

## Comparison of Static Anthropometric Characteristics among Workers of Three Iranian Ethnic Groups

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**ABSTRACT** The objective of this study was to compare anthropometric characteristics of Iranian workers with three different ethnicities including Fars, Azeri and Arab. A total number of 3436 subjects aged ranging 20 to 60 years old were randomly selected as the sample. Overall, thirty-six body dimensions besides body weight were measured. The statistical indexes consisting of mean, standard deviation, 5th and 95th percentile values were tabulated for the various body dimensions. Analysis of variance (ANOVA) and post-hoc tests were performed to determine the significant differences among the mean value of body dimensions of study ethnics. The results indicated that there are significant differences in most of the dimensions among the three ethnic groups for both males and females ( $P$ -value<0.05). The post-hoc tests showed that Fars males have larger body size compared to the Arab and Azeri. In addition, Azeri females tends to have larger body. Azeri male and Fars female have the smallest body size compared to other ethnics. In conclusion, there is a significant morphological difference among the three Iranian ethnic groups with the same nation. Furthermore, there are various body dimension differences among different nations. Thus, considering the ethnicity factor while designing, for the Iranian population, is highly recommended.

### INTRODUCTION

Engineering anthropometry is one of the ergonomics branch which provides body dimensions for the purpose of a fit product for users (Chandra et al. 2011, Gupta et al. 2014). Anthropometric dimensions are mostly depended on gender, race, nation and age. The anthropometric differences among races are greater than nations (Lin et al. 2004). Different races of the same nation may also have varied body sizes and bodily proportions due to differences in genetic. Ethnic diversity is always a significant factor that may affect the anthropometric data and the scopes of its applications (Roebuck et al. 1975). Pheasant and Haslegrave (2005) suggested that the variations in body dimensions of different groups can be observed in terms of overall body

size. The mean anthropometric dimensions, for example stature and sitting height, are the most typical distinctions among ethnic groups.

For efficient design of machinery and equipment, it is necessary to determine people anthropometric characteristics and consider principles of ergonomics, which provide an orientation towards fulfillment of physiological and psychological needs of operators (Das and Grady 1983; Das and Sengupta 1996). In this regard, the basic information required is the anthropometric body dimensions of the users.

Iran is an ethnically diverse country. The main ethno-linguistic minority groups in Iran are Fars, Azeri, Kurds, and Arabs etc. The literature relating to anthropometric data of Iranian workers is limited. The first anthropometric study of Iranian was done among male soldiers for military design and sizing the bodies in 1967 (Mouodi 1996). However, no information has been issued about the results. Kanaani et al. (2010) determined 8 foot dimensions for design of shoes and other foot equipments. Davodiyantalab et al. (2013) reported 18 body dimensions of 400 Irani-

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an workers. However, there is a paucity of data pertinent to Iranian population.

The anthropometric data are considered more critical in designing for a group of diverse population such as in Iran. However, there is a lack of sufficient anthropometric data involving these ethnics in Iran. It will be interesting to find out whether there are significant differences in mean body dimensions of these peoples under varied socioeconomic situations.

According to above-mentioned statements, the aim of this study was to compare anthropometric dimensions among three Iranian ethnic groups.

## METHODS

An anthropometric research was carried out in 6 states that three Iranian ethnic groups were inhabited. The subjects were selected among factory workers in each state depending on the size of total workers population by cluster sampling. In total, 3436 subjects (2762 males and 674 females) with ages ranging from 20-60 years were selected randomly (Table 1). Personal information was also collected by a questionnaire.

In this study thirty-six body dimensions, besides weight of male and female workers of three Iranian ethnic groups were collected. This study was limited to measuring those body dimensions that were considered important and useful for the design of tools and equipment used by Iranian workers and as well as for design of their workplace environments.

The dimensions were measured according to standard definitions given by Pheasant and Haslegrave (2005). The collected data of body dimensions was the kind of static data. The dimensions included length, width, lines and depth. All measurements were taken based on the standard body positions. In the standing position,

there were 11 measurements including 7 heights, 2 breadths, and 2 reaches. In the sitting posture there were 17 measurements consisting of 9 heights, 7 breadths, and 2 reaches. Moreover, 9 other dimensions included 2 depth, 3 breadth, 3 lengths and weight.

## Measuring Instruments

In this study 15 anthropometric set including traditional tools (Kouchi et al. 2014) (made by Kanoon Tarrahan Ferasat Company) were used to measuring anthropometric dimensions of Iranian workers, each anthropometric set included following instruments:

1. Weighting scale: to measure the weight (accuracy of 0.1 kg)
2. Stadiometer (The grid sheet (100cm×200cm) which can be installed on the wall -angle 90 degree)
3. Measuring tape which was used to measure some distances.
4. Steel measurement tape for measuring long dimensions
5. Plummert: for measuring the precise liner distance between some of the body dimensions and the floor (i.e. shoulder joint, elbow, wrist, knee, and the greater trochanter of femur)
6. A small and a large Calipers (accuracy of 0.1 mm)
7. A Spreading caliper for measuring depth
8. Adjustable chair was used for the measurements in the sitting positions.

The measurements were taken by a group of thirty engineers and one anthropologist. Body dimensions of the subjects were measured from the right hand side. While measuring body dimensions, the head was positioned in the Frankfurt horizontal plane described by Lohman et al. (1992) and for dimensions in standing posture; the subjects were in erect position with the weights equally distributed on both feet, whereas in sitting position the knee and hip angles were controlled to be about 90 degree. Before starting the measurements, the instruments were calibrated to reduce both inter and intra investigator validity. Each dimension was measured three times and the mean values were recorded in the data sheets. In order to eliminate inter observer variations, all measurements were made by the same person for all the participants. The engineers were provided instructions for using

**Table 1: Distribution of Iranian workers in each ethnic group**

| Ethnic groups | Number           |        |      |        |
|---------------|------------------|--------|------|--------|
|               | Total population | Female | Male | Sample |
| Azeri         | 235054           | 234    | 660  | 894    |
| Fars          | 532255           | 350    | 1682 | 2032   |
| Arab          | 136921           | 100    | 420  | 520    |
| Total         | 904230           | 684    | 2762 | 3446   |

anthropometric instruments in the laboratory. Before data collection, several trials were conducted in the laboratory to make sure that the measurers were fully understood all procedures of measurement. Additionally, they were followed consistently over the period of data collection. The measurements done by each measurer in the trial sessions were checked by another measurer to determine the accuracy and consistency of the measurements.

During data collection, two independent measurements were performed for each dimension and each subject. If the difference between the two measurements exceeded the acceptable level, the third measurement was performed to assure the accuracy of records.

Descriptive statistics (mean, standard deviation, 5th and 95th percentiles) related to anthropometric dimensions of the study population were calculated using SPSS software. The role of percentile in design process is to provide a basis for judging the proportion of a group of people who exceed or fall below possible design limit. Therefore, apart from mean, 5th and 95th percentile values of body dimensions were also calculated. Furthermore, ANOVA and post-hoc statistical tests (Scheffe test) were carried out in order to compare the mean body dimensions of males and females of each ethnic group.

## RESULTS

The results of anthropometric database for male and female of Azeri, Arab and Fars workers are presented in Tables 2 and 3, respectively. The mean, standard deviation, 5th and 95th percentile values of body dimensions of three Iranian ethnic groups were calculated separately for both males and females.

Statistical comparisons between the mean dimensions of the three ethnic groups were performed using ANOVA and post-hoc tests (Scheffe test), separately for men and women. The results showed that there was a total of 30 body dimensions which were significantly different among the three ethnic groups for male and 27 dimensions for the female ( $p < 0.05$ ). These significant differences were found for 8 dimensions in standing position, 16 in sitting position and 6 in other positions.

Regarding comparison of Fars and Arab male workers, a total of 25 significantly different dimensions was observed ( $p < 0.05$ ). The Arab work-

ers had larger mean dimension in buttock-knee length, buttock-popliteal length, shoulder breadth (bideltoid), shoulder breadth (biacromial), chest depth, abdominal depth, shoulder-elbow length and hand length comparing to Fars workers. What is more, Fars male had greater mean value in all the mentioned 30 items in comparison with the Azeri male. Additionally, 29 body dimensions were statistically different among the Arab and the Azeri male population. There were a total of 7 non-significant differences among male of the three ethnics. This non-significant items in standing position were: hip height, knuckle height, vertical grip reach (standing), in sitting position the only 1 non-significant item was horizontal upper limb length and the 3 other items were head length, head breadth and hand length. Regarding female workers, there was a total of 27 dimensions that were significantly different ( $p < 0.05$ ) among study ethnics. These differences were found in 7 items for standing position, 14 items for sitting position and 6 items for other positions. There were a total of 21 significant differences ( $p < 0.05$ ) between Fars and Azeri females while 19 body dimensions were observed to be statistically different ( $p < 0.05$ ) between Fars and Arab female population. Moreover, there were 23 significant different body dimensions ( $p < 0.05$ ) between Arab and Azeri female workers. The Arab female had smaller body dimensions in sitting positions compared to Azeri population. There were a total of 10 non-significant differences among the female ethnic groups. This dimensions were in standing (4 items), sitting (3 items) and others (3 items) positions. Standing positions included: stature, hip height, knuckle height, vertical grip reaches, span, elbow span, and forward grip reach. Dimensions in the sitting position were: sitting height, sitting shoulder height, vertical grip reaches (sitting), and dimensions in the other positions were: foot length, head length, and head breadth.

The post-hoc tests (Scheffe test) indicated that Fars men had the largest body size (e.g. stature, eye height-standing, shoulder height, fingertip height, sitting height, shoulder-elbow length, and elbow span) compared to the Azeri and the Arab. In opposite gender, the Azeri females had the largest body size (for example, stature, span, elbow span, shoulder breadth (bideltoid), shoulder breadth (biacromial), hip breadth (sitting), elbow-fingertip length, shoulder-grip length, and weight) compared to Fars and Arab



**Table 3: Anthropometric characteristics of Iranian female workers with different ethnicity (mm)**

| Body dimensions                | Fars   |      |        | Arab   |      |        | Azeri  |      |        |
|--------------------------------|--------|------|--------|--------|------|--------|--------|------|--------|
|                                | 5th    | Mean | SD     | 5th    | Mean | SD     | 5th    | Mean | SD     |
| Stature                        | 1471.5 | 1584 | 1691.7 | 1484.4 | 1579 | 1681.7 | 1503.0 | 1590 | 1680.0 |
| Eye height                     | 1361.4 | 1473 | 1591.6 | 1364.1 | 1470 | 1561.6 | 1382.8 | 1471 | 1580.0 |
| Shoulder height                | 1211.2 | 1311 | 1411.4 | 1213.6 | 1303 | 1391.4 | 1232.5 | 1309 | 1400.0 |
| Elbow height                   | 910.9  | 991  | 1071.1 | 912.7  | 982  | 1071.1 | 921.8  | 987  | 1060.0 |
| Hip height                     | 750.8  | 857  | 951.0  | 762.3  | 871  | 940.9  | 801.6  | 866  | 940.0  |
| Knuckle height                 | 640.6  | 703  | 770.8  | 631.9  | 689  | 750.8  | 621.2  | 690  | 760.0  |
| Fingertip height               | 530.5  | 595  | 660.7  | 531.6  | 590  | 640.6  | 551.1  | 603  | 650.0  |
| Sitting height                 | 730.7  | 822  | 890.9  | 762.3  | 829  | 900.9  | 771.5  | 819  | 880.0  |
| Sitting eye height             | 660.7  | 728  | 830.8  | 641.9  | 723  | 800.8  | 661.3  | 716  | 770.0  |
| Sitting shoulder height        | 500.5  | 563  | 640.6  | 501.5  | 566  | 620.6  | 501.0  | 564  | 590.0  |
| Sitting elbow height           | 170.2  | 219  | 270.3  | 153.5  | 212  | 293.3  | 170.3  | 219  | 250.0  |
| Thigh thickness                | 110.1  | 152  | 190.2  | 100.3  | 132  | 160.2  | 120.2  | 149  | 190.0  |
| Buttock-knee length            | 500.5  | 552  | 610.6  | 511.5  | 569  | 650.7  | 521.0  | 564  | 610.0  |
| Buttock-popliteal length       | 380.4  | 435  | 490.5  | 411.2  | 460  | 520.5  | 410.8  | 450  | 500.0  |
| Knee height                    | 440.4  | 489  | 540.5  | 451.4  | 492  | 550.5  | 410.8  | 445  | 490.0  |
| Popliteal height               | 350.4  | 400  | 440.4  | 341.0  | 380  | 440.4  | 360.7  | 390  | 430.0  |
| Shoulder breadth (bideltoid)   | 350.4  | 426  | 520.5  | 371.1  | 418  | 470.5  | 400.8  | 439  | 490.0  |
| Shoulder breadth (biacromial)  | 270.3  | 343  | 420.4  | 300.9  | 350  | 400.4  | 340.7  | 369  | 410.0  |
| Hip breadth (sitting)          | 300.3  | 364  | 420.4  | 300.9  | 347  | 390.4  | 340.7  | 386  | 440.0  |
| Chest depth                    | 210.2  | 257  | 300.3  | 210.6  | 254  | 330.3  | 200.4  | 252  | 310.0  |
| Abdominal depth                | 220.2  | 277  | 350.4  | 210.6  | 277  | 380.4  | 240.5  | 284  | 350.0  |
| Shoulder-elbow length          | 280.3  | 325  | 370.4  | 290.9  | 318  | 360.4  | 270.5  | 308  | 350.0  |
| Elbow-fingertip length         | 390.4  | 420  | 460.5  | 381.1  | 426  | 450.5  | 400.8  | 432  | 470.0  |
| Horizontal upper limb length   | 650.7  | 711  | 780.8  | 652.0  | 707  | 800.8  | 661.3  | 718  | 780.0  |
| Shoulder-grip length           | 550.6  | 616  | 700.7  | 521.6  | 595  | 680.7  | 571.1  | 625  | 680.0  |
| Head length                    | 160.2  | 180  | 200.2  | 170.5  | 184  | 220.2  | 160.3  | 179  | 200.0  |
| Head breadth                   | 130.1  | 143  | 170.2  | 130.4  | 138  | 160.2  | 120.2  | 136  | 140.0  |
| Hand length                    | 160.2  | 171  | 190.2  | 160.5  | 176  | 190.2  | 160.3  | 170  | 190.0  |
| Hand breadth                   | 70.1   | 77   | 90.1   | 70.2   | 75   | 80.1   | 70.1   | 74   | 80.0   |
| Foot length                    | 210.2  | 229  | 250.3  | 210.6  | 234  | 250.3  | 210.4  | 227  | 260.0  |
| Foot breadth                   | 70.1   | 85   | 100.1  | 70.2   | 84   | 100.1  | 80.2   | 88   | 100.0  |
| Span                           | 1401.4 | 1575 | 1731.7 | 1444.3 | 1586 | 1681.7 | 1493.0 | 1594 | 1700.0 |
| Elbow span                     | 740.7  | 823  | 910.9  | 742.2  | 821  | 890.9  | 781.6  | 845  | 910.0  |
| Vertical grip reach (standing) | 1771.8 | 1886 | 2022.0 | 1765.3 | 1892 | 2012.0 | 1763.5 | 1884 | 2000.0 |
| Vertical grip reach (sitting)  | 1051.1 | 1138 | 1241.2 | 1043.1 | 1133 | 1221.2 | 1042.1 | 1117 | 1190.0 |
| Forward grip reach             | 630.2  | 703  | 803.6  | 601.7  | 671  | 721.2  | 610.2  | 664  | 762.1  |
| Weight(kg)                     | 45.6   | 59.7 | 79.9   | 44.2   | 58.8 | 77.8   | 46.0   | 58   | 76.8   |
|                                |        |      | 10     |        |      | 9      |        |      | 9      |

population. Meanwhile, in the male population, Azeri had the smallest body size (such as stature, eye height, shoulder height, elbow height, fingertip height, span, elbow span, vertical grip reach (standing), sitting height, sitting eye height, sitting elbow height, buttock-knee length, knee height, popliteal height, Shoulder breadth (bideltoid), shoulder breadth (biacromial), hip breadth (sitting), shoulder-elbow length, vertical grip reach (sitting), hand breadth, foot length, foot breadth, weight) and the female Fars workers had the smallest body size (for example, hip height, buttock-knee length, buttock-popliteal length, shoulder breadth (bideltoid), shoulder breadth (biacromial), abdominal depth, and foot breadth) compared to Azeri and Arab population, respectively. Also the Arab female had the greatest chest depth, abdominal depth, buttock-knee length, buttock-popliteal length, and knee height.

Additionally, 5th and 95th percentile values related to some of the body dimensions of three Iranian ethnic groups were compared. Regarding 5th percentile, overall, Azeri male and female had the smallest and largest body dimensions, respectively. Moreover, the highest stature, standing eye height, standing shoulder height, and sitting eye height were belonged to 95th percentile of Fars group (both male and female). Considering 95th percentile, the largest sitting shoulder height also was belonged to Arab male and Fars female (Table 4).

## DISCUSSION

This study was undertaken to measure body dimensions of workers of three Iranian ethnics including Fars, Azeri and Arab. This study was limited to measure those body dimensions that are considered to be important and useful for design of facilities, equipment, and also design of work environments which are fitted to Iranian workers. Anthropometric data of male and female for Iranian ethnics aged 20 to 60 years were summarized. Overall, the mean stature and weight of male workers of these three ethnic groups were 1713 mm, and 73.9 kg, respectively. For women workers, these mean values were obtained 1584 mm and 58.8 kg. The ANOVA F results indicated that there is a total combination of 30 body dimensions which had significant differences for the male workers and 26 dimensions for female workers. This result confirms the effect of ethnicity on body dimensions.

**Table 4: 5<sup>th</sup> and 95<sup>th</sup> percentile values of some of the body dimensions, separately for male and female**

| Body dimensions          | Fars   |        |        | Arab   |        |        | Azeri  |        |        |
|--------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                          | 5th    | Mean   | SD     | 5th    | Mean   | SD     | 5th    | Mean   | SD     |
| Stature                  | 1634.9 | 1604.8 | 1845.5 | 1815.4 | 1825.5 | 1503   | 1484.4 | 1691.7 | 1681.7 |
| Standing eye height      | 1524.6 | 1504.5 | 1745.2 | 1715.1 | 1725.2 | 1382.8 | 1364.1 | 1591.6 | 1561.6 |
| Standing shoulder height | 1354.1 | 1324   | 1564.7 | 1544.6 | 1554.7 | 1232.5 | 1213.6 | 1411.4 | 1391.4 |
| Sitting height           | 842.5  | 822.5  | 1003   | 972.9  | 982.9  | 771.5  | 762.3  | 890.9  | 900.9  |
| Sitting shoulder height  | 561.7  | 551.7  | 682    | 672    | 692.1  | 501    | 501.5  | 640.6  | 620.6  |
| Sitting eye height       | 752.3  | 722.2  | 892.7  | 852.6  | 872.6  | 661.3  | 641.9  | 830.8  | 800.8  |
| Popliteal height         | 361.1  | 351.1  | 461.4  | 481.4  | 471.4  | 360.7  | 341    | 440.4  | 440.4  |

According to the survey by Liu et al. (1999), differences in anthropometric characteristics are obvious between different workers. Similar differences were expressed for four ethnic groups, named Chinese, Japanese, Korean and Taiwanese (Lin et al. 2004). These suggest dissimilarity of morphological characteristics of ethnics and races.

The researchers also compared anthropometrics data of Iranian, Chinese (Lin et al. 2004), European (Jurgens et al. 1998) and American male workers (NASA-SID-3000275e) (see Table 5). In the light of comparison, most dimensions of Iranian workers were larger than those of Chinese workers. In addition, some dimensions of Iranian population, that is, eye height, shoulder height, elbow height, sitting eye height, sitting elbow height, and thigh thickness are larger than those of European but popliteal height of European workers was larger than Iranian. The data of some of the body dimensions of Iranian and European workers are close together.

The American male workers have greater mean value in all of the dimensions, compared to Iranian and European. However, in 3 body dimensions including hand length, hand breadth

and foot breadth Iranian and American workers are nearly similar.

The Iran economic growth and technological improvements will lead to greater development of machineries used in industrial and non-industrial settings and increase in the level of demand. All increase the higher probability of human-machine interactions. In this regard, designing a successful product or workplace is of high importance and should involve the principles of ergonomics (Mokdad 2002; Mokdad and Al-Ansari 2009). The anthropometric body dimensions presented in this study across the various states of Iran will help the engineers and designers for design, development and production of improved and suitable tools and equipment for the Iranian population. Furthermore, in this study it was shown that the anthropometric differences among races are greater than among nations.

According to above-mentioned statements, anthropometric data should be considered as a necessary factor in the design of products and workplaces (Hanson et al. 2009; Klamklay et al. 2008; Wichansky 2000) for each group of population. Regarding the increasing usage of Chi-

**Table 5: Anthropometrics data for Iranian, European and American male workers (mm)**

| Body dimension                | Mean    |          |          |         |
|-------------------------------|---------|----------|----------|---------|
|                               | Iranian | European | American | Chinese |
| Stature                       | 1721.8  | 1719.9   | 1799     | 1678    |
| Eye height                    | 1614.8  | 1603     | -        | 1568    |
| Shoulder height               | 1444.3  | 1424     | 1476     | 1367    |
| Elbow height                  | 1086.6  | 1078     | -        | 1054    |
| Sitting height                | 909.4   | 905      | 942      | 908     |
| Sitting eye height            | 805.7   | 790      | 819      | 798     |
| Sitting elbow height          | 267.1   | 243      | 243      | 263     |
| Thigh thickness               | 157.2   | 146      | -        | -       |
| Sitting shoulder height       | 618.5   | 623      | 654      | -       |
| Buttock-knee length           | 581.7   | 604      | 613      | 554     |
| Buttock-popliteal length      | 471.4   | -        | 512      | 457     |
| Knee height                   | 531.6   | 530      | 567      | 493     |
| Popliteal height              | 411.2   | 444      | 444      | 413     |
| Shoulder breadth (bideltoid)  | 454.7   | 474      | 489      | 431     |
| Shoulder breadth (biacromial) | 401.2   | 380      | 411      | 375     |
| Hip breadth (sitting)         | 381.1   | 368      | 384      | 306     |
| Chest depth                   | 237.4   | -        | 250      | -       |
| Abdominal depth               | 257.5   | 237      | -        | -       |
| Head length                   | 189.6   | 192      | 200      | -       |
| Head breadth                  | 150.5   | 149      | 157      | -       |
| Hand length                   | 188.6   | 182      | 193      | 183     |
| Hand breadth                  | 86.9    | 81       | 89       | -       |
| Foot length                   | 257.5   | 255      | 273      | -       |
| Foot breadth                  | 100.3   | 96       | 99       | -       |
| Elbow span                    | 902.7   | -        | 920      | -       |
| Forward grip reach            | 772.3   | 728      | -        | -       |

nese, European and American products in Iran, and based on the differences observed in this study, it is worthwhile to note that manufacturers should consider these differences.

### CONCLUSION

Thirty-six anthropometric databases of three Iranian ethnic groups were collected, summarized, and compared in this investigation. The results of statistical analyses showed that most of mean values had significant differences and the morphological characteristics of the three ethnic peoples were not the same.

In conclusion, the obtained results suggest that there are various body dimension differences among the ethnics in Iranian population. Therefore, the principles of ergonomic and anthropometrics should become a necessary item in the design of products and workplaces.

Regarding the results of the present study, it is worthwhile to note following remarks.

- ♦ This study investigated the differences among three Iranian ethnic groups and the results confirmed differences in morphological characteristics of these people. Therefore, it is recommended that designers consider ethnicity as a crucial element while designing goods and workplaces.
- ♦ Morphological characteristics of nations also differ which shows the need to hence attention to anthropometric dimensions of the target user while importing goods.
- ♦ It is recommended to enlarge the sample size in future studies including larger group of women and also people of other Iranian ethnic groups.

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