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Full Length Research Paper

Anthropometric study among adults of different ethnicity in Malaysia

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A study was done to determine the differences of anthropometrics data among three ethnic populations in Malaysia. Measurements were collected among 300 respondents representing 150 males and 150 females ranging from the age of 18 to 24 years. A total of thirty-three body dimensions were measured. The statistical test includes, mean, standard deviation, standard error of mean, coefficient of variation, minimum, maximum, 5th percentile, 50th percentile and 95th percentile for the various body dimension were tabulated. ANOVA F using post-hoc Scheffe test were performed to determine the significant differences between the means of anthropometric dimension and within the three ethnic's. The result shows that the significant differences ($p<0.05$) in most of the measurements taken between the three ethnics and among the different genders respectively. The post-hoc Scheffe test indicated that the Malay male's have the largest body size compared to the Chinese and Indian. In addition, the Chinese female's have the largest body size compared to the Malay and Indian population. In the male and female population, Indian and Malay have the smallest body size respectively. As a conclusion, the results suggest that there are various body dimension differences between the ethnics in Malaysian population and there is a need to consider ethnicity aspect when designing for the Malaysian population.

Key words: Anthropometry, adults, ergonomic, ethnicity.

INTRODUCTION

Malaysia is located in Southeast Asia. It consists of West Malaysia and East Malaysia which are divided by the South China Sea. It is a multi-ethnic country with a total population of 27.73 millions in 2008. The major ethnic in this country are Malays, Chinese and Indians. In the aspect of economic growth, Malaysia has recorded an impressive average growth rate of 6.7% in the decades between 1971 and 2000. The Malaysian government has planned to fully develop the country by the year 2020 with the creation of a competitive, dynamic, robust and resilient economy.

The Malaysian economic growth and technological improvements will lead to greater demand and development of machines and devices used in industrial and non-industrial settings and which also increase the higher probability of human and machine interaction (Klamklaya et al., 2008). One of the important aspects in

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Table 1. Descriptive statistics of participants (n = 300).

Characteristics	Min	Max	Mean	Std dev.
Male				
Malays	18.00	24.00	19.64	1.08
Chinese	18.00	24.00	19.64	0.85
Indians	18.00	24.00	19.86	1.20
Female				
Malays	18.00	24.00	20.06	1.17
Chinese	18.00	24.00	19.42	0.91
Indians	18.00	24.00	19.86	1.28

designing a successful product or workplaces for human and machine interaction involve the principles of ergonomic (Mokdad and Ansari, 2009; Mokdad, 2002).

Anthropometry is the science of measurement and the art of application that establishes the physical geometry, mass properties and strength capabilities of human body (Leilanie and Prado, 2007). The anthropometric data provide important information in product/equipment and workplace/workstation design (Hanson et al., 2009; Tayyari, 2000). The utilization of anthropometric data will enable designers to accommodate a desired portion of the potential user population in their designs (Tayyari, 2000).

The anthropometry data are considered more critical in designing for a group of diverse population such as in Malaysia where it involves the three main ethnic groups. Similar to the Lin et al. (2004) study, it will be interesting to find out whether there are significant differences in mean body dimensions and bodily proportions of these three ethnics. However, there is a lack of sufficient anthropometric data involving these ethnics in Malaysia. This may due to the reason of high expenditure and time consuming aspect in running the anthropometry data collection process. Therefore, this study was undertaken to fulfill the needs of anthropometry data in Malaysia. The first objective of this study is to develop an anthropometric database for Malay, Chinese and Indian adults in Malaysia. The second objective is to identity the statistical significance between the means of anthropometric dimension among the three ethnics and the third objective is to identify where the differences lie and their level of significance within the three ethnics.

METHODOLOGY

Sample

The financial and time constraints have restricted the participation of large ethnic's population. Therefore, male and female polytechnic students who come from different ethnics were enrolled on a voluntary basic to participate in this study. A group of 300 students (150 males and 150 females) was enrolled in this study (Table 1).

Body dimensions

It has been highlighted by previous researchers that it may require over 300 dimensions to obtain a complete human body dimensions (Hu et al., 2007; Pheasant, 1986; Roebuck et al., 1975). In this study, 33 anthropometrical dimensions were measured for both males and females in centimeter (cm). The dimensions were related to standing, sitting, hands, feet, head and weight of human body (Table 2 and Figure 1) as mentioned in similar research (Motmans, 2005). Each measurement was taken 3 times and the mean value was recorded. The measurements were taken with participants wearing light clothing and with bare feet.

Equipment

There are a variety of methods available for anthropometry measurements which range from highly sophisticated equipment such as 3-D scanners to traditional tools. But due to the financial limitations, the traditional anthropometric tools which are simple and less expensive are used in this study. Previous research has highlighted that traditional measurement also produces data as reliable and accurate as those obtained from the high-technology methods (Mokdad and Ansari, 2009; Ghoddousi et al., 2007). In this study, 2 sets of Harpenden standard anthropometer was used to measure the body dimensions. Each of the set was borrowed respectively from the Institute of Gerontology and Department of Community Health, Universiti Putra Malaysia.

Anthropometric survey team

The survey team consists of 4 members (2 males and 2 females) who carried out the whole data collection. A comprehensive training session for a week (includes theoretical and practical) was provided to the members in order to familiarize them with the data measurement methods. Due to the Malaysian culture, the survey group performed measurement on their data collection according to their same gender. The whole survey was completed approximately in one month.

Data analysis

Data analysis using SPSS was performed to determine the descriptive statistics (mean, standard deviation, standard error of mean, coefficient of variation, minimum, maximum, 5th percentile, 50th percentile and 95th percentile) in order to achieve the first objective of this study which is to determine the anthropometric

Table 2. List of anthropometrical measured position.

Position					
Standing	**Sitting**			**Others**	
Stature	Crown buttock height	Buttock popliteal length	Hip breadth	Hand length	Foot breadth
Eye height	Eye height	Buttock knee length	Shoulder breadth	Hand breadth	Head length
Shoulder height	Shoulder height	Buttock heel length	Elbow breadth	Hand thickness	Head breadth
Elbow height	Elbow height	Elbow grip length		Thumb breath	Head height
Fist height	Popliteal height	Forward grip reach		Forefinger tip breath	Circumference
Vertical grip reach	Thigh thickness	Abdominal depth		Foot length	Weight

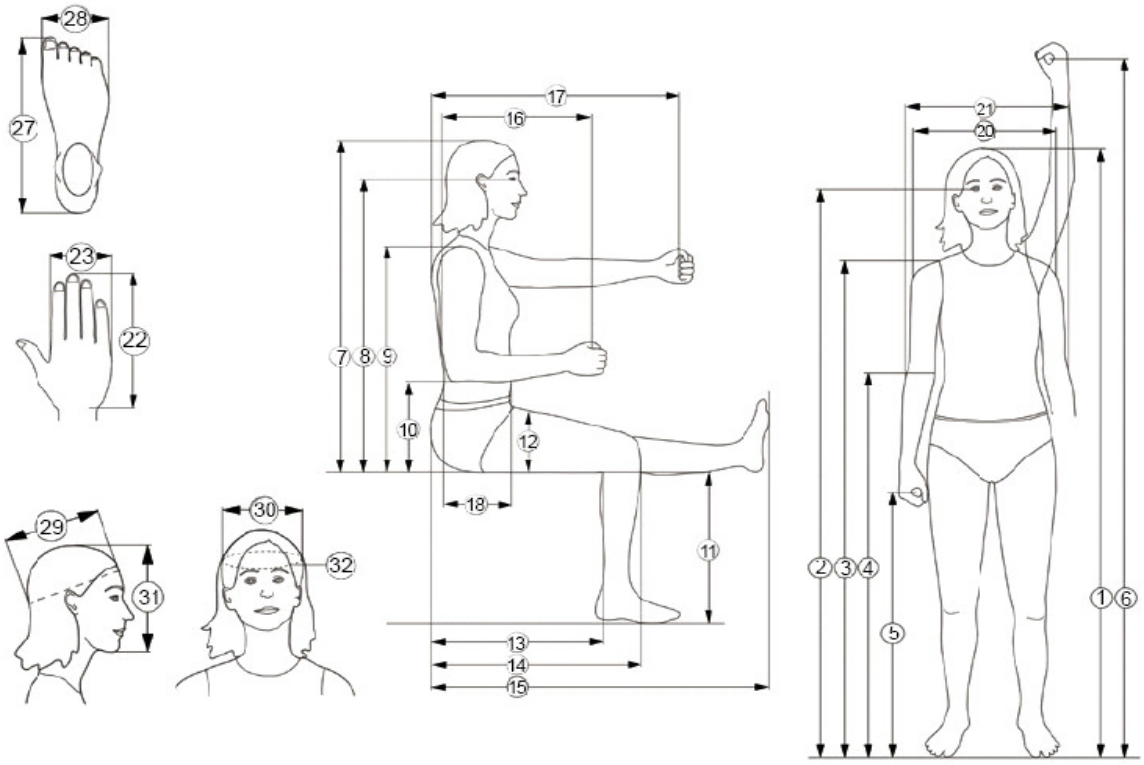

Figure 1. The illustration of the measured anthropometric dimensions (Source: Motmans, 2005).

dimensions of the samples. In order to achieve the second and third objectives, a further statistical comparison between the mean dimensions of the males and females of each ethnic was performed using ANOVA F and post-hoc Scheffe tests.

RESULTS AND DISCUSSION

Anthropometric database for Malay, Chinese and Indian adults

The results of anthropometric database for Malays, Chinese and Indians are presented in Tables 3 to 5. They highlight the statistical analyses of anthropometric measurements which include the mean, standard deviation (SD), standard error of mean (SEM), coefficient of variation (CV), minimum (Min), maximum (Max), 5th percentile, 50th percentile and 95th percentile for male and female among the three ethnics.

The statistical significant differences between the means of anthropometric dimensions among the three ethnics

Statistical comparisons between the mean dimensions of the males and females of each ethnic were performed (Table 6) using ANOVA F test. It is possible to state that there is indeed a significant difference between the

Table 3. Anthropometric data for Malays (male and female), aged 18 to 24 years.

	Measurement[a]	Male (n = 50)									Female (n = 50)								
		Mean	SD	SEM	CV (%)	Min	5th	50th	95th	Max	Mean	SD	SEM	CV (%)	Min	5th	50th	95th	Max
1	Weight (kg)	72.57	16.27	2.30	22.43	46.00	54.00	68.15	102.45	105.00	57.97	13.66	1.93	23.56	38.00	40.55	57.00	98.00	100.00
2	Stature	178.57	2.96	0.42	1.66	174.40	174.56	177.75	184.75	186.80	153.30	9.54	1.35	6.22	141.50	141.61	147.35	167.64	170.10
3	Eye height (standing)	166.44	3.46	0.49	2.08	161.90	162.33	165.05	174.72	175.30	140.86	8.35	1.18	5.93	130.20	131.17	137.45	155.70	156.10
4	Shoulderheight (standing)	148.10	4.04	0.57	2.73	142.20	142.51	147.50	156.75	157.30	125.40	8.03	1.14	6.41	112.50	113.85	123.50	138.74	139.00
5	Elbo height (standing)	112.49	3.76	0.53	3.34	106.10	106.70	111.60	119.59	120.10	96.04	5.82	0.82	6.06	76.90	87.20	95.35	104.50	105.30
6	Fist height (standing)	75.64	5.88	0.83	7.77	52.80	59.18	76.45	81.99	82.50	65.02	6.79	0.96	10.45	50.20	53.05	64.65	75.50	85.60
7	Vertical grip reach (standing)	212.70	5.84	0.83	2.75	200.10	203.66	213.05	223.07	224.50	180.84	10.58	1.50	5.85	160.00	160.16	179.50	196.60	197.20
8	Shoulder breadth (sitting)	45.79	3.47	0.49	7.59	40.10	40.50	45.90	52.58	54.50	37.84	2.76	0.39	7.29	31.80	33.21	37.40	42.45	42.80
9	Elbow breadth (sitting)	47.14	3.71	0.52	7.87	40.50	41.82	47.40	54.05	56.40	42.49	4.07	0.58	9.58	34.10	36.51	42.20	53.57	54.10
10	Thigh thickness (sitting)	14.88	1.76	0.25	11.86	10.20	12.31	14.85	18.79	19.00	14.76	2.55	0.36	17.26	9.70	10.46	15.25	19.05	19.60
11	Abdominal depth (sitting)	18.91	3.42	0.48	18.07	12.40	13.95	18.55	25.65	27.70	18.58	2.99	0.42	16.09	13.40	14.46	18.45	24.47	26.10
12	Hip breadth (sitting)	32.62	3.40	0.48	10.43	24.90	24.96	32.45	38.10	40.30	33.00	4.84	0.68	14.69	13.50	26.51	31.95	41.14	41.00
13	Crown buttock height (sitting)	88.73	3.32	0.47	3.74	76.40	81.84	88.75	93.44	94.80	77.19	5.15	0.73	6.68	65.30	65.36	76.55	84.94	85.80
14	Eye height (sitting)	76.63	3.40	0.48	4.43	66.60	69.12	76.65	81.83	85.20	66.76	5.76	0.81	8.62	52.40	52.61	66.45	74.74	75.00
15	Shoulder height (sitting)	45.79	3.47	0.49	7.59	40.10	40.50	45.90	52.58	54.50	37.84	2.76	0.39	7.29	31.80	33.21	37.40	42.45	42.80
16	Elbow height (sitting)	20.59	3.16	0.45	15.34	14.50	15.20	21.05	26.54	29.00	18.88	3.22	0.45	17.03	13.60	14.36	17.70	25.50	28.80
17	Elbow grip length (sitting)	35.33	2.42	0.34	6.86	24.00	32.56	35.55	38.84	41.90	36.05	5.13	0.73	14.24	25.10	27.51	34.55	43.50	45.50
18	Forward grip reach (sitting)	77.54	3.33	0.47	4.29	70.60	71.83	77.60	83.35	84.50	66.41	4.92	0.70	7.41	54.30	58.57	66.40	71.35	87.10
19	Buttock popliteal length (sitting)	52.39	2.07	0.29	3.95	49.10	49.16	52.40	55.45	57.30	45.26	4.16	0.59	9.18	36.30	38.90	44.80	51.45	53.20
20	Buttock knee length (sitting)	63.38	3.02	0.43	4.76	52.10	56.78	63.35	67.34	67.50	56.66	4.34	0.61	7.65	46.60	47.16	56.75	63.84	66.40
21	Buttock heel length (sitting)	115.00	2.68	0.38	2.33	107.00	111.40	115.30	121.00	121.80	99.98	4.96	0.70	4.96	91.40	93.61	98.45	109.19	109.40
22	Popliteal height (sitting)	41.18	1.25	0.18	3.04	39.30	39.56	40.90	43.81	44.40	38.26	3.00	0.42	7.83	31.40	31.56	39.25	42.25	43.50

Table 3. Contd.

23	Hand length	19.98	1.33	0.19	6.67	17.60	18.13	19.70	24.00	24.80	16.95	1.19	0.17	7.00	15.10	15.36	17.00	19.03	20.30
24	Hand breadth	7.07	0.48	0.07	6.74	5.80	6.40	7.10	8.05	8.70	6.45	0.79	0.11	12.28	4.60	5.02	6.50	7.95	8.10
25	Hand thickness	2.93	0.31	0.04	10.50	2.30	2.50	3.00	3.50	3.50	2.40	0.28	0.04	11.60	1.80	1.86	2.40	2.80	3.00
26	Thumb breath	2.07	0.10	0.01	4.63	1.80	1.96	2.10	2.30	2.30	1.76	0.12	0.02	6.82	1.50	1.56	1.70	1.90	2.00
27	Forefinger tip breath	1.62	0.13	0.02	8.10	1.40	1.40	1.60	1.90	1.90	1.58	0.15	0.02	9.49	1.30	1.30	1.60	1.80	3.10
28	Foot length	27.12	1.04	0.15	3.84	25.00	25.37	27.05	28.69	29.70	22.47	1.54	0.22	6.84	18.80	20.11	22.45	25.00	26.30
29	Foot breadth	9.92	0.68	0.10	6.85	7.90	8.90	9.85	10.98	11.50	8.48	1.17	0.17	13.75	7.00	7.00	8.30	11.29	11.40
30	Head length	18.22	1.20	0.17	6.56	12.50	17.10	18.20	19.55	22.30	17.57	1.15	0.16	22.42	14.50	15.50	17.50	19.85	21.20
31	Head breadth	15.28	1.13	0.16	7.00	13.20	13.36	15.30	18.85	18.90	15.06	1.55	0.22	10.00	12.40	12.50	14.60	18.46	18.70
32	Head height	24.41	1.52	0.21	6.21	19.50	21.03	24.50	26.65	27.40	22.29	1.35	0.19	6.04	20.20	20.30	22.00	24.55	25.30
33	Circumference	56.28	1.79	0.25	3.18	52.70	53.06	56.60	59.00	59.40	54.94	2.64	0.37	4.81	49.50	49.87	55.10	59.79	60.10

[a] measured in centimeters.

Table 4. Anthropometric data for Chinese (male and female), aged 18 to 24 years.

	Measurement[a]	Male (n=50)									Female (n=50)								
		Mean	SD	SEM	CV (%)	Min	5th	50th	95th	Max	Mean	SD	SEM	CV (%)	Min	5th	50th	95th	Max
1	Weight (kg)	64.17	14.70	2.08	22.91	42.00	47.10	61.00	100.00	113.00	55.82	12.56	1.92	22.50	40.00	41.08	52.00	86.80	88.00
2	Stature	169.38	5.91	0.84	3.49	158.40	159.97	169.60	179.52	182.40	158.58	5.14	0.78	3.24	150.10	151.48	157.00	170.46	170.70
3	Eye height (standing)	158.10	6.61	0.94	4.18	142.30	148.19	159.50	168.25	170.40	147.28	5.02	0.77	3.41	139.50	140.42	146.10	159.56	159.70
4	Shoulder height (standing)	140.23	5.79	0.82	4.13	130.40	131.26	140.40	150.69	156.60	130.35	5.01	0.76	3.85	120.50	121.42	129.80	140.86	140.90
5	Elbow height (standing)	107.16	3.94	0.56	3.68	98.40	101.00	106.90	113.81	121.40	100.18	4.18	0.64	4.18	90.00	91.24	100.10	107.74	108.00
6	Fist height (standing)	72.92	2.99	0.42	4.10	65.10	67.72	73.15	79.41	81.60	67.40	3.45	0.53	5.11	60.00	60.86	67.80	73.98	74.10
7	Vertical grip reach (standing)	201.33	9.15	1.29	4.55	183.50	184.66	201.85	216.80	217.80	186.58	7.27	1.11	3.89	163.50	174.14	186.10	198.60	199.40
8	Shoulder breadth (sitting)	43.07	2.93	0.41	6.80	37.50	38.93	42.40	49.64	50.30	37.38	3.21	0.49	8.59	32.50	33.56	36.10	44.20	44.30
9	Elbow breadth (sitting)	44.68	4.08	0.58	9.14	37.50	39.00	44.30	52.82	57.30	40.94	3.70	0.56	9.03	34.40	34.68	40.60	50.24	51.40
10	Thigh thickness (sitting)	14.94	1.82	0.26	12.15	9.80	11.26	14.75	18.07	19.50	13.04	2.60	0.40	19.94	8.70	9.64	12.20	18.76	18.90
11	Abdominal depth (sitting)	18.14	2.95	0.42	16.28	11.70	13.37	18.00	23.90	28.10	17.43	3.42	0.52	19.59	13.00	13.34	16.30	25.56	25.80

Table 4. Contd.

12	Hip breadth (sitting)	30.79	2.84	0.40	9.21	21.40	24.94	30.60	35.74	38.40	31.45	3.62	0.55	11.51	26.60	26.72	30.60	38.48	39.40
13	Crown buttock height (sitting)	85.54	3.41	0.48	3.99	79.30	80.01	85.35	91.52	93.50	81.68	3.79	0.58	4.65	72.40	75.56	81.70	89.78	89.80
14	Eye height (sitting)	73.71	3.56	0.50	4.83	65.90	68.07	73.55	79.90	80.00	69.89	5.40	0.82	7.72	54.60	55.70	70.20	79.18	79.30
15	Shoulder height (sitting)	57.17	2.97	0.42	5.20	51.60	52.66	56.65	62.50	64.40	54.07	3.48	0.53	6.44	44.40	46.58	54.50	59.20	60.10
16	Elbow height (sitting)	20.07	3.11	0.44	15.50	14.30	15.09	19.60	25.45	27.40	21.36	3.58	0.55	16.77	12.50	14.24	22.60	25.54	25.60
17	Elbow grip length (sitting)	33.10	2.37	0.33	7.15	23.50	30.37	33.20	37.07	38.40	33.63	4.28	0.65	12.74	28.80	28.92	32.40	41.76	43.30
18	Forward grip reach (sitting)	74.07	5.27	0.75	7.12	62.50	64.17	74.65	84.85	85.30	66.26	3.61	0.55	5.44	59.90	60.44	66.20	73.16	73.20
19	Buttock popliteal length (sitting)	49.37	3.47	0.49	7.03	38.40	43.90	49.45	55.42	56.30	44.93	3.15	0.48	7.01	40.00	40.02	44.50	50.18	52.50
20	Buttock knee length (sitting)	60.38	3.70	0.52	6.13	49.20	53.90	61.40	67.45	68.30	55.11	3.82	0.58	6.93	38.90	49.60	54.90	59.72	63.40
21	Buttock heel length (sitting)	109.68	4.87	0.69	4.44	101.10	101.91	110.10	118.99	120.40	99.83	5.17	0.79	5.18	89.50	90.24	99.70	108.50	108.50
22	Popliteal height (sitting)	41.00	1.10	0.16	2.69	38.60	39.10	40.85	43.13	43.50	39.28	1.60	0.24	4.08	33.40	34.70	39.40	41.30	41.40
23	Hand length	18.22	1.33	0.19	7.31	13.50	15.91	18.45	20.29	20.80	17.17	1.13	0.17	6.60	14.40	14.68	17.00	19.40	19.50
24	Hand breadth	6.90	0.58	0.08	8.44	5.30	6.02	6.80	8.09	8.40	6.90	0.79	0.12	11.50	5.20	5.40	7.10	8.30	8.40
25	Hand thickness	2.95	0.33	0.05	11.03	2.30	2.36	3.00	3.45	3.70	2.36	0.26	0.04	11.19	2.10	2.10	2.30	3.00	3.00
26	Thumb breath	2.07	0.17	0.02	8.31	1.80	1.80	2.10	2.30	2.90	1.77	0.15	0.02	8.73	1.40	1.52	1.80	2.08	2.10
27	Forefinger tip breath	1.55	0.12	0.02	7.75	1.30	1.36	1.50	1.80	1.90	1.57	0.16	0.02	9.94	1.30	1.30	1.60	1.80	2.00
28	Foot length	25.35	1.70	0.24	6.70	20.40	21.53	25.45	28.30	29.50	23.14	1.14	0.17	4.93	20.30	20.42	23.30	25.28	25.40
29	Foot breadth	9.68	0.66	0.09	6.82	7.70	8.47	9.60	10.91	11.40	8.65	0.90	0.14	10.37	6.30	7.20	8.80	9.70	10.10
30	Head length	18.02	1.05	0.15	5.81	15.40	16.58	18.20	19.08	23.50	17.71	1.42	0.22	8.02	14.40	15.92	17.50	21.94	23.40
31	Head breadth	15.39	0.92	0.13	5.98	13.10	13.50	15.50	16.65	16.90	14.60	0.96	0.15	6.59	12.60	12.66	14.60	16.46	17.30
32	Head height	24.53	1.08	0.15	4.41	21.60	22.46	24.50	26.30	26.50	22.49	1.36	0.21	6.05	19.40	20.20	22.40	24.78	25.50
33	Circumference	55.90	1.48	0.21	2.65	52.40	52.83	56.15	58.30	58.30	55.01	1.93	0.29	3.50	51.00	51.22	55.10	58.18	60.20

[a] measured in centimeters.

means of measured anthropometry dimensions if a significant outcome exists ($p<0.05$).

The ANOVA test shows that there is a total of 25 items which are significantly different ($p<0.05$) between the three ethnics in the male populations. Based on this total items, there are around 15 items which indicated the most significant differences with the value of $p<0.01$. Among the significant difference, can been seen at the

Table 5. Anthropometric data for Indians (male and female), aged 18 to 24 years.

	Measurement[a]	Male (n=50)									Female (n=50)								
		Mean	SD	SEM	CV (%)	Min	5th	50th	95th	Max	Mean	SD	SEM	CV (%)	Min	5th	50th	95th	Max
1	Weight (kg)	65.32	15.79	2.23	24.17	41.00	43.10	63.00	93.45	100.00	55.59	13.49	1.91	24.27	36.00	38.00	53.00	90.45	93.00
2	Stature	168.10	7.68	1.09	4.57	157.50	158.14	165.05	182.44	183.60	156.83	6.79	0.96	4.33	145.50	146.72	159.40	168.88	169.90
3	Eye height (standing)	156.41	9.57	1.35	6.12	132.10	140.06	153.70	173.19	174.60	145.59	6.96	0.98	4.78	130.10	134.38	146.90	157.98	158.90
4	Shoulder height (standing)	141.39	7.52	1.06	5.31	132.00	133.39	138.30	157.30	157.40	130.11	6.13	0.87	4.72	121.30	122.21	127.55	141.45	145.40
5	Elbow height (standing)	106.65	5.51	0.78	5.16	99.50	99.96	105.15	118.75	119.60	100.02	5.45	0.77	5.45	87.30	90.12	101.00	109.86	110.40
6	Fist height (standing)	72.25	4.88	0.69	6.76	63.70	64.07	72.45	82.59	83.50	67.52	3.96	0.56	5.86	60.30	61.84	68.10	74.37	74.70
7	Vertical grip reach (standing)	203.97	10.59	1.50	5.19	190.30	191.26	201.45	225.65	233.50	188.37	10.47	1.48	5.56	172.60	177.15	185.35	219.71	220.30
8	Shoulder breadth (sitting)	43.26	3.44	0.49	7.95	37.30	37.84	42.30	49.05	54.50	38.01	2.93	0.41	7.72	34.00	34.16	37.45	44.08	45.10
9	Elbow breadth (sitting)	46.09	4.32	0.61	9.37	39.20	39.83	45.15	55.27	56.90	42.37	4.91	0.69	11.58	35.30	36.26	41.35	52.72	53.30
10	Thigh thickness (sitting)	14.66	2.45	0.35	16.74	9.90	11.25	14.20	19.26	20.00	12.57	2.06	0.29	16.43	9.10	9.36	12.25	16.68	17.40
11	Abdominal depth (sitting)	19.10	3.67	0.52	19.21	14.60	14.91	17.85	28.01	29.10	18.01	3.69	0.52	20.47	13.10	13.30	17.25	28.19	30.50
12	Hip breadth (sitting)	31.53	3.27	0.46	10.37	20.10	27.56	31.30	38.18	40.80	30.95	4.37	0.62	14.13	20.50	22.06	30.20	41.35	42.00
13	Crown buttock height (sitting)	82.35	4.81	0.68	5.85	71.70	72.19	81.75	91.29	93.40	76.72	4.65	0.66	6.06	68.40	68.86	76.50	83.99	89.30
14	Eye height (sitting)	70.53	4.94	0.70	7.00	58.50	60.56	69.95	79.87	80.60	66.50	4.75	0.67	7.15	57.40	60.16	65.45	75.00	75.50
15	Shoulder height (sitting)	54.81	3.93	0.56	7.18	47.60	48.81	54.40	63.03	65.10	51.72	4.89	0.69	9.46	42.50	44.36	51.30	60.25	64.40
16	Elbow height (sitting)	18.64	3.63	0.51	19.45	11.80	12.99	18.30	26.05	26.20	18.63	2.89	0.41	15.52	12.00	15.59	17.55	22.54	31.00
17	Elbow grip length (sitting)	33.69	2.89	0.41	8.57	23.50	28.24	33.50	38.25	38.50	34.36	4.19	0.59	12.19	28.20	29.09	33.00	43.91	45.50
18	Forward grip reach (sitting)	74.77	5.75	0.81	7.69	62.40	62.94	74.35	84.99	87.90	68.88	5.38	0.76	7.82	57.30	62.11	68.15	77.84	86.30
19	Buttock popliteal length (sitting)	49.96	3.39	0.48	6.79	41.40	43.68	49.80	55.28	58.60	47.30	4.44	0.63	9.38	40.30	40.83	46.20	55.33	55.80
20	Buttock knee length (sitting)	60.89	3.60	0.51	5.92	52.70	55.66	60.35	67.79	68.40	57.19	3.85	0.55	6.74	51.90	52.27	56.25	64.75	65.30
21	Buttock heel length (sitting)	111.59	6.13	0.87	5.50	99.20	100.94	110.95	120.91	122.80	103.20	4.58	0.65	4.44	95.80	97.02	102.75	111.96	112.50

Table 5. Contd.

22	Popliteal height (sitting)	41.45	1.44	0.20	3.47	38.80	39.37	41.40	43.50	48.30	39.89	1.90	0.27	4.77	33.50	35.34	40.10	42.79	42.90
23	Hand length	18.51	1.31	0.19	7.09	14.60	15.91	18.50	20.30	21.20	17.31	1.18	0.17	6.83	15.40	15.91	17.20	19.69	21.10
24	Hand breadth	6.84	0.85	0.12	12.43	4.50	4.71	6.80	8.24	8.50	6.82	0.69	0.10	10.05	5.10	5.36	7.10	7.60	7.60
25	Hand thickness	2.79	0.30	0.04	10.68	2.00	2.10	2.75	3.25	3.40	2.39	0.36	0.05	14.87	1.80	1.96	2.30	3.40	3.40
26	Thumb breath	1.97	0.21	0.03	10.72	1.60	1.60	1.90	2.30	2.90	1.77	0.25	0.04	14.13	1.40	1.40	1.80	2.20	2.20
27	Forefinger tip breath	1.54	0.14	0.02	8.99	1.30	1.30	1.50	1.85	1.90	1.48	0.19	0.03	12.62	1.20	1.20	1.50	1.80	1.90
28	Foot length	25.66	1.76	0.25	6.84	22.70	23.02	25.80	28.55	28.70	23.48	1.47	0.21	6.25	20.20	21.36	23.30	26.04	26.40
29	Foot breadth	9.60	0.81	0.11	8.41	7.90	8.26	9.50	11.39	11.50	8.66	0.80	0.11	9.25	6.30	7.10	8.70	10.25	10.30
30	Head length	18.13	0.80	0.11	4.42	16.20	16.51	18.30	19.39	19.50	18.32	2.04	0.29	11.11	15.20	15.56	17.60	23.00	23.80
31	Head breadth	14.83	0.73	0.10	4.91	13.30	13.46	14.90	16.30	16.50	14.32	0.90	0.13	6.29	12.50	12.88	14.35	16.25	17.30
32	Head Height	22.97	1.27	0.18	5.51	19.60	20.75	23.10	24.85	25.20	21.79	1.34	0.19	6.14	19.10	19.46	21.85	24.45	24.50
33	Circumference	54.85	2.79	0.39	5.09	40.00	51.87	55.30	58.29	59.10	54.22	2.03	0.29	3.75	50.10	51.46	54.05	58.19	58.40

[a] measured in centimeters.

Table 6. A One-way analysis of variance (ANOVA) test for Malays, Chinese and Indians (male and female).

	Measurement[a]	Male (n = 150)							Female (n = 150)						
		ANOVA				Post-hoc Scheffe test			ANOVA				Post-hoc Scheffe test		
		df1	df2	F	Sig.	M - C	M - I	C - I	df1	df2	F	Sig.	M - C	M - I	C - I
1	Weight (kg)	2	147	4.256	0.016*	0.029	0.071	0.029	2	147	0.478	0.621	0.741	0.67	0.996
2	Stature	2	147	47.64	0.000*	0.000	0.000	0.55	2	147	6.109	0.003*	0.004	0.065	0.531
3	Eye height (standing)	2	147	29.309	0.000*	0.000	0.000	0.485	2	147	10.774	0.000*	0.000	0.004	0.51
4	Shoulder height (standing)	2	147	0.965	0.384	0.587	0.96	0.421	2	147	8.741	0.000*	0.002	0.002	0.985
5	Elbow height (standing)	2	147	26.115	0.000*	0.000	0.000	0.851	2	147	9.710	0.000*	0.001	0.001	0.989
6	Fist height (standing)	2	147	7.148	0.001*	0.019	0.002	0.779	2	147	3.872	0.023*	0.078	0.048	0.993
7	Vertical grip reach (standing)	2	147	23.105	0.000*	0.000	0.000	0.322	2	147	8.225	0.000*	0.019	0.001	0.674
8	Shoulder breadth (sitting)	2	147	10.661	0.000*	0.000	0.001	0.959	2	147	0.553	0.576	0.750	0.963	0.594
9	Elbow breadth (sitting)	2	147	4.646	0.011*	0.011	0.434	0.223	2	147	1.831	0.164	0.223	0.99	0.279
10	Thigh thickness (sitting)	2	147	0.272	0.762	0.988	0.862	0.782	2	147	11.378	0.000*	0.003	0.000	0.64
11	Abdominal depth (sitting)	2	147	1.145	0.321	0.524	0.958	0.361	2	147	1.333	0.267	0.268	0.704	0.712

Table 6. Contd.

12	Hip breadth (sitting)	2	147	4.182	0.017*	0.018	0.237	0.506	2	147	3.364	0.037*	0.182	0.049	0.870
13	Crown buttock height (sitting)	2	147	33.387	0.000*	0.000	0.000	0.000	2	147	15.963	0.000*	0.000	0.878	0.000
14	Eye height (sitting)	2	147	28.715	0.000*	0.002	0.000	0.001	2	147	5.705	0.004*	0.020	0.971	0.010
15	Shoulder height (sitting)	2	147	24.732	0.000*	0.002	0.000	0.003	2	147	3.743	0.026*	0.080	0.97	0.046
16	Elbow height (sitting)	2	147	4.654	0.011*	0.729	0.015	0.102	2	147	9.868	0.000*	0.002	0.923	0.000
17	Elbow grip length (sitting)	2	147	10.121	0.000*	0.000	0.007	0.519	2	147	3.521	0.032*	0.041	0.183	0.742
18	Forward grip reach (sitting)	2	147	7.015	0.001*	0.002	0.02	0.777	2	147	4.663	0.011*	0.989	0.037	0.032
19	Buttock popliteal length (sitting)	2	147	13.771	0.000*	0.000	0.001	0.624	2	147	4.991	0.008*	0.921	0.041	0.019
20	Buttock knee length (sitting)	2	147	10.78	0.000*	0.000	0.002	0.762	2	147	3.274	0.041*	0.183	0.808	0.049
21	Buttock heel length (sitting)	2	147	15.893	0.000*	0.000	0.002	0.141	2	147	7.354	0.001*	0.989	0.005	0.005
22	Popliteal height (sitting)	2	147	1.641	0.197	0.770	0.561	0.201	2	147	6.549	0.002*	0.101	0.002	0.437
23	Hand length	2	147	25.313	0.000*	0.000	0.000	0.547	2	147	1.232	0.295	0.650	0.301	0.852
24	Hand breadth	2	147	1.68	0.19	0.433	0.212	0.894	2	147	4.861	0.009*	0.018	0.054	0.873
25	Hand thickness	2	147	4.36	0.014*	0.95	0.062	0.028	2	147	0.226	0.798	0.820	0.995	0.866
26	Thumb breath	2	147	5.637	0.004*	0.984	0.021	0.013	2	147	0.044	0.957	0.972	0.964	1.000
27	Forefinger tip breath	2	147	6.032	0.003*	0.02	0.008	0.954	2	147	5.609	0.005	0.565	0.005	0.114
28	Foot length	2	147	18.973	0.000*	0.000	0.000	0.617	2	147	6.627	0.002*	0.077	0.002	0.512
29	Foot breadth	2	147	0.789	0.456	0.772	0.868	0.459	2	147	0.519	0.596	0.717	0.652	0.997
30	Head length	2	147	0.487	0.616	0.618	0.916	0.853	2	147	1.226	0.297	0.671	0.785	0.297
31	Head breadth	2	147	1,367	0,258	0,625	0,262	0,797	2	147	5,097	0,007*	0,154	0,008	0,556
32	Head height	2	147	22,232	0.000*	0,905	0.000	0.000	2	147	3,387	0,037*	0,779	0,183	0,048
33	Circumference	2	147	6,199	0,003*	0,664	0,004	0,048	2	147	1,843	0,162	0,987	0,281	0,240

*Significant at $p<0.05$; M: Malays, C: Chinese, I: Indians; [a] measured in centimeters.

standing (3 items), sitting (8 items) and others (4 items) positions.

In the standing position, the statistically significant difference was found at eye height [$F(2,147)=29.309$, $p<0.01$], elbow height [$F(2,147)=26.115$, $p<0.01$] and vertical grip reach [$F(2,147)=23.105$, $p<0.01$]. In the sitting position, the 8 significant differences ($p<0.01$) items are shoulder breadth, crown buttock height, eye height, shoulder height, elbow grip length, buttock popliteal length, buttock knee length and buttock heel length. Meanwhile, stature [$F(2,147)=47.64$, $p<0.01$], hand length [$F(2,147)=25.313$, $p<0.01$], foot length [$F(2,147)=18.973$, $p<0.01$] and head height [$F(2,147)=22.232$, $p<0.01$] are the 4 others position items which are significantly different among the three male ethnics.

There are 8 non significant ($0.1<p<0.8$) items

among the male ethnic populations. These none significant differences are in standing (1 item), sitting (3 items) and others (4 items) positions. The respective 8 none significant items are shoulder height (standing), thigh thickness, abdominal depth, popliteal height (sitting position), hand breadth, foot breadth, head length and head breadth (other position).

Meanwhile there is a total of 22 items of significantly differences ($p<0.05$) between the female ethnics population. Within these 22 items, the most significant difference ($P<0.01$) are seen in 7 items. These 7 significant differences are in standing (4 items) and sitting (3 items) positions. In standing position, the significant differences was found in eye height [$F(2,140)=10.774$, $p<0.01$], shoulder height [$F(2,140)=8.741$, $p<0.01$], elbow height [$F(2,140)=9.710$, $p<0.01$] and vertical grip reach [$F(2,140)=8.225$, $p<0.01$]. Meanwhile for the sitting position, the 3 significant differences items are in thigh thickness [$F(2,140)=11.378$, $p<0.01$], crown buttock height [$F(2,140)=15.963$, $p<0.01$] and elbow height [$F(2,140)=9.868$, $p<0.01$].

There are a total of 11 non-significant differences ($0.1<p<0.9$) among the female ethnics group. The 11 the non-significant items are in standing (3 items) and others (8 items) position. Among related sitting position are shoulder breadth, elbow breadth and abdominal depth. The others positions are such as thumb breath, weight, hand thickness, foot breadth and head length.

Identification of the differences and their level of significant within the three ethnics

In order to find where the significant differences lie between the races, a post-hoc test (Scheffe test) was carried out (Table 7). The results are presented according to the comparison of gender and ethnic groups.

Comparison among males

Among the male group, there is a total combination of 25 items which has significant differences between them. Out of this total combination, there are only 3 items that significantly differences between the three races such as in crown buttock height (sitting) [$F(2,147)=33.387$, $p<0.01$], eye height (sitting) [$F(2,147)=28.715$, $p<0.01$] and shoulder height (sitting) [$F(2,147)=24.732$, $p<0.01$]. A post-hoc Scheffe test indicates that the significant value for this 3 items are in the range of $0 < p <0.003$.

Malays – Chinese

The post-hoc Scheffe test indicates that among the significant differences ($p<0.01$) were shown in stature, eye height (standing), elbow height (standing), vertical grip reach (standing), shoulder breadth (sitting), crown buttock height (sitting), elbow grip length (sitting), buttock popliteal length (sitting), buttock knee length (sitting), buttock heel length (sitting), hand length and foot length. The Malay compared to Chinese population, have greater mean value in all the mentioned 20 items expect in shoulder height (sitting).

Malays – Indians

There are a total of 21 statistically significant ($p<0.05$) items between the Malay and Indian male population. The post-hoc Scheffe test indicates that among the significant differences ($p<0.01$) are in stature eye height standing, elbow height (standing), vertical grip reach (standing), crown buttock height (sitting), eye height (sitting), shoulder height (sitting), hand length, foot length and head height. And similar to Malay and Chinese population, the Malay has smaller mean shoulder height (sitting) compared to the Indian population.

Chinese – Indians

Meanwhile, there are only 6 significant differences ($p<0.05$) items between the Chinese and Indian population. Based on post-hoc Scheffe test, it is noticed that the Chinese have larger crown buttock height (sitting), eye height sitting, shoulder height (sitting), head height and circumference compared to the Indian population. The Indians has larger weight compared to the Chinese population.

Comparison among females

The Anova F tests between the female population have indicated that there is a total of 22 combination item which are significantly differences ($p<0.05$) between them.

A further post-hoc Scheffe test revealed that none of these items have significant differences between them. The significance is more in term of combination between the races.

Malays – Chinese

There are a total of 12 significant ($p<0.05$) differences between the Malay and Chinese females' population as indicated by the post-hoc Scheffe test. The Malay have larger mean value of elbow grip length and thigh thickness compared to Chinese population in sitting position. The Chinese have greater mean value of standing (eye height, shoulder height, elbow height and vertical grip reach), sitting (crown buttock height, eye

Table 7. Summary of Post-hoc Scheffe test for significant differences within the three ethnics.

	Measurement	Male (n = 150)			Female (n = 150)		
		M - C	M - I	C - I	M - C	M - I	C - I
1	Weight	>	-	<	-	-	-
2	Stature	>	>	-	<	-	-
3	Eye height (standing)	>	>	-	<	<	-
4	Shoulder height (standing)	-	-	-	<	<	-
5	Elbow height (standing)	>	>	-	<	<	-
6	Fist height (standing)	>	>	-	-	<	-
7	Vertical grip reach (standing)	>	>	-	<	<	-
8	Shoulder breadth (sitting)	>	>	-	-	-	-
9	Elbow breadth (sitting)	>	-	-	-	-	-
10	Thigh thickness (sitting)	-	-	-	>	>	-
11	Abdominal depth (sitting)	-	-	-	-	-	-
12	Hip breadth (sitting)	>	-	-	-	>	-
13	Crown buttock height (sitting)	>	>	>	<	-	>
14	Eye height (sitting)	>	>	>	<	-	>
15	Shoulder height (sitting)	>	<	>	-	-	>
16	Elbow height (sitting)	-	>	-	<	-	>
17	Elbow grip length (sitting)	>	>	-	>	-	-
18	Forward grip reach (sitting)	>	>	-	-	<	<
19	Buttock popliteal length (sitting)	>	>	-	-	<	<
20	Buttock knee length (sitting)	>	>	-	-	-	<
21	Buttock heel length (sitting)	>	>	-	-	-	<
22	Popliteal height (sitting)	-	-	-	-	<	-
23	Hand length	>	>	-	-	-	-
24	Hand breadth	-	-	-	<	-	-
25	Hand thickness	-	-	-	-	-	-
26	Thumb breath	-	>	-	-	-	-
27	Forefinger tip breath	>	>	-	-	>	-
28	Foot length	>	>	-	-	<	-
29	Foot breadth	-	-	-	-	-	-
30	Head length	-	-	-	-	-	-
31	Head breadth	-	-	-	-	>	-
32	Head height	-	>	>	-	-	>
33	Circumference	-	>	>	-	-	-
	Total	20	21	6	12	13	9

(M: Malays, C: Chinese, I: Indians, >: significant with mean value higher, <: significant with mean value lower, - : no significant).

height and elbow height) and others (stature and hand breadth) positions compared to Malay female ethnics.

Malays – Indian

The post-hoc Scheffe test shows that there are a total of 13 statistically significant ($p<0.05$) between the Malay and Indian population. The Indian compared to the Malay population has larger mean dimension in the items of eye height (standing), shoulder height (standing), elbow height (standing), fist height (standing), vertical grip reach (standing), forward grip reach (sitting), buttock popliteal length (sitting), popliteal height (sitting) and foot length. Meanwhile the Malays have larger thigh thickness (sitting), hip breadth (sitting), forefinger tip breath and head breadth compared to the Indian population.

Chinese – Indian

There are a total of 9 significant differences ($p<0.05$) between the Chinese and Indian population as indicated by the post-hoc Scheffe test. The Chinese have larger crown buttock height (sitting), eye height (sitting), shoulder height (sitting), elbow height (sitting) and head

height compared to the Indians. The Chinese have smaller body parts size in sitting (forward grip reach, buttock popliteal length, buttock knee length and buttock heel length) and other (head height) positions compared to Indian population.

CONCLUSIONS

Anthropometric data of male and female for Malaysian ethnics aged 18 to 24 years were collected, analyzed and summarized. The first part of this paper presents the database of 33 anthropometric dimensions for the population with some basic statistical analyses such as the mean, standard deviation, standard error of mean, coefficient of variation, minimum, maximum, 5th percentile, 50th percentile and 95th percentile for the three ethnics.

In the second and third part of this paper, an ANOVA F test and followed by a further post-hoc Scheffe test was performed in order to identity the statistical significant ($p<0.05$) between the means of anthropometric dimension and the level of significant within the three ethnic's. The ANOVA F results indicated that there is a total combination of 25 and 24 items which has significant differences between the male and female groups respectively. In term of the level of significant within the three ethnics, the post-hoc Scheffe test indicated that the Malay male's have largest body size (such as in weight, stature, eye height-standing, elbow height-standing, fist height-standing, vertical grip reach-standing, shoulder breadth-sitting, elbow breadth-sitting, hip breadth-sitting, crown buttock height-sitting, eye height-sitting, elbow grip length-sitting, forward grip reach-sitting, buttock popliteal length-sitting, buttock knee length-sitting, buttock heel length-sitting, hand length, forefinger tip breath and foot length) compared to the Chinese and Indian. In opposite gender, the Chinese female's have largest body size (such as in crown buttock height-sitting, eye height-sitting, shoulder height-sitting, elbow height-sitting and head height) compared to the Malay and Indian population. Meanwhile, in the male and female population, Indian (such as in crown buttock height-sitting, eye height-sitting, head height and circumference) and Malay (such as in stature, eye height-standing, shoulder height-standing, elbow height-standing, vertical grip reach-standing, crown buttock height-sitting, eye height-sitting, elbow height-sitting and hand breadth) have the smallest body size respectively.

In conclusion, these results suggest that there are various body dimension differences between the ethnics in Malaysian population. Therefore the principles of ergonomic and anthropometric should become a necessary item whenever it involves the designing of product and workplaces (Hanson et al., 2009; Klamklaya et al., 2008; Wichansky, 2000; Pentikis et al., 2002) for this type of population. Moreover (in regards to the age range of this study) in Malaysia, designers could use this data in designing the educational furniture in order to facilitate learning by providing a comfortable and stress-free workstation. Furthermore, the usage of correct and updated anthropometric measurements for each target groups/ethnics (Hanson et al., 2009) are important in order to maximize the usability and minimize the musculoskeletal disorder symptoms corresponding to the users.

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