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Workstation Related Anthropometric and Body Composition Parameters of Indian Women of Different Geographical Regions

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Abstract:

Background: Anthropometry plays an important role in industrial design, clothing design, ergonomics and architecture where statistical data about the distribution of body dimensions in the population are used to optimize products. Changes in lifestyles, nutrition, and ethnic composition of populations lead to changes in the distribution of body dimensions (e.g. the obesity epidemic), and require regular updating of anthropometric data collections. *Aim and Objectives:* This study analyzed the variation in anthropometric dimensions and body composition parameters of working women employees of different geographical zones. *Material and Methods:* The study was undertaken on nine hundred forty (940) women employees of Defence Research and Development Organization (DRDO) working in seventeen different laboratories and belonged to different states of India. The age range of studied women was between 20-60 years. Fourteen body dimensions namely stature, popliteal height, knee height, buttock to popliteal length, hip breadth, waist breadth, shoulder breadth, forearm length, arm length, eye height (sitting), sitting shoulder height, hand length, hand breadth and elbow width were measured in cm using Martin anthropometers and Martin's sliding caliper. Body composition parameters like weight, percentage body fat, fat mass and fat free mass were recorded. *Results:* All anthropometric parameters were found significantly different ($p<0.001$). Body composition variables of women were also found significantly different in all three zones but fat free mass was not significantly different. *Conclusion:* It can be concluded that diet, environmental conditions and living style of different regions can influence the anthropometry and body composition of the individuals, however the influence of ethnic, genetic and hereditary factor are not controlled in this study.

Keywords: Arm Length, Eye Height, Fat Mass, BMI, and Fat Free Mass

Introduction:

Anthropometry is the science that measures the range of body sizes in a population. It is clear that anthropometric data is very important for product design and other applications. Many countries have been making great efforts in establishing an anthropometric database for different population groups such as civilians, military personnel, students, and workers [1-2]. Ethnic diversity is always a significant factor that may affect the anthropometric data and the scopes of its applications. Pheasant (1996) suggested that the variations of body dimensions of different groups can be observed in terms of overall body size and bodily proportions. The mean anthropometric dimensions, for example stature and sitting height, are the most typical distinctions among ethnic groups [3]. Ethnicity is a construct of biology, culture, language, religion, distinct health beliefs and behaviors, encompassing a range of biological and environmental exposures [4-6].

India is the second most populous country in the world that comprises 17% of the world's population and contributes to 16% of the world's deaths. Nutritional status of Indian population varies significantly across the regions. Certain

regions are associated with extremely high rates of childhood under nutrition (ranging from 20% to 80%), whereas others have a high prevalence of adult under nutrition (>50%), and some have both [7]. Data regarding the nutritional status of adults, as determined by body mass index (BMI), indicate that 50% of Indian adults suffer from different types of chronic energy deficiency, in that they have a BMI<18.5 kg/m^2. In the same survey, it was observed that the BMI values were similar in men and women; however, there were more overweight/obese (BMI⩾ 25 kg/ m^2) women (6.6%) than men (3.5%) [7]. According to the National Family Health Survey (NFHS), the percentage of ever-married women aged 15–49 years who are overweight or obese increased from 11% in NFHS-2 to 15% in NFHS-3. Under nutrition is more prevalent in rural areas, whereas overweight and obesity are more than three times higher in urban areas. This may be due to lesser physical activity in the urban areas. Furthermore, under nutrition and overweight / obesity are both higher for women than men [8]. The prevalence of obesity is increasing in all populations, and this is especially true in countries such as China and India [9].

In the present study body composition of women employees belonging to different geographical region of India were studied along with the purpose of investigating variation in anthropometry and body composition of office going women for workstation related parameters belonging to three different geographical regions such as north, south and west of India.

Material and Methods:

Study sample

This study was conducted among women employees of Defence Research and Development Organization (DRDO) working in different laboratories and belonged to different states of India. No criterion was applied to select women for this study. These working women belonged to Delhi, Uttarakhand, Uttar Pradesh, Punjab, Haryana, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra and Rajasthan. Nine hundred forty women employees in the age range of 20-60 years from seventeen DRDO laboratories volunteered as subjects. They were all physically fit and without any physical deformities. Prior to the initiation of the study, subjects were informed about its purpose and methods and their consent was taken.

Zone distribution: According to S Bharati *et al* [10] the women considered in the present study were distributed in three different geographical zones as mentioned below. Ethnicity was not considered in the division of zones but respondents were simply asked to name the place of origin.

North zone: Delhi, Uttar Pradesh, Uttarakhand, Punjab and Haryana.

South zone: Karnataka, Tamil Nadu, Kerala, and Andhra Pradesh.

West Zone: Maharashtra and Rajasthan.

Anthropometric and Body Composition Parameters Measurement:

Body measurements in sitting position of the subjects were measured as per the standard operating procedure recommended by Lohman [11]. Fourteen body dimensions were measured and all measurements were in cm or otherwise specified. These were namely stature, popliteal height, knee height, buttock to popliteal length, hip breadth, waist breadth, shoulder breadth, forearm length, arm length, eye height, sitting shoulder height, hand length, hand breadth and elbow width. Martin anthropometer manufactured by GPM, Switzerland (to the nearest 0.1 cm) and Martin's sliding caliper (to the nearest 0.1 cm) were used to take the measurements.

Body composition parameters like weight (to the nearest 0.2kg), percentage body fat (to the nearest

0.1%), Fat Mass (FM) and Fat Free Mass (FFM) were recorded using the bio electrical impedance method using a bipodal device (TANITA Bioelectric impedance analyzer, model TBF-310 (Tanita Corporation, Tokyo, Japan) [12]. This instrument has been found to provide estimates of Percentage Body Fat (PBF) that are within 2% of body estimation by dual x-ray absorptiometry (DEXA) [13] and is very reliable, with <1% variation within itself [14].

All statistical analyses such as mean, standard deviation and post hoc analysis (Tukey) were carried out using ANOVA of Statistical Package of Social Science (SPSS) version 11.5. The mean difference was considered significant at $p<0.05$. Approval for the study has been taken from the ethical committee of institute.

Result:

In the present study, women of different zones of India were distributed into five categories of BMI such as underweight <18.50, normal weight 18.5-22.99, overweight 23.00-24.99, 25.00-29.99 pre obese and obese >30.00 as shown in (Table 1).

The mean and SD of age of women from north, south and west zone were 38.8 ± 10.7, 41.9 ± 10.5 and 42.3 ± 9.1 years respectively. Anthropometric parameters such as buttock to popliteal length, hip breadth, shoulder breadth, sitting eye height, sitting shoulder height, hand breadth and elbow width were found to be significantly different at significance level p=0.000 as shown in (Table 2) and some other anthropometric parameters such as forearm length (p=0.001 & F=7.65), arm length (p=0.002 & F=6.33) and hand length (p=0.014 and F= 4.299) were also found significantly different in all three zones. Anthropometric parameters such as stature, popliteal height, knee height and waist breadth of the women employees of three different zones were not significantly different as shown in (Table 2).

Body composition variables such as body weight, BMI, PBF, FM of women were found significantly different in all three zones but FFM was not significantly different as shown in (Table 3).

The distribution of different anthropometric parameters of women from different geographical areas through post hoc tests is given in (Table 4).

When post hoc analysis was done, sitting eye height was found significantly different in all three zones. A significant difference was also found between north & south and north & west zones women's for parameters such as hip breadth, shoulder breadth, shoulder height, and hand breadth, ($p<0.05$) and no significant difference was found between women of south and west zones. For buttock to popliteal length, arm length, hand length, elbow width and forearm length measurement, all were found significantly different ($p<0.05$) between women of north and south zones.

Table 1: Frequency in Terms of Percentage of Women in Different Category of BMI

Zone	Under weight <18.50 (kg/m2)	Normal weight 18.50-22.99 (kg/m2)	Over weight 23.00-24.99 (kg/m2)	Pre Obese 25.00-29.99 (kg/m2)	Obese >30.00 (kg/m2)
North	3.35	33.26	16.29	33.48	13.62
South	3.46	21.90	18.73	38.62	17.29
West	2.76	19.31	19.31	42.07	16.55

BMI=Body Mass Index

Table 2: Anthropometric Variables of Women of Different Zones (in cm)

Parameters	North =448	South=347	West=145	F value	P value
	mean ± SD	mean ± SD	mean ± SD		
Stature	155.18 ± 6.10	154.45 ± 6.07	154.37 ± 5.87	1.82	0.163
Popliteal height	35.9 ± 1.88	36.15 ± 1.73	36.01 ± 1.59	1.80	0.167
Knee height	45.19 ± 2.42	45.47 ± 2.37	45.25 ± 2.24	1.42	0.241
Buttock to popliteal length	40.79 ± 2.52	41.59 ± 2.63	41.12 ± 2.61	9.52	0.000
Hip breadth	33.44 ± 3.19	34.58 ± 3.53	35.12 ± 3.57	18.65	0.000
Waist breadth	23.31 ± 3.50	23.80 ± 3.30	23.41 ± 3.08	2.14	0.119
Shoulder breadth	34.96 ± 2.13	34.35 ± 2.08	34.13 ± 2.07	12.70	0.000
Forearm length	23.05 ± 1.76	23.36 ± 1.63	22.74 ± 1.53	7.65	0.001
Arm length	47.04 ± 3.12	47.81 ± 3.10	47.54 ± 2.84	6.33	0.002
Eye height (sitting)	70.23 ± 3.33	68.52 ± 3.26	69.41 ± 3.35	26.19	0.000
Sitting shoulder height	55.53 ± 2.91	54.20 ± 2.86	54.78 ± 2.95	20.67	0.000
Hand length	16.27 ± 0.94	16.45 ± 0.93	16.43 ± 0.97	4.30	0.014
Hand breadth	8.96 ± 0.58	8.79 ± 0.50	8.77 ± 0.48	13.12	0.000
Elbow width	6.13 ± 0.61	5.92 ± 0.54	6.01 ± 0.52	13.24	0.000

**The mean difference is significant at the 0.05 level*

Table 3: Body Composition Parameters of Women of Different Zones

Parameters	North	South	West	F value	P value
	mean ± SD	mean ± SD	mean ± SD		
Weight (kg)	60.33 ± 10.94	62.04 ± 11.69	62.24 ± 10.54	2.97	0.052
BMI (kg/m^2)	25.09 ± 4.54	26.09 ± 4.60	26.13 ± 4.28	5.85	0.003
PBF	30.22 ± 7.55	31.43 ± 7.52	31.85 ± 7.01	3.88	0.021
Fat mass (kg)	18.99 ± 7.80	20.34 ± 7.85	20.67 ± 7.82	4.09	0.017
Fat free mass (kg)	41.36 ± 3.60	41.99 ± 4.31	41.29 ± 5.03	2.69	0.069

**The mean difference is significant at the 0.05 level*

Table 4: Multiple Comparisons in Anthropometric and Body Composition Parameters of Women through Post Hoc Tests (Tukey HSD)

Dependent Variable	North & South		North & West		South & West	
	Mean Difference	p	Mean Difference	Sig.	Mean Difference	p
Buttock to popliteal length (cm)	-0.803(*)	0.000	-0.335	0.36	0.467	0.158
Hip breadth (cm)	-1.141(*)	0.000	-1.682(*)	0.000	-0.541	0.239
Shoulder breadth (cm)	0.610(*)	0.000	0.835(*)	0.000	0.226	0.524
Forearm length (cm)	-0.309(*)	0.028	0.313	0.125	0.622(*)	0.001
Arm length (cm)	-0.770(*)	0.001	-0.499	0.205	0.271	0.645
Eye height (cm)	1.711(*)	0.000	0.829(*)	0.024	-0.882(*)	0.019
Sitting shoulder height (cm)	1.326(*)	0.000	0.747(*)	0.020	-0.579	0.108
Hand length (cm)	-0.186(*)	0.016	-0.165	0.159	0.021	0.972
Hand breadth (cm)	0.173(*)	0.000	0.192(*)	0.001	0.019	0.931
Elbow with (cm)	0.209(*)	0.000	0.123	0.064	-0.086	0.281
BMI (kg/m^2)	-0.999(*)	0.006	-1.038(*)	0.044	-0.04	0.996
Fat mass (kg)	-1.346(*)	0.043	-1.677	0.064	-0.331	0.904

**The mean difference is significant at the 0.05 level*

Forearm length was also significantly different between south & west zone.

When post hoc analysis was applied, it was found that those women of north & south and north & west zone were significantly different in their BMI while FM was significantly different only among women of north and south zones. There was no significant difference between women of south and west regions for BMI and FM.

Discussion:

The present classification of BMI was used because the WHO Expert Consultation concluded that the proportion of Asian people with a high risk of type 2 diabetes and cardiovascular disease is substantial at BMI's lower than the existing WHO cut-off point for overweight (= 25 kg/m^2) [15-16]. It is clear from the table-1 that 33.26 % women of north zone fell within the normal range of BMI which is comparatively more than women of south and west zones. West zone had the least number of women in underweight category of BMI in comparison to south and north zones. Obesity was more prominent in women of south zone with 17.29 % of them belonging to obese category of BMI as shown in (Table 1).

Hence, from the table-1 it was observed that 66.74 % women in north zone, 78.10 % in south zone and 80.69% in west zone were not having normal BMI range. An earlier study had shown that the percentage of women who are overweight or

obese was highest in Punjab (30%), followed by Kerala (28%) and Delhi (26%), all of which are relatively better economy states. Data from NFHS showed that in India, the overall prevalence of overweight was low, whereas under nutrition remained high [8]. Overweight was more prevalent among the urban and high socioeconomic status groups, especially among women [17].

Stature, shoulder breadth, sitting eye height, sitting shoulder height, hand breadth and elbow width of women of northern zone was higher compare to women of south and west zone. It was also observed, in a study on population of India that the geographical gradients of stature with respect to climatic environmental variation, the mean height of north zone population was higher compared to population of west and south region of India [18]. Popliteal height, knee height, buttock to popliteal length, waist breadth, arm length and hand length of southern region women was larger for women of north and west, but hip breadth of women of western region was greater than women of north and south region as shown in (Table 2).

Body composition parameters such as weight, BMI, PBF and FM of women of west zone were found greater than women of north and south region of India but fat free mass was lesser than women of both geographical regions. It may be due to the difference in physical activity level among different geographical regions (Table 3) [7].

From the result of the post hoc analysis, it was observed that all the anthropometric and body composition parameters shown in (Table 4) are significantly different only in women of north & south zone but few workstation related parameters (hip breadth, shoulder breadth, eye height, sitting shoulder height, hand breadth and BMI) of women of north & west zone were found significantly different. In the case of south & west zone's women, only two anthropometric parameters (forearm length and sitting eye height) were found significantly different while the remaining parameters were not found significantly different.

The present study has importance because this data base can be used for designing workstation for Indian women which was not available still now according to the best of our knowledge. Available workstations in India are designed according to measurement of Indian male body dimension which are totally different from the Indian women body dimension. Hence existing workstation used by women are not found compatible for them. In a similar kind of study among 1066 Indian office going women it was found that for those who use the computer >6 hours daily, there was a statistically significant chance of developing back pain [19].

It can be concluded that diet, environmental conditions and living style of different regions can influence the anthropometry and body composition of the individual, however the influence of ethnic, genetic and hereditary factor are not controlled for in this study.

Limitations:

Results are representation of urban working women of different geographical regions and hence cannot be applied to rural and sedentary women. Eastern zone women could not be included in the present study because of lesser availability of women belonging to the eastern zone in the same organization. Some women employees may not necessarily be working in a laboratory which is situated in a similar zone from which they belong to.

The importance of regional anthropometric difference found in the present study did not take

into consideration the effect of ethnic, genetic and hereditary factor. This can further be studied in subsequent studies.

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