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Comparison of Anthropometric Parameters of Women and Men Agricultural Workers Pertaining to Tractor Operator Workspace

K. T. Arya [a++*], C. Ramana [b#], B. Ravindra Reddy [c†], B. HariBabu [a‡] and M. V. Ramana [c^]

[a] Department of Farm Machinery and Power Engineering, Dr. NTR College of Agricultural Engineering, Bapatla, Andhra Pradesh, India.
[b] Regional Agricultural Research Station (RARS), Tirupati, Andhra Pradesh, India.
[c] Department Agricultural Engineering, SV Agricultural College, ANGRAU, Andhra Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Women are equally capable of carrying all the works that the men can do at the agricultural field. But it is strange that they were not selected for operating agricultural machineries. Especially they were not well expert in tractor operation. So a study was conducted to analyse the anthropometric

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[++] Ph.D. Scholar;
[#] Principal Scientist & University Head;
[†] Project Officer, ITDA Office;
[‡] Assistant Professor;
[^] Professor;
**Corresponding author: E-mail: aryakthankappan72@gmail.com;*

and strength parameters required for the tractor operator workspace design. The comparison of anthropometric data indicated that out of twenty seven anthropometric parameters except ten parameters via. Buttock Popliteal height, elbow rest height, wall to acromian, shoulder grip length, thigh clearance sitting, hip breadth sitting, grip diameter, grip span and span akimbo were having higher values for female workers than that of male workers.

Keywords: Anthropometry; constraints; tractor; women; workspace.

1. INTRODUCTION

The 2015-16 agriculture Census record of India shows that about 11.72% of the total operated area in the country was managed by female agricultural workers. But, in most of the situations women's contribution in the agricultural and food production was not remarked and quantified accurately. Usually, their contribution was recognized along with men's contribution [1]. Agriculture is carried out by labour contributions of men and women workers in a collaborative manner [2]. For example, men provide the labour to clear the field and women plant and weed the crops. At the same time, both men and women are involved in harvesting [3]. Hence, it becomes impossible to categorize the output by gender [4]. But the truth is that women workers are facing a lot of constraints in the same field.

Farm mechanization leads an important role in the field of sustainable agriculture. Human labour was replaced by machinery due to contribution of farm mechanization. Machines are the acting labour in the agriculture field [5]. It is impossible to have a day without get in touch with a machine that may be useful for any stage of agricultural field operation. Now, main mechanical power source in the field is tractor. Tractor operation is become mandatory in the agricultural field. Men agricultural workers are indented to operate tractor than women workers. Since women are capable of operating machines, it is necessary to consider them in the tractor operation.

Ergonomics is the scientific study which deals with the relationship between a person and their working environment. Proper matching machine requirements with the human capabilities would be mandatory for optimum performance of any man-machine system [6]. For the purpose anthropometric data is necessary in connection with design and development of machines under ergonomic considerations. Hence, this study was conducted to focus on the anthropometric data required for tractor operator workspace design and comparison of anthropometric data of male and female agricultural workers.

2. MATERIALS AND METHODS

Anthropometric parameters required for tractor workspace design was identified and measured at the laboratory. Anthropometric data of both men and women workers were analysed and comparison was done.

2.1 Selection of Subjects for the Study

Research was carried out to identify the anthropometric parameters fit to the design of tractor workspace. An effort was taken to compare the required anthropometric data using both men and women agricultural workers. Anthropometric measurements were carried out on 20 male workers and 20 female workers worked as tractor operator and agricultural farm labours at Regional Agricultural Research Station (RARS), Tirupati. The selection process was done based on their age group and physical health conditions. The age of selected workers was lies between 25 to 48 years.

2.2 Measurement of Anthropometric Parameters

Twenty seven anthropometric parameters which were required for the design of tractor operator workspace [7] were identified and are given in Table 1. The parameters were measured at the laboratory (Fig. 1). The observations were taken carefully to measure the dimensions in correct posture. Subjects were asked to stand on a flat surface to take vertical dimensions. Moreover other dimensions were measured in sitting posture for that subject were asked to sit with their body vertically erected, while their shoulders and head touched the same vertical plane [8]. The measurements were recorded using a vertical scale and tape.

Table 1. Anthropometric parameters suitable for tractor operator workspace design

Sl. No.	Body Dimension	Brief Description
1	Weight, kg	Body weight as measured on a physician scale (without shoes)
2	Stature	Vertical distance from floor to vertex of head
3	Vertical reach	The vertical distance from the standing surface to the height of the middle finger when arm, hand and fingers are extended vertically.
4	Biacromial Breadth	The distance across the shoulder from right to left acromian. The subject stands erect and looks straight forward.
5	Sitting eye height	The height from the sitting surface to the external canthus. The subject sits erect and looks straight forward.
6	Popliteal height sitting	The height of the underside of the upper leg above the footrest surface. The subject sits erect and looks straight forward.
7	Buttock Popliteal length	Horizontal distance from the rear most surface of buttock to the back of lower leg.
8	Hip breadth	The maximum breadth of the lower torso. The subject stands erect and looks straight forward.
9	Interscye breadth	The distance across the back between the posterior axillary folds at lower level of the armpit
10	Sitting acromial height	The height from the sitting surface to the top of the acromian. The subject sits erect and looks straight forward.
11	Elbow rest height	The height of the bottom of the tip of the elbow above the sitting surface
12	Wall to acromian distance	The horizontal perpendicular distance from the wall to acromian measured when the subject stands erect against a wall.
13	Shoulder grip length	The horizontal distance from a pointer held in the subject's fist to a wall against which he/she stands, measured with the arms extended horizontally.
14	Elbow grip length	The distance from the tip of the bent elbow to the corner of the clenched fist.
15	Thigh clearance height sitting	The height of the highest point of the thigh above the sitting surface. The subject sits erect and looks straight forward.
16	Knee height sitting	The height from the footrest surface of the musculature just above the knee. The subject sits erect and looks straight forward.
17	Buttock knee length	The horizontal distance from the rear most surface of the buttock to the front of the knee cap.
18	Foot length	The length of the foot measured parallel to its long axis.
19	Foot breadth	The maximum breadth of the foot as measured at right angles to its long axis.
20	Heel breadth	The maximum breadth of the heels as measured below the projection of the ankle bones.
21	Hip breadth sitting	The breadth of the body as measured across the widest portion of the hips. The subject sits erect looking straight forward.
22	Grip diameter	The diameter of the widest level of a cone which the subject can grasp with his /her thumb and middle finger touching each other.
23	Grip span	The maximum distance between the palm and the tip of middle finger when fingers are in grip position.
24	Hand breadth across thumb	The breadth of the hand as measured at the level of distal end of the 1st metacarpal of the thumb.
25	Span akimbo	The distance between the elbow point measured with the arms flexed and held horizontally, palms down, fingers straight and together and palm and thumbs touching the chest at the nipple level.
26	Span	The distance between the tips of right and left middle finger when the subject arms maximally extended laterally.
27	Functional leg length	The distance from the back at the waist level to the heel, measured along the long axis of the leg with the subject sitting erect on the edge of a chair, leg extended forward with his knee straightened.

Fig. 1. Anthropometric measurement of male and female workers

3. RESULTS AND DISCUSSION

3.1 Comparison of Anthropometric Data

Anthropometric data collection of both men and women agricultural workers at RARS, Tirupati is presented in Table 2.

Comparison of anthropometric data of male and female agricultural workers is represented in (Fig. 2). The comparison of data indicated that out of twenty seven anthropometric parameters except ten parameters via. Buttock Popliteal length, elbow rest height, wall to acromian, shoulder grip length, elbow grip length, thigh clearance sitting, hip breadth sitting, grip diameter, grip span and span akimbo having higher values for female workers than male workers. Remaining values were shown to be higher for male workers. The average stature of male and female workers was 1744.0 mm and 1568.0 mm respectively. The average stature of female workers was found out higher than the average stature of female workers in Kerala which is 1509.2 mm [9]. The difference between 5^{th} and 95^{th} percentile value is also given in Table-2 which is helpful in defining the possibility of an adjustable design if farm equipments. Average value of data may not be sufficient to design equipment [10,11] since it only represents the size of a person who bearded that value. So to have proper design of equipments to suit majority of the users, the concept of percentiles such as 5^{th} and 95^{th} percentile values were used [7,12].

The tractor operator workspace design includes access to workplace, workplace dimensions, seat design, control locations and actuating force required to operate controls [13,14,15,16,17]. The above selected anthropometric measurement was relevant to each mentioned aspects. Considering the workspace access and location of controls, wall to acromian distance, elbow rest height, thigh clearance sitting, buttock knee length, buttock popliteal length, foot length, hip breadth sitting and foot breadth were the anthropometric data used for the design [18]. From the (Fig. 2), the value of Buttock Popliteal length, elbow rest height, wall to acromian, shoulder grip length, elbow grip length, thigh clearance sitting, hip breadth sitting, grip diameter, grip span and span akimbo were higher for female workers than male workers. Moreover, male workers are indented as the operator of tractors and other equipments, their anthropometric data was taken prominently for the workspace design.

Hence, the results of this study revealed that it is highly recommend to consider the women anthropometric capabilities for the design of tractor operator workspace.

Table 2. Anthropometric data of male and female agricultural workers

Sl. No.	Body dimension	Male					Female				
		Mean	SD	CV (%)	5^{th} per	95^{th}per	Mean	SD	CV(%)	5^{th}per	95^{th}per
1	Weight, kg	70.40	9.94	14.11	59.45	85.30	58.20	8.99	15.45	45.45	68.65
2	Stature	1744.00	8.97	5.14	1621.0	1815.0	1568.0	8.47	5.40	1484.50	1670.0
3	Vertical reach	2170.00	17.52	8.07	1940.0	2337.0	2015.0	8.32	4.13	1934.50	2115.0
4	Biacromial breadth	273.00	2.98	10.93	244.50	320.00	244.00	1.05	4.30	230.00	257.75
5	Sitting eye height	751.00	1.52	2.03	734.50	770.00	726.00	3.10	4.27	683.50	765.50
6	Popliteal height sitting	455.00	3.34	7.34	420.00	503.00	420.00	3.43	8.17	374.50	461.00
7	Buttock popliteal length	431.00	4.70	10.91	360.00	465.50	442.00	1.03	2.34	430.00	455.50
8	Hip breadth	394.00	3.66	9.28	337.00	420.00	347.00	2.11	6.08	324.50	375.50
9	Interscye breadth	398.00	0.42	1.06	390.00	400.00	361.00	2.02	5.61	334.50	385.50
10	Sitting acromial height	623.00	4.16	6.68	560.50	660.00	556.00	1.51	2.71	534.50	575.50
11	Elbow rest height	240.00	1.83	7.61	220.00	270.00	282.00	2.90	10.28	237.00	310.00
12	Wall to acromian distance	95.00	0.53	5.55	90.00	100.00	128.00	0.92	7.18	114.50	140.00
13	Shoulder grip length	703.00	4.35	6.18	670.00	780.00	761.00	4.75	6.24	688.00	810.00
14	Elbow grip length	363.00	2.00	5.52	330.00	380.00	409.00	4.36	10.65	350.00	462.00
15	Thigh clearance height sitting	80.00	0.00	0.00	80.00	80.00	97.00	1.06	10.92	84.50	111.00
16	Knee height sitting	536.00	2.37	4.41	520.00	580.00	484.00	3.41	7.04	444.50	525.50
17	Buttock knee length	532.00	4.49	8.44	480.00	590.00	509.00	1.20	2.35	494.50	525.50
18	Foot length	240.00	1.33	5.56	220.00	260.00	229.00	1.31	5.71	214.50	247.75
19	Foot breadth	52.00	0.42	8.12	50.00	60.00	90.00	0.00	0.00	90.00	90.00
20	Heel breadth	115.00	0.53	4.58	110.00	120.00	43.00	0.26	6.00	40.00	45.00
21	Hip breadth sitting	389.00	5.06	13.02	339.00	460.00	327.50	2.42	7.38	300.00	360.00
22	Grip diameter	71.50	0.24	3.38	70.00	75.00	953.00	9.29	9.74	839.00	1065.0
23	Grip span	81.00	0.74	9.11	70.00	90.00	495.00	11.47	23.18	384.50	655.50
24	Hand breadth across thumb	120.50	0.83	6.90	110.00	130.00	109.50	0.16	1.44	107.25	110.00
25	Span akimbo	718.00	6.03	8.40	640.00	781.00	848.00	3.68	4.33	800.00	890.00
26	Span	1848.00	8.82	4.78	1717.0	1925.50	1609.00	8.60	5.34	1524.50	1715.50
27	Functional leg length	874.00	3.98	4.55	834.50	930.00	793.00	5.48	6.91	729.00	866.50

(All dimensions are in mm unless it is specified)

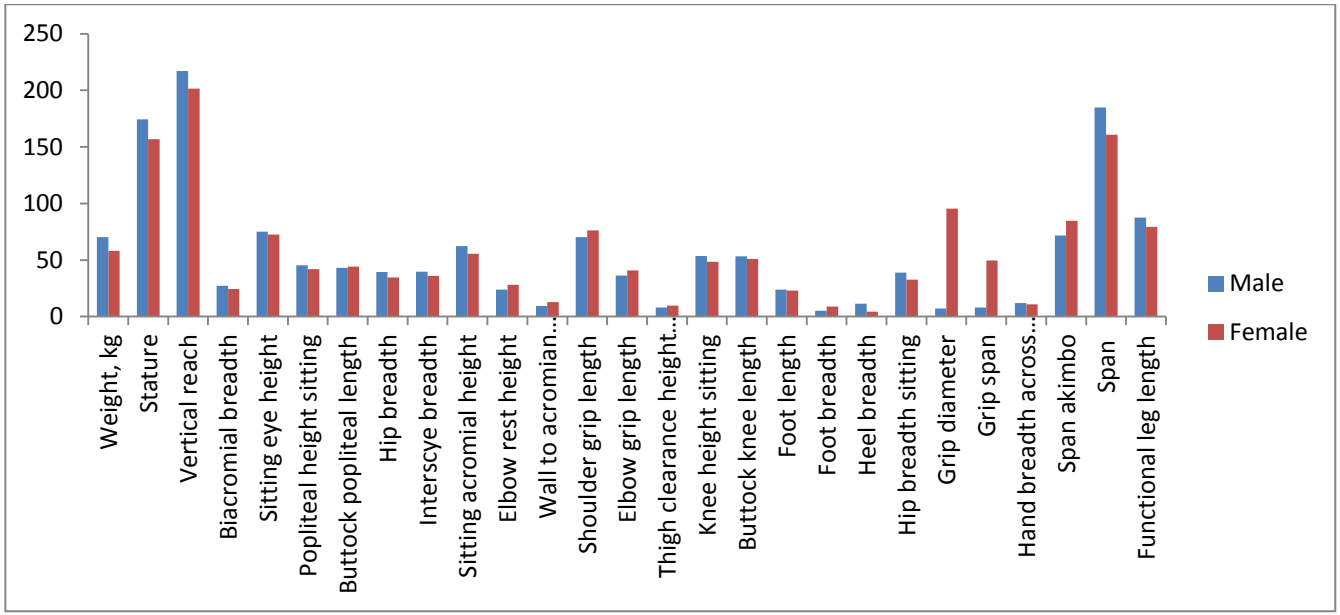

Fig. 2. Comparison of anthropometric data of male and female agricultural workers

4. CONCLUSION

Considering the facts that the machines are becoming the active labour for agricultural operation and increase in the strength of women agricultural workforce it is necessary to train them to operate those tractors and machineries. But majority of tractors were designed to suit with men anthropometric capabilities. Therefore it is not guaranteed that the tractor operator workspace may suit to women capabilities. Results obtained from comparison made on the anthropometric data reveal the need to embark on an ergonomic evaluation of an existing farm equipment and tractor workspace, so that it can be re-designed to suit the anthropometric capabilities meant for both men and women.

APPLICATION OF RESEARCH

The presented research can be utilized to the modification of tractor operator workspace design to suit women anthropometric parameters.

RESEARCH CATEGORY

Agricultural Engineering, Ergonomics.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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