A data-driven approach to predict anthropometric dimensions of Central Indian women workers via principal component and factorial analysis

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In India, the contribution of women workers in agriculture is steadily increasing daily, which governs a major share of the Indian agriculture sector. Hence farm tools and equipment must be designed by considering region-specific anthropometric data of women workers. However, measuring and recording anthropometric dimensions is time-consuming and economically taxable. In the present study, regression models have been developed to predict different anthropometric dimensions using anthropometric data of 79 body dimensions of 720 women workers in central India aged between 25 and 55 years. Principal component and factorial analysis techniques were employed to extract significant body dimensions. The major objective of this study was to predict various anthropometric dimensions by regression models so that the time and effort required for several body dimension measurements would be reduced.

Keywords: Agriculture, correlation, factor analysis, principal component analysis, women workers.

INDIA is an agrarian country and more than 250 million people work in agriculture and agro-based industries. Women play a crucial role in shaping the national agricultural economy in rural and tribal communities. By 2030, the contribution of women will account for 45% of the total agricultural workers and thus women will play a key role in this sector[1]. Therefore, the development of machinery and workplaces that are ideal for women workers is the need of the hour to improve the comfort of women and for to promote women's empowerment.

In India, a variety of work-related health issues such as excessive physical exertion, task-related exhaustion, operational problems and decreased efficiency are common as most of the agricultural operations are carried out in the squatting and bending posture[2,3]. Poor working conditions and discordance between anthropometric traits and the dimensions of the equipment/machines utilized are important factors for the genesis of such disorders[4,5].

Man, machine and environment are necessary for the optimal performance of workers. To achieve this, applying anthropometric dimensions of the target user population in product development is the most important criterion[6,7]. The body size and shape vary from person to person and it is rarely possible to provide machines suitable for all workers. Hence the designed equipment/machine/tools should be suitable for most agricultural workers rather than just single users[8]. Therefore, designers use anthropometric data to accommodate 90% of the user population. Several researchers have collected and compiled anthropometric data on the Indian population[9–13]. However, such activities were mostly focused on a single region/community, or a specific need.

Anthropometry is the measurement of human body dimensions, which is used in human-centred design like automotive and aircraft design, vehicles, agricultural machinery, workstations, etc. It aids in the enhancement of human efficiency, productivity, safety and work comfort[14]. The distance between distinct landmarks, which are dictated by topographic aspects of the body surface or skeletal architecture, is measured by anthropometrists. Several methods for measuring anthropometric dimensions, including manual and 3D scanning. The body scanning technique can measure more people in a shorter period, but it is costlier than traditional methods. The post-scanning processing may require some time before completion, and scan-derived single-dimension measurements are not always at par with those measured by traditional methods. In India, anthropometric dimensions are manually measured using a measuring tape, calliper, Harpenden-make anthropometer, stadiometer and sitting height table. However, manual measurement has certain limitations, e.g. it is resource-consuming, time-consuming, economically taxable and necessitates intimate contact with people[15]. The average time required for anthropometric assessment and data recording for one person is 75 min

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(ref. 12). Also, the reliability, reproducibility and accuracy of data are sometimes questionable. Considering the limitations of manual and 3D scanning methods, measuring anthropometric dimensions is not cost-effective. So, the main aim is to obtain detailed body dimensions accurately and cost-effectively. The prediction of anthropometric dimensions using numerical methods rather than their actual measurement is gaining popularity nowadays. Several researchers have worked out relations between body segments from pre-existing anthropometric databanks and proposed regression equations to forecast body size and shape[16,17]. The main aim of this study was to develop a set of models to estimate the majority of anthropometric dimensions using the least number of body dimensions to reduce the efforts required to collect these dimensions.

Materials and methods

Selection of subjects

The anthropometric data were taken from 720 women agricultural workers aged 25–55 years from nearby villages of the Bhopal region in central India (23.2599°N, 77.4126°E). Care was taken while selecting subjects regarding their physical fitness, history of illness and willingness to participate in the study.

Anthropometric dimensions

Totally 79 body dimensions were identified for the study based on previous research[10,18,19]. The terminologies of anthropometric dimensions as mentioned in the book on anthropometric sources were used in this study[19]. Due attention was also given to ISO 7250 and the procedure recommended by the Conference on Standardization of Anthropometric Techniques and Terminologies[20]. The anthropometric parameters were categorized into six classes. The first class consisted of 37 dimensions of the subjects, which were measured in standing position, the second class had 16 dimensions in sitting position and the third class had 12 hand dimensions measured while the subjects were standing and sitting. Seven foot dimensions, three head dimensions and four skinfold dimensions made up the fourth, fifth and sixth classes.

Equipment used

The anthropometric dimensions of selected subjects were measured using a Harpenden-make anthropometer, stadiometer and sitting height table, skinfold calliper and weighing balance. The inside grip's diameter was measured using a handcrafted wooden cone. A portable digital weighing balance with the least count of 0.1 kg was used to measure body weight.

Procedure

A group of 8–10 subjects were allowed to have light breakfast and wear comfortable clothes. They were informed about the purpose of the study and the data collection process. The workers were compensated for their work loss. All measurements were made by two observers. To ensure scientific rigour, body dimensions were taken from the right side. For the collection of anthropometric data, the procedure explained by Majumdar *et al.*[18] was followed. The anthropometric dimensions were measured in standing and sitting positions. In the former posture, the subjects were made to stand straight so that their body weight would be equally distributed on their lower limbs, while in the latter position the angle between the torso and thighs as well as thighs and shank was kept nearly 90°. Before taking the actual measurements, a standard protocol was developed for using different equipment and procedures to limit inter- and intra-researcher variations. All dimensions of each subject were measured twice.

Statistical analysis

The measured body dimensions were organized in increasing order on the basis of height of the subjects using Microsoft Excel tool. To reduce human errors, arbitrary data and outliers were carefully deleted. The statistical parameters such as mean, standard deviation (SD), standard error mean (SEM), coefficient of variation (CV), percentile values (5th and 95th), skewness and kurtosis of selected women workers were estimated. The data normality for anthropometric parameters in the study was ensured by calculating skewness and kurtosis, which ranged between –1 and +1. For values tending towards +1, the tails of anthropometric measurements broadened more towards the right side of the mean, while for values tending towards –1, it fell on the left side of the mean. The Pearson correlation coefficients (PCC) of anthropometric dimensions were worked out to identify the degree by which the dimensions were correlated with one another. Positive and negative kurtosis showed peakness and flatness of data distribution respectively.

A multivariate data analysis (principal component analysis) was carried out with orthogonal rotation to reduce intercorrelated variables into tiny groups of independent elements. The principal component and factor analysis (PCFA) with varimax rotation[21] was used for 72 anthropometric dimensions of 600 subjects to categorize dimensions in higher order groups, which would accommodate the highest part of the variance. For analysis, only the key components having eigen values more than or equal to 1.0 were considered. The anthropometric body dimensions were grouped into four sections for PCFA. Thirty-seven stature-related body dimensions measured in standing posture were grouped into the first section. In the second section, 16 anthropometric dimensions measured in sitting position were grouped.

Table 1. Results of factor analysis of 37 anthropometric dimensions in standing posture

	Factor pattern					
Dimensions	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Weight (kg)	0.601[a]	0.755[a]	–0.008	0.023	–0.100	–0.055
Stature (mm)	0.901[a]	–0.237	–0.098	0.117	–0.062	0.016
Vertical reach (mm)	0.921[a]	–0.267	–0.032	–0.019	0.083	–0.028
Vertical grip reach (mm)	0.924[a]	–0.258	–0.002	–0.006	0.036	–0.014
Eye height (mm)	0.918[a]	–0.263	–0.086	0.092	–0.068	0.027
Acromial height (mm)	0.905[a]	–0.350	–0.031	0.110	–0.055	0.036
Elbow height (mm)	0.875[a]	–0.319	–0.052	0.190	–0.119	0.071
Olecranon height (mm)	0.878[a]	–0.291	–0.078	0.229	–0.069	0.037
Iliocrystale height (mm)	0.876[a]	–0.362	–0.043	0.033	–0.100	–0.109
Iliospinal height (mm)	0.847[a]	–0.382	–0.121	0.023	–0.121	–0.151
Trochanteric height (mm)	0.808[a]	–0.404	–0.107	–0.001	–0.139	–0.132
Metacarpal-III height (mm)	0.747[a]	–0.241	–0.051	0.375	–0.194	0.104
Knee height (mm)	0.822[a]	–0.270	–0.085	–0.032	–0.162	–0.152
Waist back length (mm)	0.541	–0.142	–0.280	0.179	0.009	0.594
Scapula to waist back length (mm)	0.407	0.316	0.279	0.479	0.450	0.199
Wall to acromion distance (mm)	0.064	0.348	0.625[a]	–0.031	–0.239	0.394
Arm reach from the wall (mm)	0.807[a]	–0.071	0.357	–0.295	0.019	0.004
Biacromial breadth (mm)	0.323	0.336	–0.376	–0.318	0.523	0.148
Bideltoid breadth (mm)	0.422	0.653[a]	–0.324	–0.307	0.073	0.089
Chest breadth (mm)	0.345	0.757[a]	0.104	0.084	0.123	–0.109
Chest depth (mm)	0.322	0.694[a]	–0.314	–0.158	–0.222	–0.012
Inter-scye breadth (mm)	0.381	0.574	–0.105	0.128	0.121	0.034
Waist breadth (mm)	0.432	0.683[a]	–0.004	–0.119	–0.097	0.196
Hip breadth (mm)	0.409	0.548	0.003	0.097	–0.285	0.063
Wall to lumbo-sacral joint distance (mm)	0.156	0.495	0.346	0.331	0.125	–0.317
Abdominal extension to the wall (mm)	0.326	0.793[a]	0.009	–0.089	–0.264	–0.113
Chest circumference (mm)	0.461	0.814[a]	–0.101	–0.099	–0.070	–0.013
Wrist circumference (mm)	0.466	0.330	–0.029	0.187	0.240	–0.239
Waist circumference (mm)	0.381	0.838[a]	–0.006	–0.095	–0.106	0.040
Thigh circumference (mm)	0.333	0.750[a]	–0.010	0.183	–0.035	–0.141
Calf circumference (mm)	0.458	0.675[a]	0.022	0.241	0.072	–0.009
Thumb tip reach (mm)	0.769[a]	–0.172	0.349	–0.235	0.062	0.018
Shoulder grip length (mm)	0.728[a]	–0.049	0.476	–0.219	0.117	0.025
Elbow grip length (mm)	0.674[a]	–0.133	0.243	–0.366	–0.057	0.039
Forearm hand length (mm)	0.874[a]	–0.151	0.043	–0.244	0.062	–0.098
Span (mm)	0.896[a]	–0.180	–0.053	–0.173	0.172	–0.055
Span akimbo (mm)	0.782[a]	–0.139	–0.025	–0.032	0.409	0.001
Eigen value	16.346	8.138	1.650	1.474	1.253	1.005
Variance explained by each factor (%)	44.180	22.000	4.460	3.980	3.390	2.540
Cumulative variation (%)	44.180	66.180	70.640	74.620	78.010	80.550

[a]Factor loading greater than 0.6.

In the third and fourth sections 12 hand and 7 foot dimensions were included respectively.

The linear regression equations (simple and multiple) were determined to predict the relevant body dimensions of 600 women workers with 0.70 or more correlation coefficients (r values). Regression analysis was carried out using SAS software on the basis of components obtained from PCFA. The independent variables explaining the most variation of the dependent variables and having a correlation coefficient ≥0.7 with the dependent variables were considered[21]. The statistical regression models for prediction of anthropometric dimensions were validated by testing data of 120 workers.

Results and discussion

Anthropometric dimensions of women agricultural workers

Appendix 1 shows the descriptive statistics of the anthropometric dimensions of the selected subjects. The mean and SD of weight of the selected subjects were 45.74 and 7.53 kg respectively, and for stature it was 1510 and 4.98 mm respectively. In order to achieve maximum efficiency for agricultural workers at the workplace difference of 5th and 95th percentile stature should not exceed the 200 mm range. In this study, it was found 159.6 mm with values 5th percentile

Table 2. Results of factor analysis of 16 anthropometric dimensions in sitting posture

	Factor pattern		
Dimensions	Factor 1	Factor 2	Factor 3
Height (mm)	0.713[a]	–0.336	0.482
Vertical grip reach (mm)	0.796[a]	–0.379	0.081
Eye height (mm)	0.633[a]	–0.381	0.461
Acromion height (mm)	0.631[a]	–0.420	0.487
Popliteal height (mm)	0.695[a]	–0.374	–0.377
Knee height (mm)	0.776[a]	–0.220	–0.410
Thigh clearance height (mm)	0.571	0.553	0.165
Elbow rest height (mm)	0.321	–0.155	0.813[a]
Coronoid fossa to hand length (mm)	0.659[a]	–0.235	–0.318
Abdominal depth (mm)	0.493	0.723[a]	0.130
Buttock–knee length (mm)	0.817[a]	0.063	–0.382
Buttock–popliteal length (mm)	0.738[a]	0.084	–0.450
Hip breadth (mm)	0.633[a]	0.531	0.226
Elbow–elbow breadth (mm)	0.567	0.689[a]	0.060
Knee–knee breadth (mm)	0.517	0.550	0.125
Functional leg length (mm)	0.823[a]	–0.139	–0.283
Eigen value	7.015	2.764	2.304
Variance explained by each factor (%)	43.840	17.270	14.400
Cumulative variation (%)	43.840	61.110	75.510

[a]Factor loading greater than 0.6.

Table 3. Results of factor analysis of 12 anthropometric dimensions of the hand

	Factor pattern			
Dimensions	Factor 1	Factor 2	Factor 3	Factor 4
Grip diameter (inside) (mm)	0.804[a]	–0.294	0.189	0.105
Grip diameter (outside) (mm)	0.758[a]	–0.479	–0.157	0.222
Middle finger–palm grip diameter (mm)	0.746[a]	–0.227	0.327	–0.104
Grip span (mm)	–0.052	0.707[a]	0.512	–0.272
Maximum grip length (mm)	0.462	–0.023	0.628[a]	0.462
Hand length (mm)	0.908[a]	0.097	0.059	–0.214
Hand breadth at metacarpal-III (mm)	0.601[a]	0.143	–0.463	–0.040
Hand breadth across thumb (mm)	0.511	0.334	–0.393	0.413
Hand thickness at metacarpal-III (mm)	0.278	0.690[a]	–0.198	–0.039
First phalanx digit-III length (mm)	0.828[a]	0.036	–0.070	–0.225
Palm length (mm)	0.732[a]	–0.004	–0.030	–0.438
Index finger diameter (mm)	0.358	0.706[a]	0.054	0.338
Eigen value	4.867	1.986	1.243	1.052
Variance explained by each factor (%)	40.560	16.550	10.360	7.790
Cumulative variation (%)	40.560	57.110	67.470	75.260

[a]Factor loading greater than 0.6.

value as 1433.1 and 95th percentile value as 1592.7 mm respectively. The mean value of vertical reach was 1946 (±50), vertical grip reaches 1842 (±76), eye height 1409 (±51), acromial height 1260 (±48), elbow height 960 (±39), olecranon height 934 (±40), trochanteric height 799 (±39) and knee height was 433 (±22) mm. The mean values of arm reach from the wall, abdominal extension to the wall, shoulder grip length, elbow grip length and forearm hand length in standing posture were 759 (±34), 233 (±65), 651(±31), 323(±18) and 423 (±20) mm respectively. The mean values of selected women agricultural workers in a sitting posture for sitting height was 775 (±25), vertical grip reach 1106 (±44), eye height 678 (±26), acromial height 528 (±24), popliteal height 388 (±24), knee height 468 (±25) and elbow rest height was 204 (±19) mm. In hand measurements, the mean of grip diameter (inside), grip diameter (outside) and maximum grip length was 48 (±3), 90 (±6) and 119 (±10) mm respectively.

The values of computed SD for all dimensions were low, excluding vertical reach and weight. The greater the SD value, the more samples deviate from the mean and vice versa. Higher SD values indicate that a large number of samples deviate from the mean value. In sample populations, the SD values for index and middle finger diameter were relatively low. SEM estimates were less than 1 for all anthropometric dimensions. SEM values that are moderately

Table 4. Results of factor analysis of seven anthropometric dimensions of the foot

	Factor pattern		
Dimensions	Factor 1	Factor 2	Factor 3
Foot length (mm)	0.839[a]	–0.070	–0.316
Instep length (mm)	0.790[a]	–0.203	–0.481
Foot breadth (ball of the foot) (mm)	0.738[a]	–0.070	0.292
Heel breadth (mm)	0.728[a]	–0.275	0.140
Medial malleolus height (mm)	0.252	0.869[a]	0.072
Lateral malleolus height (mm)	0.321	0.819[a]	–0.142
Bimalleolar breadth (mm)	0.709	–0.015	0.501
Eigen value	3.073	1.553	1.071
Variance explained by each factor (%)	43.900	22.190	10.170
Cumulative variation (%)	43.900	66.090	76.260

[a]Factor loading greater than 0.6.

Table 5. Regression equations for the prediction of certain body dimensions (mm)

Dimensions	Equation	*F*-value	R^2	Standard error of the estimate
*p*3	$1.37 \times p2 - 13.16$	665.26**	0.82	8.06
*p*4	$1.23 \times p2 - 2.98$	647.6**	0.81	7.36
*p*5	$0.95 \times p2 - 2.99$	1150.44**	0.81	7.36
*p*6	$0.88 \times p2 - 7.14$	880.63**	0.88	4.24
*p*7	$0.7 \times p2 - 10.33$	579.28**	0.85	4.49
*p*8	$0.7 \times p2 - 12.62$	534.63**	0.78	4.58
*p*9	$0.74 \times p2 - 20.82$	435.74**	0.74	5.35
*p*10	$0.73 \times p2 - 25.67$	396.46**	0.73	5.59
*p*11	$0.07 \times p2 + 0.78 \times p10 + 1.79$	535.13**	0.87	3.62
*p*12	$0.06 \times p2 + 0.6 \times p8 - 0.65$	205.1**	0.73	4.11
*p*13	$0.12 \times p2 + 0.29 \times p9 - 4.15$	205.44**	0.73	2.96
*p*19	$0.18 \times p27 + 0.31 \times p51 + 12.11$	113.82**	0.71	1.72
*p*20	$0.26 \times p27 + 2.24$	241.12**	0.72	1.39
*p*23	$0.04 \times p1 + 0.07 \times p27 + 0.13 \times p29 - 0.028 \times p47 + 0.1 \times p51 + 1.93$	93.44**	0.69	1.67
*p*26	$0.09 \times p1 + 0.19 \times p21 - 0.08 \times p27 + 0.14 \times p29 + 0.32 \times p47 + 0.05 \times p51 + 2.39$	102.25**	0.81	1.9
*p*27	$0.45 \times p29 + 0.1 \times p30 + 0.2 \times p31 + 1.01 \times p44 + 0.34 \times p47 + 18.70$	138.72**	0.82	3.27
*p*33	$0.32 \times p17 + 0.44 \times p32 + 0.10 \times p34 + 6.45$	134.36**	0.73	2.97
*p*36	$0.76 \times p37 + 0.27 \times p39 + 0.38 \times p42 + 0.33 \times p43 + 2.16 \times p59 - 1.69$	225**	0.88	4.97
*p*38	$0.12 \times p2 + 0.001 \times p39 + 0.43 \times p40 + 0.32 \times p41 + 10.72$	139.67**	0.78	3.63
*p*39	$0.23 \times p3 - 0.07 \times p35 + 0.17 \times p36 + 0.7 \times p41 + 5.04$	121.26**	0.76	4.82
*p*40	$0.11 \times p5 - 0.04 \times p36 + 0.75 \times p38 + 0.35$	104.88**	0.7	3.9
*p*42	$0.1 \times p2 - 0.07 \times p35 + 0.06 \times p36 + 0.53 \times p43 - 8.87$	93.41**	0.72	3.19
*p*46	$0.73 \times p35 - 0.01 \times p36 + 0.1 \times p59 + 0.42 \times p63 + 2.25$	85.77**	0.7	2.05
*p*48	$0.84 \times p49 + 13.49$	389.52**	0.72	1.95
*p*50	$0.22 \times p1 + 0.01 \times p27 + 0.019 \times p29 + 0.04 \times p30 + 17.81$	81.73**	0.7	1.8
*p*53	$0.2 \times p2 + 0.25 \times p13 - 0.32 \times p35 + 0.14 \times p36 + 0.11 \times p43 + 0.64 \times p48 - 0.0004 \times p49 + 4.90$	77.73**	0.81	4.58
*p*59	$0.21 \times p35 - 0.009 \times p36 + 0.5 \times p63 + 0.5 \times p64 + 0.08 \times p66$	94.56**	0.81	0.78
*p*63	$0.058 \times p35 + 0.008 \times p36 + 0.018 \times p46 + 0.17 \times p59 - 0.06$	64.04**	0.7	0.4
*p*67	$0.06 \times p35 + 0.5 \times p66 + 2.38$	91.64**	0.75	1.09

**Significant ($p < 0.01$).

low show that the data are distributed to a lower extent. For most of the anthropometric dimensions CV values were moderately low (<10%). The CV values were more than 10% for weight, wall-to-acromion distance, chest breadth, chest depth, waist breadth, wall-to-lumbo-sacral joint distance, abdominal extension to the wall, abdominal depth, grasp span and skinfolds (Appendix 1). Anthropometric dimensions with a reasonably high CV should be utilized with caution. Skewness and kurtosis values were derived for all anthropometric dimensions along with indices referenced in Appendix 1.

Appendix 2 lists 50 anthropometric dimensions of selected women workers having a correlation coefficient ≥0.7. Stature was found to be highly correlated with 19 anthropometric measurements ($r > 0.8$; $P < 0.01$). The correlation coefficients with high *r*-values were significantly different from

Table 6. Measured and estimated values from the developed regression model

Parameters (mm)	Measured value	Estimated value	Error
Vertical reach	1952.07	1935.73	16.34
Vertical grip reach	1844.61	1826.27	18.34
Eye height	1407.04	1403.65	3.39
Acromial height	1259.82	1256.52	3.30
Elbow height	959.39	953.00	6.39
Olecranon height	937.89	930.10	7.79
Iliocrystale height	906.50	908.46	–1.96
Iliospinal height	853.82	844.87	8.95
Trochanteric height	790.04	789.51	0.52
Metacarpal-III height	654.86	646.78	8.08
Knee height	427.79	402.47	25.32
Bideltoid breadth	377.75	377.43	0.32
Chest breadth	249.36	232.81	16.54
Waist breadth	229.10	217.00	12.10
Abdominal extension to wall	231.36	227.21	4.14
Chest circumference	809.29	808.67	0.62
Shoulder grip length	661.18	644.89	16.29
Span	1545.79	1549.05	–3.26
Sitting height	783.89	753.12	30.77
Vertical grip reach sitting	1107.82	1100.92	6.90
Sitting eye height	687.11	684.36	2.74
Popliteal height sitting	382.75	368.90	13.85
Coronoid fossa to hand length	358.00	354.58	3.42
Buttock–knee length	518.32	506.40	11.92
Hip breadth sitting	313.89	320.72	–6.83
Functional leg length	952.61	922.07	30.53
Hand length	169.96	176.57	–6.61
First phalanx digit-III length	58.50	58.21	–0.29
Instep length	168.25	162.86	5.39

All dimensions are in millimetres.

each other at a 1% level of significance ($P < 0.01$). The anthropometric dimensions, viz. vertical reach, vertical grip reach, eye height, acromial height, elbow height, olecranon height, iliocristal height, illiospinal height, trochanteric height, metacarpal-III height, knee height, forearm hand length, span, sitting height, sitting vertical grip reach, sitting popliteal height, knee height, buttock–knee length and functional leg length of all subjects showed a strong correlation with their stature. The *r*-values between height and chest breadth, abdominal extension to the wall and thigh circumference were found to be poor.

Principal component factor analysis and regression analysis

The Kaiser criterion was used to address the number of components in PCFA[22]. A component with an eigen value >1 was maintained according to Kaiser's 1960 requirements. For limiting the useful number of principal components, the screen test plot and variance ratio were observed. Tables 1–4 show factor loading matrices of anthropometric dimensions of selected women workers in standing, sitting, hand and foot postures respectively. In anthropometric dimensions for a standing posture, 20 factors were estimated in component 1 (Table 1). Factor 1 showed higher loading for weight, stature, vertical reach, vertical grip reach, eye height, acromial height, elbow height, olecranon height, iliocrystale height, iliospinal height, trochanteric height, metacarpal-III height, knee height, arm reach from the wall, thumb-tip reach, shoulder grip length, elbow grip length, forearm hand length, span and span akimbo. In the standing posture, three breadth-related variables, namely bideltoid breadth, chest breadth, and waist breadth; three circumference-related variables, namely chest circumference thigh circumference and calf circumference; and weight, chest depth and abdominal extension to the wall could all can be predicted in factor 2. Arm reach from the wall had higher loading variables in factor 3.

Stature-related parameters in sitting posture, viz. sitting height, vertical grip reach, eye height, acromion height, popliteal height, knee height, thigh clearance height, coronoid fossa to hand length, buttock–knee length, buttock–popliteal length, hip breadth sitting, and functional leg length all had high loading in factor 1 (Table 2). Factor 2 had larger loadings for abdominal depth sitting and elbow–elbow breadth sitting, while factor 3 had a factor loading of 0.813 for elbow rest height. The factor analysis of hand dimensions showed that four dominating factors explained a cumulative variation of 75.2% (Table 3). Factor 1 had a

Appendix 1. Summary of descriptive statistics of the anthropometric dimensions of selected women workers (n = 150)

	Parameters	Mean	SD	Min	Max	5th	95th	CV (%)	SEM	skew	kurt
Standing measurements											
p1	Weight (kg)	45.7	7.6	28.0	76.0	34.1	58.2	16.5	0.7	1.0	2.0
p2	Stature	1510.4	50.0	1383.0	1660.0	1433.1	1592.7	3.3	0.4	0.0	0.1
p3	Vertical reach	1946.1	75.9	1715.0	2160.0	1828.8	2071.0	3.9	0.7	–0.2	0.3
p4	Vertical grip reach	1842.2	68.6	1630.0	2065.0	1736.3	1955.1	3.7	0.6	0.0	0.5
p5	Eye height	1409.2	50.6	1286.0	1559.0	1331.1	1492.4	3.6	0.4	0.2	0.2
p6	Acromial height	1260.7	47.6	1120.0	1410.0	1187.2	1339.1	3.8	0.4	0.2	0.7
p7	Elbow height	960.1	39.4	848.0	1098.0	899.2	1025.0	4.1	0.3	0.3	1.1
p8	Olecranon height	934.1	39.7	830.0	1062.0	872.9	999.3	4.2	0.3	0.2	0.5
p9	Iliocrystale height	910.1	42.7	717.0	1014.0	844.1	980.4	4.7	0.4	–0.5	2.1
p10	Iliospinal height	862.6	43.1	679.0	983.0	796.1	933.5	5.0	0.4	–0.4	1.9
p11	Trochanteric height	799.8	39.2	667.0	911.0	739.3	864.2	4.9	0.3	0.1	0.8
p12	Metacarpal-III height	654.6	31.3	578.0	763.0	606.2	706.1	4.8	0.3	0.4	1.0
p13	Knee height	433.2	22.0	340.0	486.0	399.2	469.4	5.1	0.2	–0.4	1.8
p14	Waist back length	361.9	18.7	323.0	407.0	332.9	392.7	5.2	0.2	0.2	–0.5
p15	Scapula to waist back length	527.1	33.2	450.0	640.0	475.8	581.6	6.3	0.3	0.5	0.0
p16	Wall to acromion distance	94.6	12.5	67.0	130.0	75.2	115.2	13.2	0.1	0.1	–0.4
p17	Arm reach from the wall	759.0	34.1	682.0	849.0	706.4	815.1	4.5	0.3	0.3	0.1
p18	Biacromial breadth	276.9	18.8	220.0	368.0	247.8	307.8	6.8	0.2	0.5	3.8
p19	Bideltoid breadth	380.4	29.7	280.0	491.0	334.5	429.3	7.8	0.3	0.5	2.4
p20	Chest breadth	237.8	25.4	185.0	317.0	198.6	279.6	10.7	0.2	0.5	0.5
p21	Chest depth	217.2	26.2	129.0	294.0	176.8	260.3	12.1	0.2	–0.1	1.2
p22	Inter-scye breadth	287.3	23.8	211.0	383.0	250.5	326.5	8.3	0.2	0.2	1.8
p23	Waist breadth	227.2	28.1	170.0	322.0	183.8	273.3	12.4	0.2	0.7	0.7
p24	Hip breadth	304.4	19.9	231.0	402.0	273.7	337.2	6.5	0.2	0.7	4.4
p25	Wall to lumbo-sacral joint distance	43.0	10.7	18.0	90.0	26.5	60.5	24.8	0.1	1.2	4.4
p26	Abdominal extension to wall	233.2	33.2	164.0	355.0	181.9	287.7	14.2	0.3	0.6	0.6
p27	Chest circumference	807.9	75.2	650.0	1120.0	691.6	931.6	9.3	0.7	0.8	1.4
p28	Wrist circumference	146.6	6.9	125.0	165.0	136.0	158.0	4.7	0.1	0.0	0.0
p29	Waist circumference	698.7	90.0	535.0	1030.0	559.7	846.6	12.9	0.8	0.7	0.7
p30	Thigh circumference	449.7	47.2	330.0	600.0	376.8	527.3	10.5	0.4	0.3	0.3
p31	Calf circumference	283.8	23.4	240.0	360.0	247.7	322.3	8.2	0.2	0.5	0.6
p32	Thumb tip reach	694.1	33.4	620.0	783.0	642.6	749.0	4.8	0.3	0.3	–0.1
p33	Shoulder grip length	651.4	30.9	577.0	735.0	603.7	702.2	4.7	0.3	0.3	0.2
p34	Elbow grip length	323.9	18.4	281.0	388.0	295.6	354.1	5.7	0.2	0.3	0.3
p35	Forearm hand length	423.8	19.7	377.0	467.0	393.4	456.3	4.7	0.2	–0.2	–0.5
p36	Span	1547.6	66.1	1370.0	1692.0	1445.6	1656.3	4.3	0.6	–0.2	–0.2
p37	Span akimbo	773.6	36.9	680.0	875.0	716.6	834.2	4.8	0.3	–0.1	–0.2
Sitting measurements											
p38	Height	775.7	25.2	720.0	849.0	736.7	817.2	3.2	0.2	0.2	–0.3
p39	Vertical grip reach	1106.8	44.0	909.0	1221.0	1038.9	1179.1	4.0	0.4	–0.7	3.4
p40	Eye height	678.8	26.1	567.0	753.0	638.5	721.7	3.8	0.2	–0.2	1.8
p41	Acromion height	528.2	24.0	421.0	591.0	491.1	567.7	4.5	0.2	–0.4	2.1
p42	Popliteal height	388.9	23.5	312.0	450.0	352.5	427.6	6.1	0.2	–0.3	1.0
p43	Knee height	468.6	25.0	384.0	575.0	429.9	509.7	5.3	0.2	0.3	1.9
p44	Thigh clearance height	120.8	12.7	86.0	154.0	101.2	141.7	10.5	0.1	–0.2	0.2
p45	Elbow rest height	204.7	18.6	159.0	265.0	176.0	235.3	9.1	0.2	0.2	0.2
p46	Coronoid fossa to hand length	361.7	18.8	310.0	408.0	332.7	392.6	5.2	0.2	–0.3	–0.1
p47	Abdominal depth	214.5	35.1	152.0	340.0	160.2	272.3	16.4	0.3	0.8	0.8
p48	Buttock–knee length	521.1	23.8	461.0	603.0	484.2	560.3	4.6	0.2	0.4	0.9
p49	Buttock–popliteal length	454.5	24.0	389.0	532.0	417.4	494.0	5.3	0.2	0.2	0.0
p50	Hip breadth	316.4	24.5	263.0	403.0	278.6	356.7	7.7	0.2	0.5	0.5
p51	Elbow–elbow breadth	356.7	33.2	285.0	489.0	305.4	411.3	9.3	0.3	0.9	1.4
p52	Knee–knee breadth	168.4	14.7	136.0	235.0	145.7	192.6	8.7	0.1	0.9	2.5
p53	Functional leg length	940.5	37.9	830.0	1040.0	882.0	1002.8	4.0	0.3	–0.1	0.2
Hand measurements											
p54	Grip diameter (inside)	48.3	3.3	40.0	58.0	43.2	53.7	6.8	0.0	0.2	0.2
p55	Grip diameter (outside)	90.3	6.5	63.0	101.0	80.2	100.9	7.2	0.1	–1.8	5.5
p56	Middle finger-palm grip diameter	28.9	2.0	24.0	34.0	25.7	32.2	7.1	0.0	0.0	0.1
p57	Grip span	61.9	8.1	49.0	110.0	49.3	75.3	13.2	0.1	3.4	15.9
p58	Maximum grip length	119.2	9.6	89.0	142.0	104.4	135.0	8.0	0.1	–0.5	0.4

(*Contd*)

Appendix 1. (*Contd*)

	Parameters	Mean	SD	Min	Max	5th	95th	CV (%)	SEM	skew	kurt
p59	Hand length	171.5	8.2	151.0	191.0	158.8	185.0	4.8	0.1	–0.1	–0.1
p60	Hand breadth at metacarpal-III	74.5	4.3	63.0	93.0	67.8	81.6	5.8	0.0	1.0	3.1
p61	Hand breadth across thumb	88.0	4.5	75.0	99.0	81.0	95.4	5.1	0.0	–0.2	0.4
p62	Hand thickness at metacarpal-III	24.8	2.0	20.0	32.0	21.8	28.1	8.0	0.0	0.6	1.4
p63	First phalanx digit-III length	59.6	3.3	47.0	66.0	54.5	65.0	5.6	0.0	–0.8	0.8
p64	Palm length	97.6	5.5	79.0	112.0	89.1	106.6	5.6	0.0	–0.2	0.5
p65	Index finger diameter	14.3	1.0	12.0	17.0	12.8	15.9	6.7	0.0	0.2	–0.2
Foot measurements											
p66	Foot length	230.4	11.2	203.0	254.0	213.2	248.8	4.9	0.1	–0.1	–0.4
p67	Instep length	165.2	8.7	146.0	186.0	151.8	179.6	5.3	0.1	0.2	–0.5
p68	Foot breadth (ball of the foot)	87.5	5.2	76.0	103.0	79.5	95.9	5.9	0.0	0.2	–0.1
p69	Heel breadth	60.4	3.5	53.0	70.0	55.1	66.1	5.7	0.0	0.2	–0.1
p70	Medial malleolus height	73.2	5.3	55.0	85.0	65.0	81.9	7.3	0.0	–0.4	0.6
p71	Lateral malleolus height	64.1	4.7	50.0	76.0	56.9	71.9	7.3	0.0	–0.2	1.0
p72	Bimalleolar breadth	62.7	3.1	55.0	70.0	57.9	67.7	4.9	0.0	0.0	0.0
Head measurements											
p73	Head length	183.3	6.7	163.0	200.0	173.0	194.3	3.6	0.1	0.0	0.5
p74	Head breadth	138.6	5.0	125.0	155.0	130.8	146.9	3.6	0.0	0.3	0.5
p75	Menton to top of the head	200.3	10.2	171.0	246.0	184.5	217.1	5.1	0.1	0.3	2.2
Skinfolds											
p76	Bicep skinfold	22.2	9.2	6.0	70.0	8.0	37.2	41.3	0.1	1.7	5.6
p77	Tricep skinfold	40.7	19.7	12.0	140.0	10.3	73.0	48.3	0.2	1.4	3.5
p78	Subscapular skinfold	84.8	42.7	34.0	330.0	18.9	155.0	50.3	0.4	2.3	7.9
p79	Supra iliac skinfold	75.5	47.3	16.0	320.0	2.4	153.4	62.7	0.4	1.7	4.5
Indices											
a.	RSH	0.51	0.01	0.48	0.55	0.49	0.53	2.50	0.0	–0.3	0.02
b.	∑4 skinfold	223.0	97.8	96.0	752.0	71.9	383.9	43.9	0.9	1.8	5.5
c.	log∑4 skinfolds	2.3	0.2	2.0	2.9	1.9	2.6	12.9	0.0	0.5	–0.1
d.	BMI (kg/m^2)	20.0	3.0	13.6	31.8	15.4	25.0	15.1	0.3	0.9	1.7
e.	Poderal index	43.0	2.1	37.0	48.0	39.7	46.5	4.9	0.2	–0.1	0.0
f.	Body density	1.1	0.0	1.0	1.1	1.0	1.1	1.1	0.0	–0.5	–0.1
g.	Percent body fat (%)	14.5	5.3	4.3	32.8	6.3	23.3	36.5	0.5	0.5	0.1
h.	Absolute body fat (kg)	6.9	3.5	1.3	21.6	1.6	12.6	50.2	0.3	1.3	2.1
i.	Lean body mass(kg)	38.8	5.1	26.7	61.4	30.9	47.3	13.2	0.4	0.8	2.2
j.	Body surface area (cm^2)	13,825.8	1,119.8	10,847.9	17,494.0	12,095.7	15,667.8	8.1	98.2	0.4	0.6

Measurements are in mm, until otherwise specified.

Min, Minimum; Max, Maximum; SD, Standard deviation; SEM, Standard error of mean; CV, Coefficient of variation; Skew, Skewness; Kurt, Kurtosis.

very high factor loading with 0.804, 0.758, 0.746, 0.908, 0.601, 0.828 and 0.732 respectively, for grip diameter (inside), grip diameter (outside), middle finger–palm grip diameter, hand breadth at metacarpal-III, first phalanx digit-III length, palm length and hand length respectively. As the diameter was proportional to the length dimension, factor 1 was called the length factor. In factor 2, grip span, hand thickness at metacarpal-III and index finger diameter had a factor loading of 0.707, 0.690 and 0.706 respectively. The loading factor for maximum grip length was 0.628 in factor 3. Hand length, hand breadth, middle-finger–palm grip diameter, grip spread and maximum grasp length are the factors to be considered when describing hand form, according to factor analysis.

The component analysis on foot dimensions revealed that three main factors accounted for 76.26% of the total variance (Table 4). The foot length, instep length, foot breadth and heel breadth were the factors that dominated factor 1 in foot dimensions. Factor loading was most strongly connected with medial malleolus height with a value of 0.869 and lateral malleolus height with a value of 0.819 in factor 2. Foot length, medial malleolus height, instep length and foot breadth must be considered when designing protective footwear for agricultural workers. Table 5 shows the regression equations that were used to generate the prediction equations. According to the findings, stature-related variables can be interpreted mostly by factor 1. It can be concluded from this as well as from other studies[10,23], that height has the largest effect on the rest of the anthropometric characteristics. Measuring stature is relatively simple. As a result, developing a regression equation that includes height as an independent parameter will aid in predicting other dimensions with an R^2 value better than 0.7. Table 6 clearly shows that the constructed model performs best for a dataset of 30 people. In standing and sitting posture, a total of 29 anthropometric dimensions may be predicted with the least amount of error.

Appendix 2. Matrix of Pearson correlation coefficients (PCC) among different anthropometric dimensions of selected subjects

	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p17	p19	p20	p21	p23	p26	p27	p29	p30	p31	p32	p33
p1	1.00																								
p2	0.38*	1.00																							
p3	0.34*	0.91*	1.00																						
p4	0.35*	0.90*	0.95*	1.00																					
p5	0.36*	0.94*	0.92*	0.92*	1.00																				
p6	0.28*	0.93*	0.92*	0.93*	0.95*	1.00																			
p7	0.30*	0.89*	0.86*	0.86*	0.91*	0.95*	1.00																		
p8	0.33*	0.89*	0.86*	0.87*	0.90*	0.93*	0.96*	1.00																	
p9	0.26*	0.86*	0.89*	0.89*	0.90*	0.90*	0.88*	0.89*	1.00																
p10	0.24*	0.85*	0.86*	0.87*	0.88*	0.89*	0.87*	0.87*	0.96*	1.00															
p11	0.20	0.82*	0.84*	0.84*	0.85*	0.87*	0.84*	0.84*	0.91*	0.94*	1.00														
p12	0.29*	0.78*	0.71*	0.72*	0.79*	0.82*	0.86*	0.86*	0.73*	0.72*	0.71*	1.00													
p13	0.31*	0.81*	0.81*	0.82*	0.82*	0.84*	0.80*	0.79*	0.85*	0.84*	0.81*	0.65*	1.00												
p17	0.41*	0.66*	0.76*	0.76*	0.69*	0.70*	0.64*	0.63*	0.70*	0.64*	0.62*	0.50*	0.66*	1.00											
p19	0.72*	0.22	0.22	0.22	0.20	0.13	0.14	0.18	0.12	0.13	0.12	0.09	0.19	0.27*	1.00										
p20	0.76*	0.10	0.13	0.12	0.09	0.04	0.06	0.08	0.03	0.03	0.01	0.09	0.03	0.21	0.56*	1.00									
p21	0.71*	0.14	0.12	0.12	0.16	0.05	0.06	0.06	0.05	0.08	0.03	0.06	0.15	0.18	0.68*	0.51*	1.00								
p23	0.76*	0.25*	0.21	0.23	0.22	0.15	0.18	0.18	0.13	0.10	0.08	0.14	0.12	0.31*	0.65*	0.64*	0.62*	1.00							
p26	0.82*	0.12	0.08	0.10	0.11	0.03	0.04	0.03	0.04	0.01	-0.01	0.05	0.10	0.22	0.62*	0.68*	0.72*	0.68*	1.00						
p27	0.91*	0.23*	0.19	0.21	0.21	0.13	0.16	0.17	0.12	0.10	0.07	0.14	0.18	0.30*	0.76*	0.79*	0.79*	0.77*	0.80*	1.00					
p29	0.86*	0.15	0.12	0.14	0.13	0.05	0.07	0.08	0.03	0.00	-0.01	0.08	0.10	0.28*	0.70*	0.75*	0.72*	0.79*	0.87*	0.88*	1.00				
p30	0.80*	0.13	0.11	0.14	0.11	0.05	0.07	0.10	0.02	0.00	-0.07	0.14	0.08	0.18	0.57	0.65*	0.57*	0.56*	0.65*	0.72*	0.68*	1.00			
p31	0.80*	0.26*	0.23	0.25*	0.26*	0.19	0.22	0.27*	0.15	0.13	0.06	0.23	0.19	0.27*	0.56*	0.64*	0.52*	0.58*	0.61*	0.70*	0.67*	0.79*	1.00		
p32	0.32*	0.65*	0.74*	0.75*	0.70*	0.72*	0.64*	0.64*	0.69*	0.65*	0.60*	0.52*	0.60*	0.88*	0.16	0.16	0.08	0.21	0.12	0.21	0.19	0.10	0.20	1.00	
p33	0.39*	0.57*	0.66*	0.67*	0.6*	0.64*	0.58*	0.57*	0.63*	0.57*	0.54*	0.47*	0.55*	0.82*	0.21	0.26*	0.09	0.29*	0.20	0.28*	0.24*	0.14	0.27*	0.84*	1.00
p34	0.34*	0.58*	0.64*	0.64*	0.61*	0.60*	0.57*	0.53*	0.59*	0.55*	0.55*	0.41*	0.56*	0.66*	0.22	0.12	0.03	0.21	0.11	0.21	0.14	0.13	0.21	0.63*	0.60*
p35	0.40*	0.77*	0.85*	0.85*	0.80*	0.80*	0.74*	0.73*	0.80*	0.78*	0.73*	0.54*	0.78*	0.78*	0.29*	0.15	0.21	0.27*	0.17	0.28*	0.20	0.17	0.27*	0.73*	0.66*
p36	0.37*	0.83*	0.92*	0.89*	0.84*	0.84*	0.76*	0.76*	0.83*	0.8*	0.76*	0.58*	0.77*	0.77*	0.31*	0.17	0.16	0.27*	0.14	0.25*	0.18	0.14	0.25*	0.72*	0.64*
p37	0.31*	0.69*	0.79*	0.77*	0.74*	0.73*	0.68*	0.68*	0.69*	0.66*	0.63*	0.54*	0.60*	0.64*	0.27*	0.23*	0.09	0.24*	0.08	0.22	0.16	0.13	0.27*	0.61*	0.59*
p38	0.47*	0.71*	0.63*	0.63*	0.69*	0.64*	0.65*	0.66*	0.53*	0.47*	0.44*	0.63	0.44*	0.46*	0.30*	0.24*	0.19	0.31*	0.19	0.34*	0.27*	0.37*	0.42*	0.46*	0.36*
p39	0.41*	0.79*	0.81*	0.81*	0.78*	0.79*	0.74*	0.72*	0.71*	0.67*	0.64*	0.5**	0.62*	0.66*	0.28*	0.16	0.16	0.30*	0.20	0.27*	0.21	0.20	0.28*	0.64*	0.54*
p40	0.36*	0.60*	0.54*	0.55*	0.63*	0.57*	0.57*	0.57*	0.48*	0.41*	0.38*	0.55*	0.37*	0.46	0.20	0.16	0.10	0.22	0.11	0.22	0.17	0.26*	0.34*	0.47*	0.39*
p41	0.31*	0.57*	0.53*	0.54*	0.58*	0.61*	0.62*	0.59*	0.47*	0.41*	0.40*	0.57*	0.38*	0.44*	0.15	0.05	0.06	0.20	0.11	0.16	0.14	0.19	0.22	0.44*	0.33*
p42	0.23*	0.75*	0.76*	0.77*	0.77*	0.78*	0.76*	0.75*	0.79*	0.78*	0.75*	0.59*	0.79*	0.58*	0.26*	–0.04	0.22	0.14	0.09	0.13	0.08	0.04	0.16	0.53*	0.41*
p43	0.36*	0.75*	0.76*	0.77*	0.77*	0.75*	0.72*	0.72*	0.78*	0.75*	0.73*	0.55*	0.82*	0.66*	0.33*	0.08	0.28*	0.24*	0.19	0.27*	0.20	0.12	0.23*	0.58*	0.51*
p44	0.73*	0.19	0.17	0.20	0.18	0.12	0.16	0.17	0.11	0.12	0.07	0.14	0.19	0.24*	0.60*	0.59*	0.58*	0.58*	0.64*	0.71*	0.63*	0.77*	0.67*	0.14	0.17
p46	0.3*	0.62*	0.68*	0.68*	0.65	0.65*	0.59*	0.58*	0.59*	0.57*	0.56*	0.39*	0.63*	0.65*	0.26*	0.07	0.17	0.21	0.14	0.23	0.16	0.07	0.20	0.59*	0.54*
p47	0.82*	0.13	0.10	0.13	0.11	0.04	0.05	0.06	0.03	0.03	0.00	0.08	0.09	0.25*	0.60*	0.74*	0.70*	0.71*	0.86*	0.83*	0.87*	0.66*	0.60*	0.18	0.22
p48	0.55*	0.72*	0.73*	0.74*	0.74*	0.71*	0.69*	0.69*	0.76*	0.76	0.72*	0.56*	0.74*	0.66*	0.37*	0.35*	0.36*	0.39*	0.40*	0.45*	0.37*	0.30*	0.41*	0.61*	0.65*
p49	0.48*	0.61*	0.61*	0.62*	0.62*	0.60*	0.59*	0.55*	0.67*	0.67*	0.62*	0.45*	0.67*	0.61*	0.31*	0.22	0.36*	0.36*	0.43*	0.38*	0.34*	0.24*	0.28*	0.51*	0.53*
p50	0.83*	0.26*	0.19	0.24*	0.23*	0.21	0.21	0.23*	0.18	0.14	0.14	0.15	0.24*	0.38*	0.63*	0.58*	0.56*	0.66*	0.68*	0.76*	0.73*	0.70*	0.66	0.26*	0.34*
p51	0.83*	0.20	0.19	0.19	0.17	0.11	0.13	0.15	0.13	0.10	0.08	0.10	0.18	0.36*	0.74*	0.71*	0.70*	0.73*	0.79*	0.85*	0.83*	0.60*	0.61*	0.28*	0.37*
p53	0.50*	0.82*	0.81*	0.82*	0.82*	0.81*	0.79*	0.81*	0.83*	0.81*	0.75*	0.65*	0.78*	0.68*	0.28*	0.28*	0.26*	0.32*	0.25*	0.35*	0.29*	0.24*	0.40*	0.66*	0.66*
p54	0.13	0.46*	0.46	0.44*	0.43*	0.45*	0.42*	0.42*	0.44*	0.44*	0.40*	0.33*	0.41*	0.36*	0.10	–0.04	0.11	0.10	0.02	0.06	0.02	0.02	0.11	0.30*	0.14
p55	0.18	0.44*	0.43*	0.40*	0.43*	0.41*	0.39*	0.40*	0.46*	0.46*	0.41*	0.28*	0.49*	0.29*	0.28*	–0.05	0.31*	0.13	0.13	0.15	0.07	0.08	0.06	0.18	-0.01
p59	0.31*	0.61*	0.72*	0.67*	0.62*	0.64*	0.59*	0.58	0.64*	0.62*	0.58*	0.42*	0.62*	0.63*	0.26*	0.11	0.11	0.19	0.11	0.21	0.14	0.14	0.22	0.58*	0.51*
p63	0.30*	0.62*	0.67*	0.64*	0.60*	0.60*	0.55*	0.55*	0.60*	0.57*	0.54*	0.41*	0.66*	0.60*	0.26*	0.06	0.16	0.17	0.13	0.21	0.14	0.13	0.21	0.51*	0.42*
p64	0.26*	0.50*	0.55*	0.52*	0.50*	0.53*	0.51*	0.48*	0.50*	0.49*	0.46*	0.40*	0.53*	0.43*	0.13	0.07	0.07	0.07	0.10	0.17	0.12	0.16	0.21	0.42*	0.31*
p66	0.42*	0.62*	0.60*	0.61*	0.61*	0.58*	0.54*	0.55*	0.61*	0.58*	0.53*	0.40*	0.59*	0.57*	0.30*	0.14	0.24*	0.29*	0.20	0.33*	0.23*	0.21	0.32*	0.49*	0.40*
p67	0.37*	0.53*	0.56*	0.50*	0.53*	0.51*	0.47*	0.48*	0.50*	0.48*	0.45*	0.35*	0.47*	0.47*	0.20	0.20	0.15	0.26*	0.17	0.26*	0.21	0.17	0.29**	0.46*	0.44*

(*Contd*)

Appendix 2. (*Contd*)

	p34	p35	p36	p37	p38	p39	p40	p41	p42	p43	p44	p46	p47	p48	p49	p50	p51	p53	p54	p55	p59	p63	p64	p66	p67
p1																									
p2																									
p3																									
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p29																									
p30																									
p31																									
p32																									
p33																									
p34	1.00																								
p35	0.76*	1.00																							
p36	0.67*	0.91*	1.00																						
p37	0.50*	0.73	0.83*	1.00																					
p38	0.40*	0.48*	0.55*	0.52*	1.00																				
p39	0.56*	0.72*	0.77*	0.63*	0.71*	1.00																			
p40	0.38*	0.41*	0.47*	0.46*	0.82*	0.63*	1.00																		
p41	0.44*	0.45*	0.46*	0.37*	0.77*	0.70*	0.68*	1.00																	
p42	0.43*	0.70*	0.73*	0.53*	0.46*	0.63*	0.38*	0.39*	1.00																
p43	0.55*	0.76*	0.74*	0.54*	0.42*	0.64*	0.37*	0.39*	0.82*	1.00															
p44	0.18	0.21	0.19	0.16	0.32*	0.21	0.23*	0.16	0.17	0.26*	1.00														
p46	0.63*	0.84*	0.76*	0.61	0.36*	0.60*	0.35*	0.37*	0.61*	0.65*	0.14	1.00													
p47	0.08	0.17	0.16	0.12	0.20	0.17	0.10	0.08	0.06	0.13	0.62*	0.10	1.00												
p48	0.54*	0.71*	0.69*	0.59*	0.38*	0.55*	0.34*	0.33	0.61*	0.71*	0.47*	0.55*	0.38*	1.00											
p49	0.49*	0.65*	0.60*	0.43*	0.24*	0.49*	0.24*	0.26*	0.57*	0.66*	0.40*	0.55*	0.36*	0.85*	1.00										
p50	0.29*	0.34*	0.26*	0.14	0.36*	0.33*	0.25*	0.30*	0.17	0.34*	0.66*	0.28*	0.66*	0.39*	0.39*	1.00									
p51	0.24*	0.30*	0.25*	0.20	0.22	0.21	0.14	0.11	0.13	0.26*	0.60*	0.21	0.82*	0.48*	0.40*	0.66*	1.00								
p53	0.49*	0.73*	0.77	0.67*	0.51*	0.65*	0.46*	0.39*	0.68*	0.75*	0.33*	0.55*	0.28*	0.82*	0.70*	0.36*	0.35*	1.00							
p54	0.34*	0.57*	0.54*	0.34*	0.32*	0.44*	0.29*	0.29*	0.51*	0.46*	0.07	0.54*	0.01	0.28*	0.37*	0.15	0.04	0.37*	1.00						
p55	0.24*	0.52*	0.49*	0.25*	0.30*	0.40*	0.25*	0.27*	0.63*	0.55*	0.16	0.48*	0.07	0.33*	0.42*	0.18	0.14	0.32*	0.72*	1.00					
p59	0.63*	0.84*	0.76*	0.57*	0.41*	0.60*	0.36*	0.38*	0.57*	0.62*	0.17	0.73*	0.11	0.53*	0.50*	0.26	0.23	0.54*	0.67*	0.56*	1.00				
p63	0.59*	0.79*	0.73*	0.54*	0.41*	0.60*	0.33*	0.35*	0.61*	0.65*	0.19	0.70*	0.10	0.51*	0.48*	0.24*	0.23	0.50*	0.57*	0.60*	0.80*	1.00			
p64	0.43*	0.59*	0.56*	0.42*	0.43*	0.45*	0.31*	0.35*	0.47*	0.46*	0.16	0.56*	0.09	0.42*	0.38*	0.22	0.11	0.42*	0.48*	0.44**	0.74*	0.61*	1.00		
p66	0.52*	0.70*	0.65*	0.46*	0.48*	0.55*	0.40*	0.35*	0.59*	0.62*	0.28*	0.60*	0.20	0.52*	0.49*	0.38*	0.30*	0.55*	0.50*	0.52**	0.71*	0.65*	0.54*	1.00	
p67	0.49*	0.59*	0.58*	0.48*	0.41*	0.46*	0.35*	0.29*	0.39*	0.45*	0.19	0.46*	0.16	0.44*	0.37*	0.31*	0.23*	0.53*	0.35*	0.20	0.61*	0.45*	0.41*	0.74*	1.00

*Significant ($p < 0.01$).

Conclusion

A total of 79 body dimensions and weights of 720 women agricultural workers aged 25–55 years from Bhopal, central India were assessed in this study. The correlation coefficient of 50 dimensions was greater than 0.7. Six criteria were adequate to replace 37 anthropometric parameters in standing posture, according to the findings (explained 80% variability). Sixteen anthropometric variables in the sitting position and 12 anthropometric dimensions in hand could be substituted by three and four components respectively, accounting for more than 75% of the variance. Three factors could replace seven anthropometric measures of the foot (76% variance). With the test data, the fitted multiple linear regression models showed good accuracy for each dimension ($R^2 > 0.7$). The developed models can aid in increasing the sample size of anthropometric data collection and thus improve the accuracy of the collected information.

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