach" higher percentile (95th) and "to get easy reach" lower percentile (5th) should be considered.

Study conducted by AICRP (2001) on ten women farmers involved in cutting and collecting fodder indicated that mean age of the women farmers was 30.90 ± 8.69 years, mean height was 156.60 ± 5.82 Cm, weight was 44.60 ± 5.01 kgs and their aerobic capacity score was 31.34 ± 4.62 (liter/min). Beside this 80 percent of them were endomorphic and 20 percent of them were mesomorphic. When physical fitness of women were studied, it was found that

60 percent of them were having average score, 30 percent of them were having good score and 10 percent had very good score on physical fitness index.

Gite and Singh (2001) reported that mean height and weight of Indian female agriculture workers are 148 Cm and 45 kg respectively as against 163 Cm and 50 kg for male workers.

According to Hsiao et al (2002) the increasing demands for anthropometric information for the design of machinery and personal protective equipment to prevent occupational injuries has necessitated on understanding of the anthropometric differences to be found among occupations. This study identified difference in various body measurements between occupational groups in the USA, as determined in the third National Health and Nutrition Examination survey. Approximately 16,000 of its 32,900 subjects were associated with an occupational group. The analysis of the data showed that the body size, or body segment measurements of some occupational groups differ significantly. For example, agricultural workers were shorter by an average of 2.5 Cm in height and had wider writs breadths, than other workers. Female agricultural and manufacturing workers had larger waist circumference than those in the other occupations and all occupations categories. Protective service workers (i.e. fire fighters, police and guards) were taller and heavier (7 kg heavier for males and over 10 kg heavier for females) than those in all occupation combined. These differences and other deviations as well as some age - and - ethnicity - adjusted results were tabulated for user's reference. Researchers and designers who use anthropometric database to evaluate human machine interfaces and personal protective equipment (PPE) must use caution in selecting databases that are adequate for their occupational applications.

2.4 Physiological Cost of Activities Performed by Women Farmers

Physiological cost of activities performed by women farmers in terms of heart rate, energy expenditure, muscular stress, postural stress etc. for an eight-hour work period for women workers, a physiological cost requiring oxygen at a rate of 0.61 liter/min is considered as the upper limit for acceptable work load. The heart rate for such physiological cost will be about 105 beats / min. data on heart rate, energy expenditure, muscular stress and postural stress of women workers has to be collected for different operations. It will help in finding the physiological cost of work done by them. On the basis of that data we could suggest the new tools and technologies to them so that they may alleviate themselves from drudgery.

Heart Rate

The advantages of the heart rate (HR) as a biological parameter is numerous and undeniable. As far as methodology is concerned, this parameter may be recorded without any inconvenience for the subject, and continuously, practically without any time limit.

The heart rate is generated by the autonomous cardiac system and then modified by and inhibiting action of the parasympathetic vegetative nervous system or by an activating action of the sympathetic system. This implies that any action of the vegetative system has an effect on the heart rate physical load, emotions, noise, heat, general mobilization of the organism. All this makes the heart rate a very interesting parameter for an ergonomist. In a subject, the instantaneous heart rate (calculated by taking the inverse of the interval of each successive cardiac cycle) fluctuates around an average counted over a minute. These variations correspond to continuous adjustments that follow breadth rate, thermoregulation, the control of blood pressure, and in all likelihood, other function of the vegetative system.

During physical work the heart rate increases systematically whatever the task. However the mechanisms of the increase are different according to the type of effort put in. During dynamic work an increase of the cardiac output proportion may be observed. It is accompanied by a decrease of peripheral resistance making blood flow easier and limiting the increase of blood pressure, which is insignificant during a moderate dynamic effort and which concerns only systolic blood pressure during an intense effort.

The increase of the cardiac output first results from a fast increase of stroke volume at the beginning of the exercise and then essentially from cardiac acceleration. For moderate exercise, therefore, there is an almost linear relation between the heart rate and the power of the exercise, which allows deduction of this power from the heart rate and knowledge of the subject physical capacity.

Since the heart rate increases more for arm work than leg work. One must be quite prudent when trying to assess the energy cost of a takes according to the heart rate. This can only be done with sufficient degree of certainly if an individual a calibration was realized during a simultaneous recordingof te physiological magnitudes and moreover during an exercise which involves the same muscle group as those prompted during the studied task.

Broucha (1967) had examined recovery heart rate as an index of the cardio vascular strain and claimed that method to be more reliable than measurement of the total workıng pulse during exercise.

Dhesi (1970) found that various body positions accounted for variations in the heart rate significantly. Heart rate differed significantly at the ball making, rolling and pulling action from the normal sitting position, the angle of angle and knee bend were significantly affecting heart rate, she also found that a relative increase in the angle of arm pit and knee bend would decrease heart rate of workers.

An interesting study was conducted by Nag and Dutt (1980) on cardio respiratory efficiency in some agricultural work i e. germinating seedlings and threshing. It was observed that average heart rate of 5 male subjects during rest was 75.0 ± 5.5 beats/min and it was increased during pedal threshing i.e. 140.8 ± 4.8 beats/min. Similarly when seedling operations was done the heart rate increased from 75.2 ± 5.5 (in rest) to 109.2 ± 3.0 beats/min.

Nag and Chatterjee (1981) conducted a study on physiological reactions of eight female workers in Indian agricultural works with a view to standardizing their occupational work load. Maximum oxygen uptake (VO_2 max) was 1.892 liter per minute. Average work pulse rate in many tasks was more than 130 beats / minute. Pounding was the heaviest job, while harvesting, transplanting, uprooting and carrying load were moderately heavy. Whole day energy expenditure was 10.61 MJ.

In a study on farm women it was found that energy expenditure for household activities ranged from 1.48 to 3.04 Kcal/min and for farm activities from 1.93 to 2.88 Kcal/min with heart rate of 93 to 135 beats/min (Rao 1987)

A study was carried out by Rama (1990) to study the relationship between the physiological cost and perceived exertion, the overall physiological cost of the selected activities along with their corresponding perceived exertion were scored. It was reported that among the selected farm activities, the cotton picking activity showed the least hear rate responses of 103 beats/min with the corresponding energy expenditure of 1.98 Kcal/min/m^2.

During physical activity the heart rate and oxygen consumption rate may be increased, depending upon the workload. The maximum values which could be attained in normal healthy individuals are about 190 beats/minute for heart rate and 2.01 liter / minute (upto VO_2 max) for oxygen consumption rate. However, at this extreme physiological cost, a person can work only for few seconds. Generally, physiological cost which requires oxygen at a rate of about 85 percent of VO_2 max is considered as the acceptable physiological cost for Indian workers (Saha et al 1979) and the value work out to be 0.70 liter/minute and 0.68 liter/min, for male and female workers respectively (Gite, 1993). The corresponding heart rate values for this work load will be about 110 beats / min for men and 105 beats / mınute for women.

Table 2.7: Heart Rate of Male Workers in Agricultural Operations.

Sr.No.	Agriculture Operations	Heartrate (beats/min)	Source
1	Digging Soil with pick Axe	155.20	Kaur and Splinter (1964)
2	Digging Soil with Spade	134.90 / 131.20 / 172.00	Kaur and Splinter (1964) / Nag et al (1980) / Pradhan et al (1986)
3	Fertilizer application by broad casting.	126.30	Nag et. al. (1980)
4	Seeding with manual seeder in wetland.	154.00	Nag and Dutt (1980)
5	Transplanting of rice in bending posture.	109.20	Nag et. al. (1980)
6	Weeding by uprooting the weeks in sitting posture.	113.30	Nag and Dutt (1979)
7	Weeding with hand tools in sitting posture.	98.00	Yadav and Gite (1987)
8	Harvesting with sicke.	99.00	Nag et. al. (1980)
9	Rice threshing by beating.	135.80	Nag and Dutt (1980)
10	Winnowing (Standing)	124.30	Nag et al (1980)

Source – Gite and Singh (1997) Ergonomics in agriculture and allied activities in India, CIAE, Bhopal.

Energy Expenditure

Knowledge of energy intake and expenditure has attached to it varying degrees of importance and purpose. The industrial physiologist requires knowing the intensity of work involved in varying factory processes. The agriculture economist has been concerned with the effects of mechanization on the physical demands placed on the farm worker. All are concerned with the corresponding energy intake required to elicit optimum efficiency when the subjects are in approximate energy balance. If this is not evident, gradual exhaustion or increase in fat deposits occur and peak efficiency is not attained.

Energy is required for various kinds of biological activities done by all living organisms. Muscles provide the energy in the human body. Muscles have a property of contraction, a process in which chemical reaction takes place changing energy rich phosphate compounds, adenosine tri – phosphate (ATP) into low energy state, adenosine di–phosphate (ADP). The energy thus liberated is used for various body activities and external work. In a very broad sense, physical performance or fitness of an individual is determined by his capacity for energy output (aerobic and anaerobic processes and oxygen transport), neuromuscular function (muscle strength, co-ordination and technique), joint mobility and psychological factors (motivation and tactics).

In the human machine, the muscle fibers work as the pistons of internal combustion engines. When the fuels (energy compounds) are available and oxygen is introduced to start the breaking down of fuel, part of the energy, which is thus liberated, can cause movement of the piston muscle). Heat and various waste products are produced from the balance of the energy. The oxygen transported by the blood to the muscles breaks down the foodstuffs to carbon di-oxide and water through the process of respiration. Waste products produced during the process are transported back to the lungs and to the excretory systems of the body for subsequent removal. Therefore energy consumption can be measured indirectly by measuring the oxygen consumption when one liter of oxygen is consumed in human body, there is, on an average, a turn over of 5.0 Kcal (20 kJ) of energy. Higher the oxygen consumption higher will be the energy output.

Philips (1954) estimated energy expenditure of six women with mean body weight of 55 kg during grass cutting and hoeing. The mean energy expenditure was found to be 4.3 and 4.4 Kcal respectively.

Brown (1961) reported that body weight of the individual and his energy expenditure has a linear relationship. In dynamic activity the weight of the body itself was considered to constitute the energy load.

Park and Roadburd (1962) found that the excessive bending of leg and abdominal muscles increased the oxygen consumption resulting in increased energy expenditure.

Banerjee and Saha (1970) observed that higher physiological cost with increase in body weight was expected due to the movement of heavy body concurrently involving greater muscular efforts and consequently higher energy demand.

Brun (1979) graded agricultural activities by men of 57 kg based on energy expenditure as moderate (4.4 to 6.5 Kcal/min) or heavy (6.6 – 8.7 Kcal/min)

Nag and Dutt (1979) studied the physiological responses during weeding operations. The energy required for weeding, while sitting with one or both legs flexed at the knee was 2.88 kcal/min. while it was 2.90 kcal/min during weeding. After comparing the physiological demand work performance and preference of the workers, the wheel hoe type weeder was found to be the best for Indian women.

Joshi (1985) found out that the relationship between heart rate and energy expenditure of workers among various activities. Heart rate, perceived excertion, body surface area and maximum oxygen uptake (VO_2 max) it was concluded that weeding with three weeders could be graded as moderately work. However, the khurpi appears to involved less energy consumption. The weeding efficiency with the khurpi was observed to be highest followed by the spade and 3 tine hoe.

Gite et al (1991) conducted a study on a lower operated knapsack sprayer. The study was conducted on ten subjects. During the operation of this sprayer the mean heart rate, oxygen uptake and energy expenditure of the subjects was found to be 94.6 beats/min, 0.4541 liter/min and 9.48 kg/min respectively.

Tewari et al (1991) conducted a study on three manually operated weeding devices. From the data relationship between energy expenditure rate and oxygen consumption rate and heart rate were established. Field test were carried out with the three weeders in a firm with Arhar Crop (Cojannus Cajan) during August – September when the average ambient temperature and relative humidity were 36°C and 82.00 percent respectively. The three weeders used vary in design and their operations required different postures. The average work pulse rate for all subjects varied from 104.8 ± 0.46 to 129.2 ± 7.8 beats/min. it was observed that cardio – vascular demands of weeding by a Khurpi were slightly lower than by a 3 – tine hoe and a spade. Similarly, the oxygen uptake for weeding by a Khurpi was observed to be minimum (13.8 ± 4.2 to 16.47 ± 3.1 liter/min) followed by a 3 tine hoe (18.37 ± 15.8 to 20.43 ± 6.8 liter/min) and a spade (20.89 ± 2.3 to 26.75 ± 5.1 liter/min). The relative energy cost of weeding for each of the three weeding devices considered together varied between a minimum of 25.35 ± 18.7 kJ/min to a maximum of 54.4 ± 9.4 kJ/min of the maximum oxygen uptake (VO_2 max) it was concluded that weeding with these three weeders could be graded as "moderately heavy work". However, the Khurpi appears to involved less energy consumption. The weeding efficiency with the khurpi was observed to be highest followed by the spade and 3 tines hoe.

Energy expenditure rate of a worker while performing a job can be calculated by using heart rate data. Energy expenditure in some agricultural and allied activities are given below. (Gite and Singh (1997))

Table 2.8: Energy Expenditure of Workers in Different Agricultural Operations.

Agriculture Operation	Energy Expenditure kJ/min	Source
Digging soil with spade	22.50	Nag, et al (1980)
Fertilizer application by broadcasting	9.07	Nag, et al (1980)
Seedling with manual seeder in wetland	33.40	Nag and Dutt (1980)
Transplanting rise in wetland	13.40	Nag, et al (1980)
Weeding with wheel hoe	10.50	Gite, et. al. (1980)
Harvesting with sickle	10.25	Nag, et. al. (1980)
Rice threshing by beating winnowing (standing)	19.26	Nag, et. al. (1980)

Source: Gite and Singh (1997) Ergonomics in agricultural and allied activities in India CIAE, Bhopal.

In AICRP report (1999) it was found that women in different states of India are engaged in various jobs and have to carry the work load ranging from light to very heavy in weight on their head, shoulder, back, hands etc. They found that in the age group of 21 – 30 years of age for fetching of water the heart rate increased upto 102.73 beats / min. For 31 – 40 years of aged women heart rate increased upto 107 78 beats/min. the energy expenditure was 7.32 kJ/min, 8.41 kJ/min, 11.50 kJ/min, 12.03 kJ/min respectively. The total cardiac cost of work was 574.43 and 528.80 beats respectively for different age group.

From this review it was found that since energy expenditure is related with heart rate therefore it also affects the physiological cost of work experienced by women in various activities.

Postural Stress.

The upright posture and bipedal gait of human has along evolutionary history. A stable posture can be maintained only if the various body parts are supported and maintained in an appropriate relation to the base of support, such as the feet or the squab of the seat. The size of the basis of support determines not only the stability of the body but also the postures which can be adopted. Posture may be defined as the average orientation of the body parts, with respect to each other, over a period of time.

In most cultures and throughout history people either sit on the floor, cross-legged or in other ways, or squat. Squatting is the habitual resting position of the young humans of all cultures.

In squatting, the line of action of the body centre of gravity passes through the foot support base and some of the weight of the upper body is born on the legs. As far as the lumber spine is concerned, a good working posture is one in which spine is mid-point of the ranges of movement and the trunk is unconstrained (i.e., free to move anteriorily and posteriorly). Postural stress is the term used to donate the mechanical load on the body by virtue of its posture.

Like any other mechanical system, the body may be stable or unstable, and is able to withstand a limited range of physical stresses. Stresses may be imposed both internally or externally and may be acute or chronic. The function of the ergonomist in the study of such stresses is to use principles of anatomy and biomechanics to design the working environment in order to minimize undue stress, preserve the health of the workforce, and improve task performance.

These studies are related to definition of posture and postural stress

Ideas about good and bad posture are to be found in the literature at least as far back as Andry (1743), the father of orthopedics, who illustrated good and bad posture in his treatise 'Orthopedia'. He called sitting upright a 'good posture', sitting in the full flexion he called a 'bad posture', he called the back 'crooked and round' and the posture 'ungraceful'. Long maintained postural habits, arising for instance from the use of badly designed tools and furniture and methods of using them, frequently result in permanently implanted postural abnormalities, often, accompanied by degenerative tissue changes and pain.

Frost (1944), described the importance of good posture as, "To avoid strain and to develop a good body carriage while working, some attention should be given to posture habit in standing, sitting, stooping....... while at work".

Smith (1953) classified standing postures into symmetrical and asymmetrical. He found that average duration of each stance was only 30 seconds, and 93% were held for less than a minute; while only 20% of the time his subjects stood symmetrically. Thus, considering the standing posture, work surface heights should be considered and even the type of work has to be considered along with the anthropometric dimensions of the operators. Same is the case in sitting posture. Man sits to read, work, rest and eat. "Sitting" is basically a human invention a compromise between "standing up and lying down". A good seat is one which helps the sitter to stabilize his body joints so that he can maintain a comfortable posture.(Cited in Datar,2003)

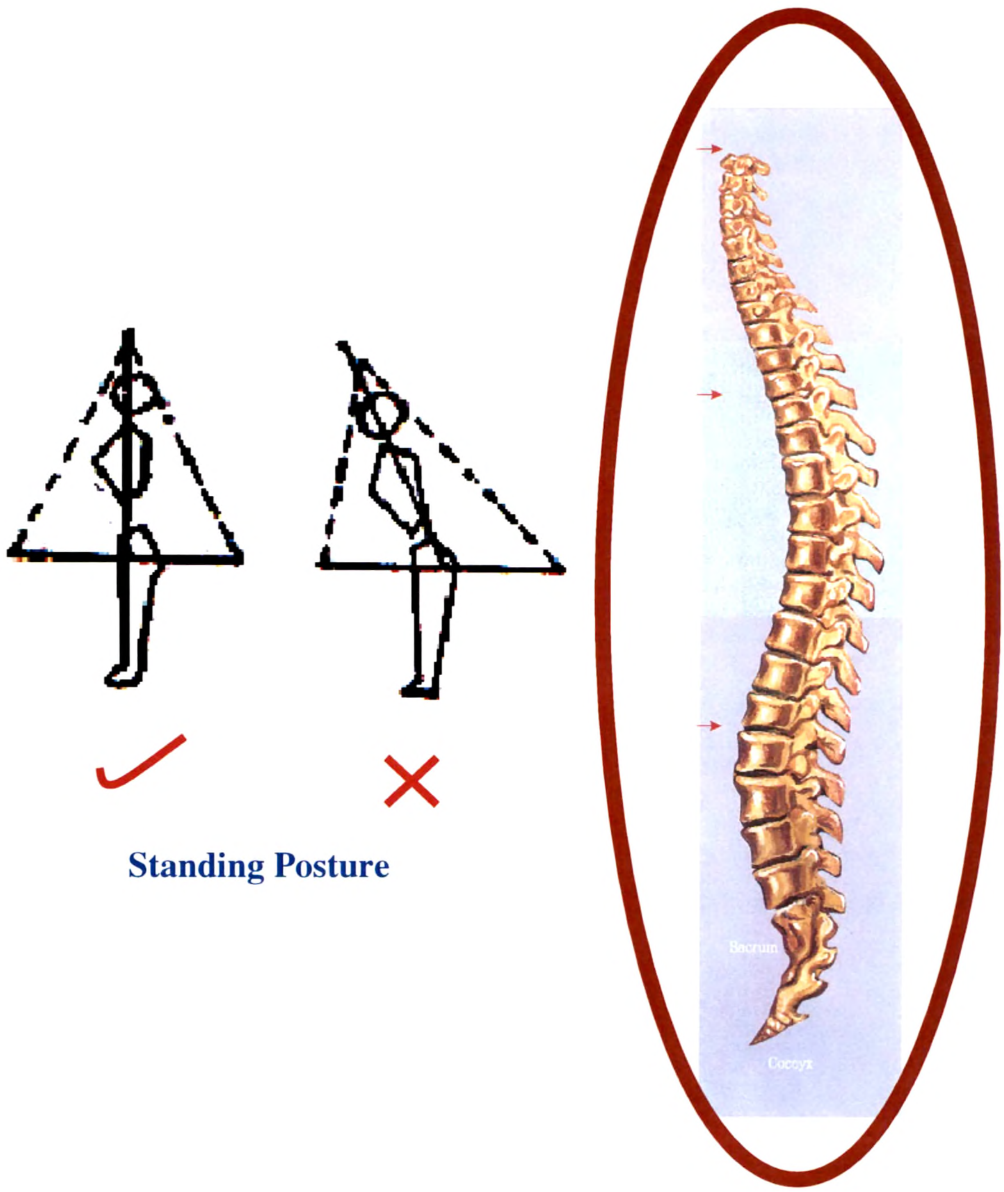

Fig. 2.1 Right and Wrong position of Back Bone in Standing Posture

Agan (1956) defines the posture as, "The position in which the body is held..." Correct posture in doing a task may be explained as the position which requires the expenditure of the smallest amount of energy. “A good standing posture is the one in which the head, neck, chest and the abdomen are one upon another so that the weight is carried mainly by the body frame work and a minimum of effort and strain upon muscles and ligaments... When the body is well balanced in the standing position, the center of gravity will pass through the middle ear, shoulder, in and outside of knee and ankle". (Agan, 1956).

Prolonged sitting may lead to a slackening of the abdominal muscles and a curvature of the spine, which in turn is bad for the organs of digestion and breathing. About 60% of adults have backache and the commonest cause of this is disc trouble. The degenerative processes impair the mechanics of the vertebral column and allow tissues and nerves to be strained and pinched, leading to various back troubles, most commonly lumbago (painful muscle cramps), and sciatic troubles, and even in severe instances to paralysis of the legs. All these problems are resulted from unnatural postures. For this reason many arthopedists have started to concern themselves with the medical aspects of the sitting posture, Akerblom (1948), Keegan (1953), Scoberth (1962) Yamaguaci (1970) and Anderssones and Ortengern (1974).

Bratton (1966) formulated that a prolonged sitting necessitates the human body to change postures, from time to time to relax various groups of muscles.

To measure vertebral compression the investigator inserted needles into the dorsal processes of two lumbar vertebrae. The change in the tension between the two dorsal processes during various sitting postures was recorded electrically. As a standard of reference he measured the tension when the subject was lying on his side with 45° angles at the hips and knees. In this position the inter-vertebral discs were subjected to minimal compression forces and the position were taken as neutral.

According to Grieve and Pheasant (1982), postural stress is the term used to denote the mechanical load on the body by virtue of its posture. Posture may be defined as the average orientation of the body parts, wit respect to each other, overa period of time. Under the influence of gravity, postural stress becomes an important part of the total mechanical stress. In order for the body to be stable, the combined center of gravity (COG) of the various body parts must fall within a base of support (the contact areas between the body and the supporting surface). When one is standing, the weight of the body must be transmitted to the floor through the base of support described by the position of the feet. The alignment of the body parts must be maintained to ensure continuing stability, and it is the maintenance of posture that much stress arises.

Corlett (1983) reported that a posture is the position adopted because it is appropriate for the task being performed. Corlett (1983) also reported that measurement of posture would need to record the forces present and the time for which the posture is held simultaneously with the posture configuration itself. (Citied in Haslegrave, 1994)

According to Gardiener (1983), posture is considered as the attitude assumed by the body, by support or coordinated muscular activity. Its purpose is to maintain the stability or to form an essential base, constantly adopted to the movement superposed to this base.

"There is no single posture which is correct for every one. Good posture should be comfortable, easy to maintain for long periods and not produce strain".(Herald of health, 1984. Cited in Datar 2003)

Rohmert and Mainzer (1986) suggested that posture could be described geometrically in 3 different ways: by three dimensional co-ordinates of individual joints, by defining the orientation angles of the long axes of body segments in space; or by recording these orientation angles relative to the proximal body part. (Citied in Haslegrave, 1994)

These studies are related to methodology of postural stress

From as early as the seventeenth century methods have become available for recording human postures (Corlett et al, 1979) but until the development of Preils method (Priel 1974), Posture recording has been by means of drawings or photographs and supplementary narratives (Gil and Tunes, 1989). Priel's method the use of a paper card called the posture gram. The analyst is required to select and then sketch a posture of interest within a job and then categorize body posture in terms of 14 different upper and lower limb positions relative to three autogonal reference planes. The procedure permits adaptations of the recorded postures to digital data transmission and processing, but takes several minutes to complete a single posture and is therefore unsuitable for dynamic activities

Gil and Tunes (1989) proposed a technique for recording sitting postures. The posture is recorded on a card that contains four different postural configurations for thigh – trunk, thigh – leg and trunk arm angles. The method possesses features allowing the identifications of different postures, as well as their relative frequency of occurrences. However, the time required to complete the card is more than 40 seconds, which can be too long for situations where postures change rapidly. In these cases, Gil and Tunes (1989) suggest a combination involving the card and films or video. Another technique for assessing postural stress, known as posture targeting was developed by Corlett et al (1979). With this system, the analyst records the position of the head, trunk, upper and lower arms/legs on a diagram of the body that has an associated set of segmented concentric circles, similar to a target. The targets are placed adjacent to each part of the body diagram and each target has four circles representing different ranges of movement (in angles). As the procedure requires about 30 seconds or more to complete, it is best suited for jobs where working postures are reasonable static. Incase were posture are adopted adopted for only a few seconds and are not repeated, Corlett et al (1979) suggest alternative methods such as photographs.

PLIBEL (methods for the identification of musculo skeletal stress factors that may have injurious effects) is a screening tool designed to identify, 'ergonomic hazards' in the work place, via the use of a checklist (Kemmlert and Kilbom, 1987). The checklist consists of questions regarding work posture, movements, workplace or tool design. These are answered in accordance with the five body regions concerned including neck/shoulders and upper part of back, elbows/forearms and hands, feet/knees and hips and low back. The tool is useful for identifying risk factor for musculoskeletal injuries of a specific body region and has been applied in several studies (Vink 1991, Jakobsson 1993). One concern with the checklist is that the inter – observer reliability is not high (Kemmlert, 1995) and it is difficult to justify the magnitude of "risk" when the combination of several factors is presented within a job.

A simpler technique for posture recording, as well as for posture classification, is the Ovako Working Posture Analyzing System (OWAS), as developed by the OVAKO by Steel company in Finland, and described in detail in several papers (Karhu et al, 1977, Corlett, 1995). The system defines the movements of body segments around the lower back, shoulder and lower extremity (including the hip, knee and ankle) as four types; bending, rotation, elevation and position. To use this system, the analyst makes an instantaneous observations of the posture and records a four – digit code, representing the position of the back (four choices), the arms (three choice), the legs (seven choices) and force, the recording procedure requires only a few seconds and can be used in conjunction with a random schedule of observations to obtain a summary description of posture OWAS also has action categories to reflect the magnitude of risks. A possible shortcoming of the system is that the posture categories are too broad to accurate posture description (Keyserling, 1986). There have been several variations on the OWAS methodology, mostly by authors who have automated the data input and output procedure such as those reported by Graf et at. (1991), Kivi and Mattila (1991), Hignett (1994) and Fransson Hall et al (1995). The OWAS method (or it is modified form) has been used in several ergonomics or epidemiologic studies, such as surveillance for ergonomic hazards at work (Karhu et al, 1981) identification of strenuous tasks and activities in particular jobs (Kant et al, 1990, Scott and Lambe, 1996), characterization of exposure in epidemiologic studies and evaluation of the effectiveness of ergonomics controls (Kivi and Mattila, 1991).

These studies are focused on various research of postural stress.

Keegan (1953) found the use of X-rays that the most relaxed or most normal, sleeping posture when people sleep on their side, is one in which there is about a 135° angle with the spine.

Keegan (1953) considered a posture of about 45° flexion of the hip to be normal; because this is the position one assumes when lying relaxed on one's side. In this position there is a complete balance between the muscles at the front and back of the pelvis. When standing the front muscles becomes tenser and at the back become more relaxed. This results in increased lordosis in the lumber region. When sitting, the muscles at the back are more tense and those in front are more relaxed; the small of the back is normally convex, i.e., it displays kyphosis, which is partly due to the tense hamstring muscles in the sitting position.

Grady (1954) described that maintaining the correct alignment of body segments affects the functioning of all the body organs. The heart and lungs may be partially affected when they are crowded by a bowed back. A tilted pelvis may be the other cause of back strain and improper functioning of abdominal organs caused by the poor posture. Unbalanced weight distribution, with resultant strain may produce pain in the back, legs and feet. The thoracic, abdominal and pelvic organs suffer from faulty nerve supply. These shifts in positions affect the organs so extensively that could not be expected to function properly.

An investigation was carried out by Bratton (1958) in New York, to study the factors affecting the body in standing/sitting posture while working in different postural conditions. Energy cost of the body, rate of work, and angle of arm lift while working in the standing and sitting positions were recorded. The task preformed was folding of towels and washings clothes. The various positions studied were:

- Standing at a counter with the height of 36 inches.
- Sitting at the above counter on a stool measuring 26 inches height with the feet on the foot rest and knee under the counter.
- Sitting in the above position but with the knees forced to the side by a cabinet front.
- Sitting on 15 inches height chair at a counter of 23 inches height with the knees under the counter and the feet on the floor.
- Sitting at a counter of 36 inches height, in a perched position on a stool measuring 30 inches height with the feet braced against the floor

Keegan (1962) used X-rays to study the shape of the spine during 34 different attitudes when standing, lying down and sitting. Orthopedists are of the opinion that when lying down on one's side, with the lower limb held at an angle of about 45° at hip and knee, the spinal column preserves a 'normal shape, in which the muscles of the back are at their optimum state of relaxation.

Gray, Hansen and Jones (1966) found that small changes in sitting and standing posture have a significant effect on neck muscle tension. Three postural images viz., most comfortable, best and greatest height were measured in terms of changes in angles between head and trunk and in the differentiated activity in the muscles of stern mastoid and upper trepezius. These postures were distinguished from each other with a high degree of statistical significance.

Lehman (1966) reported that the metabolic rate is raised by 8.3 percent in the sitting posture when compared to lying. In standing posture metabolic rate was as high as 19.7 percent. The increased metabolic rate particularly in the standing posture was due to the greater energy expenditure which is connected with the effort of keeping the whole body in balance i.e. in a state of considerable static muscular strain. So, in the opinion of the author, standing for a longer period can affect the condition of the human body and it should be Avoided or limited as far as possible.

Vonwely (1968) and Grandjean and Hunting (1977) have listed the following postures and probable site of pain

Table 2.9: Bad Postures Versus Probable Site of Pain

Bad Postures	**Probable Site of Pain**
Vanwely (1968)	
• Standing (Particularly a pigeon footed)	• Feet, lumbar region
• Sitting without lumbar support	• Lumbar region
• Sitting without support for the back	• Erector spinal muscles.
• Sitting without good footrest of the correct height.	• Knee, legs and lumbar
• Sitting with elbows rested on a working surface which is too high.	• Levator scapulae muscles and trapezius, rhomboideus
• Upper arm hanging unsupported out of vertical.	• Shoulders, upper arms
• Arms reaching upwards.	• Shoulders, upper arms
• Head bent back	• Cervical region
• Trunk bent forward, stooping	• Lumbar region position
• Lifting heavy weights with back bent forward	• Lumbar region
• Any cramped position	• The muscles involved
• Maintenance of any joint in extreme position.	• The joint involved.

Table 2.9 Cont…

Table 2.9 Cont...

Grandjean & Hunting (1977)	
• Standing	• Feet and legs (possibly various)
• Sitting without back support	• Extensor muscles of the back
• Seat too high	• Knee, lower legs and feet
• Seat too low	• Shoulders and neck
• Extended arms	• Shoulders and upper arms (possible periarthrities of shoulder)
• Inadequate grips on tools	• Lower area (possibly periarthrities)

Gschwend (1969)and Schoberth (1962) opined that the final shape of the spinal column depends on the aggregate of all the postures during its growth. They considered that, sitting for long periods deprives the body of the alternation of stress and relaxation, and as a result the correcting forces remain undeveloped. These authors suggests that it is not so much the postures themselves as the lack of corrective movements that leads to chronic defects.

Thus, Gschwend (1969) designed seat for adolescents that would allow the posture to be changed from leaning forward to leaning back, so that uncomfortable positions could be avoided.

Brantingham, et. al (1970) reported that the primary occupational symptoms and diseases related to prolonged constrained standing are pain, discomfort, fatigue, swelling of the lower extremities and foot, due to blood pooling and varicosities of the lower extremities.

Astrand and Rodahal (1970) have pointed out that the return of the venous blood to heart is reduced in a bending posture. Consequently the cardiac output decreases and there is an increase in the heart rate.

A Japanese orthopedist Yamaguchi (1970) investigated the forces acting between intervertebral discs and their dynamic responses in seated postures.

As studied by Gorecki (1973) jobs and tasks requiring prolonged constrained standing posture frequently cause fatigue, body or body part discomfort and lower extremity impairments.

A Swedish Orthopedist Andersson (1974) studied the effect of four different postures on nine healthy subjects The results disclosed that the pressure is greater when sitting than when standing.

Basmajian (1979); Cailliet (1974) reported that during erect standing posture, the line of gravity falls bilaterally anterior to the hip, posterior to the axes of rotation of the lumbar and cervical vertebrae and anterior to the thoracic vertebrae. (Citied in Zhang, et al., 1991)

According to Basmajian (1979) erect standing posture is determined by the relative arrangements of the body's link segments. Maintenance of this position depends on the counter forces (both internal and external), which attempt to neutralize the deforming forces of gravity. The skeletal, ligamentous and muscular systems attempt to maintain the body's link segment alignment with minimal energy expenditure. An alteration in the position of one segment of this kinematics chain will necessitate compensatory adjustments in adjacent segmented links, thereby, resulting in increased muscular energy expenditure. Basmajian (1979) also contends that fatigue in the lower extremities, resulting from prolonged standing, is more a result of venous and arterial circulatory insufficiencies and pressures on inert body structures than due to continuous muscular contractions.

Corlett (1981) showed adoption of poor working postures in order to perform tasks could lead to postural stress, fatigue and pain, which may in turn force the operator to stop work until the muscles recover.

The home, to quote Ring (1981) is a "a minefield" where four times as many back injuries occur as on the job Women are still in the majority of those who both run homes and take paid jobs, so they are at great risk.

In relation to posture, Corlett, and Richardson (1981) answer the question of what can be described as satisfactory and what is unsatisfactory by saying that the difference between the two cases is not necessarily the level of fitness'. Physically, each may be equally fit for the work performed. But, the major difference is the variability in posture which is possible in each job. When the same muscle groups are used every few seconds and if the work place design is poor then the attempt to use other muscle groups will inhibit the ability to do the task because the individual will have adopted a position from which he/she cannot do it.

Westgaurd and Aaras (1984) studied that, while posture is important to the comfort of all people at work. A poor posture becomes a hazard to health and safety in two main situations: in tasks, which are static in nature and involve maintaining the posture for relatively long periods; and in tasks, which involve the exertion of force. In the first situation, the postural loads on muscles and joints can lead to muscular fatigue, pain and in long term to cumulative physiological changes and injury. (Citied in Haslegrave, 1994)

Don Tigny (1985) has pointed that standing postures increase the tendency for the sacrum to be interiorly displaced, thereby increasing the tension in the sacroiliac ligaments. Small displacements of the sacrum can occur, causing soft tissues to be "pinched", which cause pain. This pain can be mistaken for low back pain.

Nag, Chintharia, Saiyed and Nag (1986) carried out the EMG (Electromyograms) analysis of sitting work, posture on women. Their findings reveal that sitting on the floor without trunk support as in the positions like sitting on floor with left leg crossed and the right leg bent at knee and resting vertically with foot flat on the ground, sittings on floor with right leg crossed and the left leg bent at knee when the foot rests on the ground, lastly sitting on a plank (10 Cm height) with both legs bent at the knee was more fatiguing than the standing position. This is because the EMG of the erector spine were certainly greater in the sitting positions. In sitting postures muscles of upper back, were more strained.

Wallance and Puckle (1987) stated that daily exposure to static effort over a long period may result in discomfort as well as pains and aches in the muscles, joints, tendons and other soft tissues. (Citied in Genaidy and Karwowski, 1993)

According to Grandjean (1988); Chaffin and Andersson (1991) and important ergonomic rule would be to avoid keeping the upper extremity outstretched either forward, backward or sideways in the standing position. (Citied in Genaidy, et al. 1993).

Redfern, et at. (1988) showed that workers required standing for long hours during work experienced significant levels of fatigue and discomfort in different areas of the body. They are also concluded that the floor surface on which he workers stands during work affects the worker's perception of tiredness and discomfort (Citied in Rys, et. at., 1994)

Lee and Wagner, cited by Zacharkew (1988), also stressed 'Never stand with weight on one foot unless it is a one foot forward position and with the weight on the forward foot'.

Rys and Konz (1989) examined the difference in foot volume and comfort level when the subject's weight was distributed (one foot forward and placed on a 100 mm flat platform) as compared with the normal standing position. The comfort ratings for condition forward was higher. The heel and neck comfort was significantly higher for forward standing. But discomfort was experienced in lower leg and ankle, hind foot and mid foot.

According to Astrand (1979), Varghese et. al. (1989) a good working posture reduces the physiological cost of work and fatigue to the minimum. Static muscular efforts and incorrect postures for long periods during household activities can damage the intervertebral discs.

Further, Varghese et. al. (1989) carried out an experimental study and ergonomically evaluated the selected household activities in the various postures. Food preparation was one of the selected household activities in the various postures. Food preparation were one of the selected activities under the study. Mainly two postures viz., standing position and sitting / squatting position were adopted during the experiments. The findings demonstrate that the cooking activity done in sitting position is less tiring than in standing position. Since the standing type of kitchens are common in urban homes the authors recommend the combination of sitting / squatting and standing posture for kitchen work.

As reported in Iida (1990) the still standing position is highly tiring for demanding static work of the involved musculature and pumping of blood to be hindered.

Burdorf, et al. (1992) reported that laboratory studies and biomechanical simulations have demonstrated that any deviation from upright standing posture produces higher loads on the lumber spine. Epidemiological studies have shown that non-neutral postures and movements, eg. Frequent bending and twisting, are significantly related to the risk of low back pain.

According to Genaidy, et. al. (1993) back extension in the standing position lead to significantly higher discomfort ratings than any other movements around the low back. Genaidy, et. al. (1993) also reported that lateral bending of the back had slightly higher discomfort values than its rotation for the standing position, and slightly lower discomfort values than rotation in sitting position.

Satzler et. al., (1993) studied (1) standing with one foot on a 100 mm flat platform (2) standing with one foot on a 100 mm, 15° angled platform (3) standing with one foot on a 100 mm high, 50 mm dia bar and, (4) standing with both feet flat on the floor. 16 subjects for 2 hours in all the four conditions were studied. The three standing aids were prepared over no aids; and of the aids, the two platform seemed better than the bar.

Thus, standing with one foot elevated was worth while.

Guidelines recommended by the authors for maintaining good posture :

1. Standing posture is better than sitting posture.
2. Stand with one foot forward position and with the weight on the forward foot.
3. Alternating standing and sitting is more restful than on continued position for a long period.
4. Higher seats and higher sloping desk leads to a more upright posture with reduced forward bending of back.
5. Using slanted surface holds the trunk in better posture.
6. Head, neck, chest and abdomen should be held one upon another so that the weight is carried mainly by the body frame work.
7. Work seats should be altered from time to time between forward and backward sitting posture.
8. To avoid strain in back muscles proper backrest with inclination and upper support is essential.

9. An adjustable chair with good lumbar support and good armrest and a 10-15° backward inclination.
10. Posture should be changed from time to time to relax the muscles if prolonged sitting is required.

Haslegrave (1994) reported that posture is a important for the performance of tasks as it is for promoting health and minimizing stress and discomfort during work. He also states that posture therefore arises from the functional demands of vision, reach, manipulation, strength and endurance and is constrained by the geometric relationship between the person's own anthropometry and the layout of the workspace. Haslegrave (1994) also reported that the geometrical or anatomical measures which can be used to record posture, and which define posture parameters, are suitable for the analysis of workspaces and of biomechanical loading under postural and external forces. However, the functional and geometrical aspects then need to be combined when designing the layout of work places or assessing the appropriateness of postures adopted during work tasks.

As studied by De Looze, et al (1994) different aspects working body posture are considered to be related to specific injuries: for instance, the need to bend the torso is generally considered to be an important factor in low back pain, repetitive or prolonged elevation of the arms above the shoulders is thought to be related to shoulder injuries, knee injuries could be related to repeated or prolonged knee flexion. If such injuries are to be prevented, these particular postures should be avoided as much as possible. To this end the frequency of their occurrence should be assessed in normal tasks.

Bredger (1995) stated that all extreme hip movements in standing were associated with high level of discomfort, abduction being the worst, followed by flexion, extension, adduction, and medical and lateral rotation. The legs having the extreme positions while standing seems to be particularly problematic. If these extreme postures are designed out, the risk of muscluo-skeletal pain can be reduced.

Cauto (1995) states that the standing position just demands long periods of contractions from the muscle of the calf, not having need of another muscular action. There is still the reduction of the intradisc pressure for the performance of the shock absorber of the organism and the liberation of cerebral areas to maintain this state, to the extent in those inferior areas of the nervous system take charge of that, liberating the superior brain centers for the work.

To maintain a comfortable work posture, to reach control locations and to minimize operational errors and fatigue, the operator's movement should be optimum, and all reaches should be located within one's leaning ark reach(Nag and Chakraborti 1996)

According to Rio (1998) those inadequate postures, as the extreme ones and the static ones, take to general and/or specific overloads of the musclo-skeletal system, being one of the main factors in the origin of musclo-skeletal disturbances related to the work – MSDRW.

AICRP (2001) conducted a study on dibbling activity. Muscular stress (grip strength) of the respondents of two ages groups i.e. 25 – 35 years and 36 – 45 years and were measured. Findings of the study indicated that average grip strength of the respondents during dibbling was highest amongst younger age group as compared to older age group. Percentage change in grip strength (Muscular stress) a subject during rest and after dibbling were higher among older women. These changes were higher during the work performed by left hand than right hand of the older women.

Guedes, et al. (2001) reported that the postures are of extreme importance in the work because they represent accommodation of the muscle-skeletal system to objective aspects of the workstation, besides some physco-motion attitudes. To that extent, ergonomically adopted workstations should allow neutral posture, that is, not to induce the postural distortions or to do it inside of acceptable limits.

Muscular Stress (Grip Strength)

The human body is able to move because it has a widely distributed system of muscles, which together make up approximately 40% of the total body weight. The most important characteristic of a muscle is it's ability to shrink to half its normal length, a phenomenon we muscular contraction. Each muscle fibre contracts with a certain force, and the strength of the whole muscle is the sum of these muscle fibres. Hand grip strength is an important limiting factors in many occupational tasks as well as in general activity. Grip strength is affected by many factors. Some of these are task related including grip span requirements, grip surface geometry and friction hand orientation, force-frame requirements, movement of the hand during the grip effort, task repetition and the use of gloves. Other factors relate to individual subject or worker strength characteristics as affected by age, gender, hand size and muscular strength acquired over time through occupational, domestic and recreational activity. As is true for any type of strength, hand grip strength is highly individualistic, population means and standard deviations should be developed for a given class with workers or product users whenever this is feasible to assure human/equipment compatibility.

The hand, operating through motions of the wrist and forearm, can rotate in three planes. These include: extension and flexion (upward and downward motion of the hand toward and way from the trunk with the palm down), and rotation of the wrist about the major axis of the forearm caused by rotating he forearm.

Handgrip strength information is important for designing hand tools and other work designing and evaluating work tasks. Among the most important information are strength magnitude, how other variables influence strength, and the nature of grıpping objects. Users should exercise care in applying handgrip data because most data is based on a method of measurement which differs significantly from the way people grip real task objects.

Researchers showed that absolutely limit of grip strength after performing various repetitive task is reduced. It is because after performing any activity repetitiously muscles become tired and therefore resulted in loss of muscular strength.

The following studies are related to methodology of muscular stress:

Akerblom (1969), Lundervold (1951), Schoberth (1969) and Floyd and Ward (1969) have measured the electrical activity of the muscles of the back as an indication of static activity. These studies show that there is increased electrical activity when sitting in an exaggeratedly erect posture, and that it falls markedly when a forward sitting posture is assumed. Their subjects preferred the latter posture because the body weight is then balanced on the spinal column and no static muscular activity was required. They also established that, with the use of a back rest, an erect posture may be assumed without electrical activity in the muscles of the back. They proved that a suitable back rest is essential to avoid strain in the back muscles.

According to Griev and Pheashant (1982)The function of skeletal muscles is to exert tension between the body points to which they are attached. Tension is exerted when a muscle changes from its resting to its active state in response to impulses from the central nervous system. The maximum tension a muscle can exert depends on its maximum cross sectional area also its length. The term "muscle contraction" refers to the physiologically active state of the muscle, rather than its physical shortening. Muscles are able to contract eccentrically, isometrically and concentrically.

1. Eccentric contractions – The muscle lengthens while contracting.
2. Isometric contractions – The muscle length remains constant during contraction.
3. Concentric contractions – The muscle shortens while contacting.

These different contractions can be illustrated by considering the action of the elbow extensors (such as the triceps muscles) of a person doing push-ups, when these muscles contract causes the elbows to extend. They contract eccentrically when lowering the body to the floor. The eccentric contraction acts like a brake. It controls the rate at which the muscles increase their length and at which the elbows flex. This contraction enables the body to be lowered smoothly to the floor in a controlled way. If the person pauses halfway, isometric contraction is required to counteract the downward pull of gravity and maintain the position of the body in space.

A close relationship exists between the length of a muscle and the tension it can exert. If a muscle is removed from the body, it assumes a resting length which depends on its own internal properties, If the muscles placed in an apparatus suitable for manipulating it's length and for measuring the tension required to maintain the muscle at a given length, a length tension curve may be plotted. As the muscle is artificially lengthened, increased tension is required to overcome the elastic resistance of the connective tissue which surrounds the individuals muscle cells and holds the muscle together (Grieve and Pheasant, 1982)

Adams (1988) reported that handgrip strength is an important limiting factor in many occupational tasks. Grip strength is affected by many factors such as orientation to the work surface, place of rotation of hand, working position, resisting force dynamics, repetition of task, barriers to motion, grip diameter and surface area, use of gloves, gender, etc. Beside this body dimension, body weight hand length and other arm dimensions are significantly correlated with handgrip strength. On an average, female grip strength is about 50 – 60 per cent of male grip strength. It is because the size of female hand is smaller then males. However, experimental results have not been established this gender difference unequivocally, some results indicate that female optimal is smaller but other indicates that both sexes have some optimal range. Gloves often increase handgrip strength provided there is sufficient clearance to accommodate the glove. Moreover, good surface friction with the grasped object should be provided when designing the tools for workers.

The HAMA method (Hand–Arm–Movement–Analysis) was developed to analyzer stress on hands and arms when tasks mainly consist of movement of upper hands (Christmansson 1994). This method consists of five fundamental ports, related to different risk factors that may influence work related stress. These include type of basic motion; type of grasp; position of the upper limb; external load; and perceived exertion. The fundamental parts are further divided into several sub – categories describing different types of motion, i.e. grasps, hand position and features of the external load. Information about hand arm motion is obtained by video taping the task, and information about hand arm motion is obtained by video taping the tasks and information about force exertion is described by the observer and augmented by the worker. The major advantage of this method is that the data is linked to the specific work activity, thus the relationship between the use of the body and the design of the work place and task can be obtained. One possible drawback is that there is no reference data available for the description of the exposure level. (This is also true for perhaps all observational methods), or the description of stress in body parts other than upper limbs.

2.5 Ergonomic Assessment of Agricultural Technologies / Tools

The rural women are usually employed in arduous field operations like sowing behind the plough, transplanting, weeding, interculture, harvesting and threshing. The activities in agro-processing involve cleaning, grading drying, parboiling, milling, grinding, decortication and storage. Women workers are also preferred in commercial agriculture like tea, coffee, tobacco and plantation crops. For some of operations, hand tools, and equipment are available. Other operations are carried out by women workers using their hands / feet. The tools / equipment available have been primarily developed for male workers, and women workers have to use them whenever required. As a result, the output is lower and many occupational health problems also crop up. It also happens that once the equipment are developed and made available predominant jobs which are done by women workers with hands are taken over by men and women are shifted to other labor intensive jobs.

One of the major constraints in taking the technologies to farm women is lack of suitable tools/equipment for women workers. To overcome this constraint efforts are needed to develop equipments and technologies suitable for women for reducing the drudgery and / or increasing their productivity.

For proper design of farm equipment for women workers, it is necessary to collect ergonomical data on farm women. The equipment will have to be designed keeping in view the anthropometric data of women workers in consideration. It will help to make the equipment women friendly and safe for operation.

A number of available improved tools/equipment may be operated successfully by women workers after minor modifications. It is necessary to identify such equipment/technologies and conduct ergonomical studies with women workers to assess the suitability of these equipment/technologies. It will help in quick refinement of the existing technologies to make them women friendly.

According to Nag et. al.(1988) sickle operation in harvesting has been analyzed with reference to design features of nine different types of sickles, and field and laboratory based investigation on biomechanical stresses and physiological valuation on six farmers. It has been indicated that the blade geometry contributes significantly to human performance and there is ample scope for further design optimization. The suggested modification is:

(i) Sickle weight – 200 g
(ii) Total length of sickle – 33 Cm
(iii) Handle length – 11 Cm
(iv) Handle diameter 10 Cm
(v) Radius of blade curvature – 15 Cm
(vi) Blade concavity – 5 Cm
(vii) Serrated sickle: tooth pitch – 0.20 Cm and tooth angle – 60 degrees
(viii) Ratio of the length of cutting surface of chord length – 1.20

According to Badiger and Hasalkar (2004) women are the indispensable labour force in the agricultural scenario of India. They perform almost all the agricultural activities with the age old tools and technologies. Technological empowerment of the farm women is the need of the day for increased productivity and efficiency. Various government and non-government institution have developed technologies for farm women but they have not reached the women. Under the National Agriculture Technologies project nine selected technologies were introduced to the farm women output. Samples of 10 women performing agricultural activities regularly were selected for each technology evaluation. The mean age was 31.66 years, with the mean height of 133.95 Cm and weight 43.17 kg All the physiological parameters were assessed through heart rate. The average physiological cost of work was observed to be lower while using the chaff lutter, sickle, bhindi plucker, seed treatment drum, weeder and groundnut oil stripper. Use of only three technologies namely showel, paddy thresher and wheel barrow showed increased physiological cost of work compared to traditional method. The work output increased with all the improved technologies except cutter and seed treatment drum. Most of the technologies are liked and accepted by the women.

According to Gupta et al (2004) agriculture occupies a key position in Indian economy and women in turn contribute substantially in this area. The long hours of heavy work and limited access to new technology are the major problems of the female agricultural labours. All the agricultural tools designed up-till today were based on the anthropometric measurements of males and as a result when she works with these tools they do not fit for her, she has to face lot of physical problems which need to be studied. The present study throws light on the ergonomic evaluation of these tools which are mainly handled by the farm women. A pilot study was conducted in the village of Sojitra (Gujarat) to know about the types of agricultural tools used by farm women. Three major tools were identified namely sickle, Garden rate and Garden Hoe. On the basis of pilot study a questionnaire was developed which included the working hours of the farm women with these specific tools, the types of postures they adopt, pain in specific areas of body while working and their anthropometric measurements required for designing these agricultural tools. Systematic random sampling method was adopted and every fifth family of Sojitra village with women actively participating in agricultural activities was made the sample. On the basis of the collected data, frequently used postures, pain areas caused due the use of agricultural tools were identified. A market survey of the existing agricultural tools was also done. Some tools design based on the anthropometric measurements of the farm women were developed and tried under simulated lab conditions. The existing tools were evaluated on the basis of oxygen consumption, postural analysis; perceived exertion and biomechanical load on the trunk / torso region of the body. The results demonstrated that the awkward working postures caused by poor agricultural tools design can lead to high cardiovascular loading, excessive / biomechanical stresses, extreme postural demands and worker perception that job demand relatively high exertion level.

Gupta; et al (2004) reported that right from ancient time women of Indian society are fully occupied and overburdened with three fold responsibilities of farm, home and live stock management. There are a number of agricultural tasks being performed by women viz; cleaning field, sowing, weeding, threshing, winnowing, filling, transplanting, fertilizer application, harvesting, drying, storage etc. The farm activities are time and labour intensive, monotonous, repetitive and more drudgery prone and are generally performed by women. Since all these operations are done manually, they cause considerable physical and mental fatigue and other health problems. Thus a mission mode NATP project on "Empowerment of Women in Agriculture" has been initiated to empower farm women technologically to reduce their drudgery in agriculture through education, training and technological intervention using participatory approach including self help women group. In order to achieve this objective appropriate strategies were worked out to disseminate tested women friendly agricultural technologies, viz improved sickle, tubular maize sheller, dibbler, weeders, groundnut decorticator, stripper, cleaner grader with sac holder, bhindi plucker, seed treatment drum, spraying safety kit, grain mill etc. for drudgery reduction of farm women. In initial phase of the project environment was built up. A number of on-campus and off-campus training programmers were organized, linkages were developed with GOs and NGOs., continuous monitoring was done to have a check on the use of equipments by farm women. The set method logical approach thus used in NATP project helped to overcome drudgery of farm women in agriculture. The ergronomic assessment of selected agriculture technologies also revealed that the improved equipment were economical in terms of time and energy and improved health and efficiency of the farm women.

According to Solanki et al (2004) their study examined the effect of Jowar harvesting on a cardiovascular system of farm women by using different sickle. While Jowar harvesting, mean heart rate of women workers during work was 117.06 beats/min with local sickle as against 119.8 beats/min and 126.56 beats/min for MAU sickle cum Khurpi and Vaibhav sickle. There was an increase of 20.94, 20.85 and 21.86 beats/m^2 of area harvested with traditional MAU and Vaibhav sickles. MAU sickle cum Khurpi could help to reduce the drudgery by 0.4% with an increase in output as 10%m^2 /hr as against traditional sickle during harvesting of Jowar.

Weeding is an important agricultural activity performed invariably by the rural women in almost all the crops grown in Northern Karnataka for maximum number of days. Earlier studies in the three agro climate zones of Northern Karnataka have shown that weeding in performed on an average for 79 days per year with the maximum drudgery index score of 53.11 percent (Biannual reports of AICRP – FRM, 1999-2001). Heart rate is one of the important parameters for estimating energy expenditure and assessing the physiological workload of any physical activity. The research focused on the introduction of improved weeding tool – SARAL Khurpi to reduce the drudgery of farm women and ergonomically assess and compare the physiological work load of women with the improved weeding tool in comparison to the existing method through heart rate and perceived exertion method. The results revealed reduction in the average total cardiac cost of work and physiological cost of work while performing weeding with the improved tool i.e., Saral Khurpi compared to existing tool. Significant number of respondents perceived weeding with improved tool – Saral Khurpi as very light compared to existing Khrupi. Almost all women felt that the Saral Khurpi is sharper, light in weight, quick in work and easy to handle compared to the existing Khrupi. (Hasalkar et al 2004)

Findings of the study by Nadre and Yeole (2004) indicated that the performance and evaluation of wheel type hand hoe e.g. Krishiratna hoe, was compared with local hand tools such as khrupi. There are numerous problems in weeding in standing crop the main constraint lies with availability of labour, suitable tool, timely operations and tediousness of job in traditional method of weeding. The time required to cover area of $100m^2$ for the Krishiratna hoe was 29 minutes and time required for the same area covered by Khurpi was 2 hr. 19 minutes. Field capacity was also more than Khurpi. Cost of weeding with Krishiratna hoe was Rs. 158=00/ha and with Khrupi was Rs. 590=00/ha. Weeding one ha area with Krupi 30 women days were required costing Rs. 590=00/ha whereas with Krishiratna hoe the same work was completed within 7 women days. The daily earning of farm women labour with this hoe was increased by Rs. 65=00.

Pund (2004) reported that harvesting is one of the important operations in the field of agriculture harvesting machines are not still common in India and this routine remains as primitive as ever. The poor economic condition of Indian farmers and fragmented land holding are major hindrances to the introduction of harvesting machines in Indian Agriculture. Among the hand tools used for harvesting, sickle maintains its importance due to ease of operation, low cost and versatility. Therefore, a new sickle was developed at college of Agricultural Engineering and Technology, Dr. Panjabrao Deshmukh Krishi Vidaypath, Akola (Maharstra) on the basis of anthropometric parameters (viz. hand breadth at metacarpal, hand breath across thumb, palm length, inside and outside grip diameter) and agro-technical requirements (namely plant height, diameter of stem and first branch height). The weight of developed sickle was 325 gms whereas overall length was 365 mm. The handle grip diameter was 35 mm and stalk was given the angle of 15^{0} with horizontal plane. A puller having length 55 mm and cross edge width of 10 mm was also provided. The developed sickle was tested for harvesting of safflower crop at central research station farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola and it's performance was compared with Akola and region sickle and

Chandrapur region sickle. The plots of 200 m^2 were marked and heart rates of the subject during the sickle operation and time to finish the job were recorded. The forward speed and output during the operation of developed sickle was found to be 1.5 m/min and 170 m^2/hr. respectively. However, AHR (increase in heart rate over the rest) for developed sickle was found to be 31.0 beats/min. On the basis subjective assessment scale, subjects favoured for the adoption of developed sickle.

According to Solanki et. al. (2004) experiment was conducted to evaluate tools to minimize the drudgery in selected farm activity weeding. Main objective of the study was to observe the effect of existing weeding tools on the cardio-respiratory responses of farm women worker and to compare the physiological cost of living weed. With the cost of traditional method of weeding average working heart-rate, energy expenditure of work were the parameter for comparison. Two weeders namely peg type and MAU wheel hoe were tested in comparison with Khrupi. All the parameters selected for determining physiological work load indicated that workload of weeding activity increased when it was performed by using peg type weeder and MAU wheel hoe was 209.96 and 207.7 m2/hr respectively. Comparatively more than Krupi 62.25 m2/hr but also increase in heart rate (23.75 and 26.52 beats/min) and energy 10.44 kJ/min.

2.6 Body discomfort / Occupational Health Hazards Experienced by Women Farmers

Musculoskeletal disorders (MSD) are injuries and illnesses of the muscles, tendons, ligaments, joints, nerves, vessels and supporting structures that are involved in locomotion. They are usually manifested by pain, numbeness, tingling, swelling or loss of function, and are primarily located in the upper limb, back and, to a lesser extent, the lower limb The tern "MSD" is not a diagnosis but a category of specific and non-specific diagnosis related to the above tissues that have some common features MSD related to work occur when there is an imbalance ın the work system that overwhelms the ındividual either suddenly or over weeks, months or years (gradual onset). Examples of these disorders most often related to workplace activities and conditions.

Workplace factors are not the sole cause of MSD. There can be a number of personal factors that can contribute to MSD either with or without contribution of work factors, including systemic disease, recreational activities, age and gender. It is only when workplace factors are significant contribute the cause or exacerbation of these MSD that they become "work related" of work related musculoskeletal disorders. Although the diagnosis of a specific order may be made in the same way irrespective of what caused it the importance of distinguishing these factors are primary and has more to do with prevention possibilities in the workplace. Personal factors such as age and gender are not as easily modifiable as changing the location or type of tool used in a workspace.

A number of studies reported by Bedale (1924), Busca and Granati (1945), Keiser and Weaver (1962), Durwin (1967), Snook and Trvin (1969); Burn (1979), Rama (1990), Sharma and Thakur (1998) found significant relationship between the fatigue and rate of perceived exertion. Pulse rate, respiration rate, heart rate, energy expenditure working in any unusual posture increased the loading on the heart rate therefore oxygen consumption rate simultaneously increased. The consequences of poor working conditions are seen as musculoskeletal disorder, illness and injuries sustained from the work.

Brantton (1969) suggested that discomfort results in an "urge of move" caused by a number of physical and physiological factors. Pressure on soft tissues can cause ischemia (depletion of the local blood supply to the tissues), resulting in a shortage of oxygen and a buildup of carbon-dioxide and waste products such as lactic acid This condition is known to lead to pain or discomfort.Active muscles convert glucose oxygen to carbon dioxide and water, liberating energy in the process They require a regular blood supply to replenish fuel and remove the waste products. During rhythmic exercises involving eccentric and concentric contractions, blood flow is facilitated by the pumping action of the muscle. Fatigue may ultimately occur as a result of the depletion of the metabolites (glucose or glycogen is one of the main causes of fatigue in endurance athletics such as marathon runners. When muscles contract, they occlude the blood vessels within them and thus diminish their own blood supply. During sustained isometric contractions, the muscle is starved of oxygen and waste products accumulate as oxygen independent metabolic processes takes place. Discomfort and fatigue occur rapidly during sustained isometric contractions for this reason.

Jearth (1970), Vimal (1992) and Varghese et al (1994) studied the occupational disease and musculoskeletal health problems of workers in agricultural work. It was found that agricultural workers faced toxic hazards while using fertilizers, insecticides and herbicides. They were victims of byssinosis, bagossosis, pulmonary tuberculosis and occupational cancer. Agricultural workers were in close contact with animals or their products due to this they suffered from pneumoconiosis and allergies. Women workers also involved standing in stagnant water during transporting of rice etc. therefore they easily picked up parasitic infections. They also suffered from various musculoskeletal problems i.e. about two - third of the subjects complained pain in upper arm.

Kroemer (1970) had shown that muscles fatigue rapidly under conditions of static loading even at low workload. Skeletal muscle can be regarded as the largest organ in the body. It is essential for all activities, rapid movement, and large forces can stimulate pain receptors in muscle. Such movements are common in the workplace, during participation in sports, and in the performance of everyday activities. Since skeletal muscle makes up

40percent of the tissues of the body, it should come as on surprise that many of the aches and pains we experience in our daily lives are of muscular origin.

Van Wely (1970); Westgaard and Aaras (1984) reported how various musculoskeletal symptoms appeared in operators performing tasks in postures which are largely static and which may well be associated with longer-term conditions and injury may experience. (Cited in Haslegrave, 1994).

Chaffin (1977) reported that the muscle fatigue starts as a feeling of discomfort, which is successfully increased to a dull, burning pain that at last makes all further muscle activity impossible. The localized muscle fatigue is characterized on hand by discomfort-pain, on the other by a decrease of muscle force. Chaffin (1977) also reported the character of localized muscle fatigue as:
Grade I: a feeling of tightening or slight cramp in the muscle;
Grade II: A sustained feeling o cramp, with a deep, intermittent, burning pain;
Grade III: A continues burning pain with a wish to cease the muscle work;
Grade IV Impossibility to go on with the muscle activity

According to Edwards (1981) the possible meaning of the scientific term 'fatigue' can be impaired intellectual performance, impaired motor performance, increased EMG activity for a given performance, shift of the EMG power spectrum towards low frequencies, or impaired force generations.

Waddel(1982) stated that back pain is a complex problem and detailed investigation of back problem is best left to expert clinicians. If a worker complains of back pain, the ergonomist's natural inclination is to search for cause in the workplace. In the case of strenuous jobs, this approach may be appropriate, but in less obvious cases, non-occupational and potentially more serious causes should be considered.

According to Astrand and Rodahl (1986) the feeling of fatigue is also a physiological warning signal and neglecting this signal may have harmful consequences for the muscles.

As studied by Gallagher and Bobick (1986) that lower back strength was reduced in kneeling postures because the strong leg muscles could not be used to aid the back muscles. (cited in Haslegrave, 1994).

Batliwala (1988) and Vimal (1992) attempt to study occupational health hazards and accidents. The consumption of agro-chemicals had increased tenfold over the last three decades. There were 52.00 % cases of pesticides poisoning and 89.00 % work accidents, 69.00 % work wounds. It was found that 40.00 % of all infant deaths occurred in the monsoon months (July o October) when the fields were being prepared for sowing operations and seedling the figure worse to 61.00 %. Agriculture labourers were also prone to snake bites as well as bites of the insects.

Gilad and Kirschenbaum (1988) investigated back pain across a broad spectrum of jobs. More back pain was found in groups who worked in unusual body positions or with the trunk laterally or forward in standing or sitting.

Kumar (1990) has shown the mechanical load is a risk factor for low back pain. He used a two-dimensional, static mathematical model of spinal loading to estimate the shear and compression force sat the lumbosacral and thoraco-lumbar joints. These forces were found to be higher in workers.

Discomfort is the body pain arising as a result of the working posture and / or the excessive stress on muscles due to the effort involved in the activity. In many studies carried out in the country, this parameter has been used for comparison of drudgery involved in different activites / equipment and those include Gite and Yadav (1991), Gite et. al (1993) and Gite (1996)

Chaffin and Andersson (1991) studied that regarding the need to consider not only the horizontal distance at the origin of the lift as low back risk factor, but also the trajectory angle and dynamics of the load being lifted near the origin of the lift (Cited in Chaffin and page, 1994).

Wall, et al (1991) stated that the increased static load on neck muscles might cause pressure ischemia and starve the muscle tissues form fuel and oxygen. Pain in neck and shoulders may result, causing muscle Spam (reflex contraction of the muscles). This condition, in turn, may exacerbate the pain and leads to vicious circle (Cited in Joshi, 1998).

Saikai et. al. (1993) reported that agricultural work has resulted in a increase in size of female labour forces making it more than 60 percent of the population engaged in agriculture. There is still a considerable muscular work load in women's job and this causes various health problems of the women farmers. Results of the study also showed that backache was prevalent among most of these women.

Boocock et al (1994) reported that work tasks involving lumbar extended postures (overhead work) are relatively common, in what may incur moderately high compressive loads on the lumber spine, and are a potential source of occupationally related back pain. It had been demonstrated that simple ergonomics intervention at the work place could result in a reduction of lumbar extension required for overhead work loading, remains to be determined.

De Looze, et al (1994) reported that different aspects of working body posture are considered to be related to specific injuries: for instance, the need to bend the torso is generally considered to be an important factor in low back pain, repetitive or prolonged elevation of the arms above the shoulders is thought to be related to repeated or prolonged knee flexion. If such injuries are to be prevented, these particular postures should be avoided as much as possible. To this end the frequency of their occurrence should be assessed in normal tasks.

Oberg, et al. (1994) reported that in ordinary working life the muscular load level varies within time periods. It is allowed to do heavy muscle work, but only for a short time. On the other hand prolonged work at low-load level can be harmful. As studied by Oberg, et al (1994) the knowledge about muscle fatigue can be used in ergonomics for the design of work places and working tools. It can also be used to design and improve working method and working routines.

Bredger (1995) stated that low back pain also can be caused by muscular fatigue in a standing person had to work with the trunk inclined forward. This posture puts static load on the low back muscles, which rapidly fatigue.

Sharma (1995) reported that negative correlation (r = - 0.961 sig. at 0.01 level) was found between frequency of occurrence of occupational health problem and output of women workers

Xiaing et. al (1999) found that back pain in an occupational health problem among farmers on small operations or family farms. A total of 194 farmers (26.20 %) reported to have at least one episode of back pain was the predominantly affected part of the body in 45.40 % of makes and 43.90 % of females. Back pain was brought on by repeated activities.

According to the Guangyan and Buckle (1999) physical exposure to risks for potential work related musculoskeletal injuries has been assessed using a variety of methods, including Pen and Paper based observations methods, video taping and computer aided analysis, direct or instrumental techniques and various approaches to self – report assessment. These methods are critically reviewed. The applications of these techniques in ergonomics and epidemiologic studies are highlighted. Finally a strategy that considers both the ergonomics experts view and the practitioner's needs for developing a practical exposure assessment tool is then discussed.

Repetitive strain injury describes a range of conditions caused by the constant repetition of certain movements. They are injuries to muscles, tendons and nerves caused by over use or misuse. They most commonly affect the hands, wrists, elbows, arms, shoulders, back or neck. Unlike strains and sprains, which usually, result from a single incident (called a cure trauma), repetitive strain injuries develop slowly over time; thus, they are also called cumulative trauma disorders or muscular skeletal disorders. (The Week 2004)

The review of existing literature covers various topics, namely organic farming, women in agriculture, anthropometric measurements. Physiological cost of work in terms of heart rate, energy expenditure, total cardiac cost of work, muscular stress and postural stress, ergonomic assessment of agricultural tools / technologies, body discomfort / occupational health hazards experiences by women farmers.

After reviewing the extensive literature it was found that although many research studies has been conducted on participation and time expenditure of women in agricultural activities. There is dearth of information on physiological cost of work done by women farmers and occupational health hazards experienced by them and how to reduce postural stress, muscular stress and body discomfort for enhancing the efficiently with special reference to women engaged in organic farming.

It is important to protect our environment from indiscriminate use of chemicals, synthetic fertilizers; therefore a need was felt to conduct a study to assessment and modification of technologies used by women in organic farming.