Original Article

Anthropometric of Adult Workers at Kota Kinabalu, Sabah, Malaysia

Hazwan Adli Hamadan,[a,*] Mohd Nur Ikhwan Shafiee,[a] Nor Sahira Mohd Salim,[a] Siti Zaharah Abd. Rahman,[a] Siti Nur Sarah Zubir,[a] Raemy Md Zein,[a] Mohd Esa Baruji,[a] Evelyn Guat-Lin Tan[b]

[a] *Consultation Research & Development Department, National Institute of Occupational Safety and Health (NIOSH), Lot 1, Jalan 15/1, Section 15, 43650, Bandar Baru Bangi, Selangor, Malaysia.*

*Corresponding author: hazwan_adli95@yahoo.com

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ABSTRACT : *Anthropometry is among the critical aspects of ergonomic design tools, computing devices, and reducing the risk of musculoskeletal problems. The design needs to fit the users. Therefore, anthropometric properties were considered during the design stage. However, there are no studies that develop the Sabah population database as a function of anthropometric dimensions. Hence, the main objective of this study is to measure 55 body dimensions and three static strengths. This study measured 276 Sabahan to achieve the objectives, composed of 150 adult males and 126 females. The tools used in this study were the NIOSH anthropometric grid, a standard set of anthropometers and a standard measuring tape, a pinch gauge, handgrip dynamometer, back-leg, and a strong dynamometer. Fifty-eight anthropometric dimensions have been measured in this study. The information collected was standing and sitting position, static strength, body weight, and circumference measurements. The result shows the mean, standard deviation, the 5th, 50th, and 95th percentile values. This finding indicates the importance for product designers to understand anthropometric measurements to create ergonomic products that account for special needs. In addition, the results help provide information for the development of an anthropometric database in Sabahan to design a safer workplace product.*

Keywords - *Anthropometrics, Ergonomics, Sabah Malaysian Workers, Safe Workplace, Standard Measuring*

1.0 INTRODUCTION

Ergonomics are key elements in the design process of any product. Research in ergonomics has led to an interest in expanding the work and furniture design based on human body biomechanics. Anthropometry is a very important element for ergonomic products to create a safer, comfortable and healthy workplace, as it collects information to design a product (Ariful Islam et al., 2013); (Bhattacharjya & Kakoty, 2020).

Anthropometry refers to the measurements of the human body dimensions, which can either be taken in static or dynamic states (Khadem & Islam, 2014);(Zaki et al., 2020). Anthropometric data are essential since they provide designers with knowledge of the user's physical dimensions, which will enable designers to propose design solutions that fulfill special needs (Taifa & Desai, 2017). It has been shown that consumers experience discomfort and, in worse cases, accidents and injuries due to unsuitable products and workspace dimensions.

In general, anthropometry is the element in ergonomic that contributes to the size, form, and strength of human biomechanics. The problem of "fitting people to machines" can be considered a center for ergonomics (Mohamad et al., 2010). Anthropometric is the part in ergonomics to specify the physical dimensions of the job, workplace, workstations, and types of equipment. The design of the tools and the product's structure significantly influence the overall performance and safety. The adjustment range for each tool and other accessories is important to meet the needs of different users (McDaniel, 1991); (Y. C. Lee et al., 2019). Adequate use of anthropometry may enhance the health and well-being of the human body (Sims, 2003). However, anthropometry may also include postural data and a person's reach capability. The user's abilities, such as strength or psychological data, are sometimes measured for specific applications and are also referred to as anthropometric data (Nurul Shahida et al., 2015). Besides, health problems such as musculoskeletal disorders are the most important consequences of mismatching anthropometric dimensions (Sadeghi et al., 2015); (Castellucci et al., 2019).

In Malaysia, musculoskeletal disorders linked to work (WMSD) have gradually increased rises over four years (Hassan et al., 2015);(Alias et al., 2020). The relationship between muscle and skeletal dysfunction in the human body usually triggers muscle disorders. Back pain, knee pain, arm, and wrist pain are the primary issues of humans that become common Musculoskeletal Disorders (MSDs). MSDs are damage to soft tissues of the back, shoulder, arm, elbow, wrist, and fingers (Tittiranonda et al., 1999). Inflammation of tendonitis, epicondylitis, bursitis, and nerve compression disorders, such as carpal tunnel syndrome, sciatica, and osteoarthritis (Punnett & Wegman, 2004). Carpal tunnel syndrome and tendonitis are the most common injuries among workers (Statistics, 2020).

Carpal tunnel syndrome is caused by nerve compression in carpal tunnel wrist syndrome. Symptoms include wrist pain and pinching in the median region of the nerves (Tittiranonda et al., 1999). The injuries are related to occupational factors like tension, repeated elbow movements, an awkward posture, mechanical stress, and vibration (Punnett & Wegman, 2004);(Alias et al., 2020). Many musculoskeletal disorders (WMSD) related to the workplace are tendonitis, including tendons and sheath injuries. This injury occurs due to highly repetitive activities or hard work, requiring uncomfortable positions over long working hours (Tittiranonda et al., 1999). Local pain, sensitivity, and swelling are the symptoms.

There are several studies done by past researchers in constructing an anthropometric database. According to (Barroso et al., 2005), the data collected will serve as a basis for the design of industrial tools, equipment, and clothing. Also, the data establish as an essential element for the ergonomic design of workplaces. (Wang et al., 1999) has constructed a static and dynamic anthropometric database for local workers for use by designers and engineers. The database consists of data for 266 static-body dimensions and 42 dynamic ranges of motion. It is expected that designers and engineers can use the data to create ergonomically designed equipment, devices, and work environment for local workers, thereby ensuring a safe work environment.

Concurrently, (H. P. Lee et al., 2015) have also put up a Singaporean anthropometric database that includes 2000 Singapore citizens and permanent residents in a total of 5 age groups. (Hassan et al., 2015) had conducted a study of the development of anthropometric data for the Malaysian population database. This study has been conducted with 23 static anthropometric dimensions of 1134 Malaysian workers comprising of 863 males and 261 females' measurements from 10 industrial sectors. In West Malaysia, the ethnic study of foot anthropometric had been conducted with 320 respondents on Murut adult ethnic groups. At present, there are no comprehensive anthropometric data for the adult working population in Sabah. For several of the Sabahan populations, anthropometric data relevant for anthropometric have either been lacking. This lack of data can jeopardize the match between workers and the workplace and products used by the workers.

Therefore, there is a need to collect and combine anthropometry measurements of the Sabahan population. As mentioned in the abstract, the objective of this study was to i) measure fifty-five body dimensions, ii) measure three static strengths. To create an ergonomic product, anthropometry plays the main role in design development. Appropriate anthropometry in product design may improve users' well-being, health, comfort, and safety (Mohamad et al., 2010).

2.0 METHOD

2.1 Study Design and Subject Selection

A descriptive convenience cross-sectional study was conducted among Sabahan workers in February 2020. The respondents were selected using non-probability convenience sampling. Invitations for this study were sent through email, social media, instant messaging applications, and prospective advertisement participants.

2.2 Inclusion and Exclusion Criteria

The inclusion criterion is that the participants should be Malaysian citizens aged between 18-54 years old. Meanwhile, the exclusion criteria included pregnancy or any neurological and musculoskeletal diseases that may affect the measurement process.

2.3 Study Tools

A questionnaire was used to gather information based on the participant's demographic background, such as age, gender, ethnicity, marital status, and occupational category. For example, participants involved with manual handling at work were categorized as operations workers. In contrast, those not involved were categorized as operations workers, whereby those who did not fall under these two categories were classified as management workers. Next, their waist circumference and waist-hip ratio were measured using a calibrated measuring tape. Five measurements were collected from two males and three females for each measurement session. Each participant was asked to wear minimal clothing during the measurement sessions.

2.4 Research Ethic

Before anthropometric measurement, the researcher had obtained ethical approval for the study from the National Institute of Occupational Safety and Health Malaysia (NIOSH Malaysia) Ethics Committee. Therefore, all the information obtained shall be handled confidentially in compliance with the Malaysian Personal Data Act 2010. The anthropometry dimension of the respondents will be measured by using NIOSH anthropometric grid (Hassan et al., 2015) and a calibrated standard anthropometric set (TTM Martin's Human Body Measuring Kit, Mentone Educational Centre Carnegie, and Vic, Australia).

2.5 Anthropometric Dimensions Selection

The selection of anthropometric dimensions was based on the previous studies (Hassan et al., 2015), Malaysian Standard 2017: MS ISO 7250:2017-Basic Measurement for Technological Design, and existing guidelines for the design of BIFMA.

2.6 Anthropometry Measurements Procedure

This study used three main equipment: the TTM Martin anthropometer, NIOSH anthropometric grid (Hassan et al., 2015), and measuring tape. An anthropometric grid measuring 213.36cm x 274.32cm standing and sitting body dimension was designed and developed to facilitate the measurement. For the NIOSH anthropometric grid, the measurement will be marked using an erasable color marker pen, and respondents will stand erect depending on the measurements. The dimensions of measurement are divided into 25 dimensions on NIOSH anthropometric grid, 27 dimensions with TTM Martin anthropometer, and three static strength measurements, which is handgrip strength test, were used (Baseline Digital Smedley Dynamometer), pinch grip test was used (Baseline Pinch Gauge). In addition, a back strength test was used (Baseline back, leg, and chest Dynamometer), circumference measurement, and body weight. For circumference measurement, researchers used measuring tape as a standardized method. IBM SPSS version 24 was used. In this study, the development of the anthropometric database on the Sabah population, the mean, standard deviation (SD), 5th, 50th, 95th percentile is being calculated.

2.7 Technical Error Measurement (TEM)

Technical Error Measurement (TEM) was the method to clarify the precision and accuracy of any anthropometrist, which may result in data accuracy (Perini et al., 2005). Before the TEM session, each measurer must go through an essential anthropometric measurement to be familiarized with the equipment and body landmark. The TEM in this study uses similar equipment for real data collection. The method of TEM was adapted from (Jamaiyah et al., 2010); (Knapp, 1992); (Perini et al., 2005).

2.8 Statistical Test

All collected data were analyzed using IBM SPSS Statistic Software Version 19 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). The categorical variables were presented as frequency (percentage), while the continuous variables were presented as mean (M) and Standard Deviation (SD). Furthermore, an independent t-test was used to determine the statistical difference between male and female respondents in each dimension. The study significance level was set at $P < 0.05$.

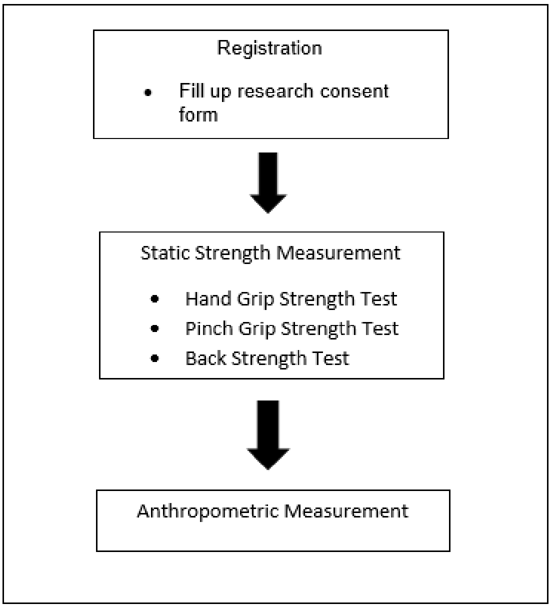

Figure 1 Flow of Data Collection

Figure 2 Anthropometric Grid Measurement (Vertical Grip Reach)

Figure 3 Anthropometer Measurement (Shoulder Elbow Length)

Table 1 Anthropometric Measurement Landmarks

Standing Posture	Cervical height	**Circumference measurement**
Vertical grip reach	Buttock popliteal height	Bodyweight
Fingertip reach height	Popliteal height	Head circumference
Stature	Knee height	Arm circumference
Eye height	Sitting hip breadth	Wrist circumference
Shoulder height	Thigh clearance	Waist circumference
Armpit height	Thight-thight breadth	Hip circumference
Elbow height	Knee-knee breadth	Ankle circumference
Hip height	Ankle height	
Knuckle height	Foot breadth (right)	**Sitting Posture**
Fingertip height	Foot breadth (left)	Vertical reach seated
Tibial height	Foot length (right)	

Biacromial	Foot length (left)	Sitting height
Bideltoid	Hand length (right)	Sitting eye height
Elbow span	Hand length (left)	Sitting shoulder height
Arm span	Handbreadth (right)	Sitting elbow height
Grip reach	Handbreadth (left)	
	Palm length (right)	**Static Strength**
Anthropometer	Palm length (left)	Hand Grip Test
Standing hip breadth	Palm breadth (right)	Pinch Grip Test
Chest depth	Palm breadth (left)	Back Dynamometer
Elbow fingertip length	Head length	
Shoulder elbow length	Head breadth	

Table 2 Demographic Background of Respondent (n: 276)

Variable	Number (n)	Percentage (%)
Age		
<19	1	0.4
20-29	50	18.1
30-39	100	36.2
40-49	72	26.1
50-59	50	18.1
60-69	3	1.1
Gender		
Male	150	54.3
Female	126	45.7
Marital Status		
Married	197	71.4
Single	74	26.8
Widowed	5	1.8
Ethnicity		
Malay	5	1.8
Chinese	4	1.4
Sabah	22	8.0

Others	2	0.7
Malay Sabah	36	13.0
Chinese Sabah	17	6.2
Indian Sabah	1	0.4
Kadazan	56	20.3
Bajau	20	7.2
Dusun	45	16.3
Sungai	3	1.1
Rungus	1	0.4
Brunei	21	7.6
Sino-kadazan/dusun	15	5.4
Idahan	3	1.1
Murut	2	0.7
Iranun	5	1.8
Bisaya	2	0.7
Suluk	3	1.1
Tidong	1	0.4
Kedayan	3	1.1
Bugis	1	0.4
Jawa	1	0.4
Kadazan-Singh	1	0.4
Kadazan-Dusun	1	0.4
Kedayan-Dusun	1	0.4
Iban	1	0.4
Banjar	1	0.4
Position		
Management	194	70.3
Operation	81	29.3
Sectors		
Manufacturing	2	0.7
Electricity, gas, steam, and air conditioning supply	120	43.5
Transportation and storage	7	2.5
Information and communication	7	2.5
Financial and insurance/takaful activities	13	4.7
Administrative and support service activities	19	6.9
Public administration and defense; compulsory social security	10	3.6
Water supply and waste management	1	0.4
Construction	1	0.4
Professional, Scientific, and technical activities	4	1.4
Other Service activities	57	20.7

Table 3 Mean and Standard Deviation for Sabah Male and Female Workers

	Male		Female	
Anthropometry Dimension (cm)	**Mean**	**SD**	**Mean**	**SD**
Standing Posture				
Vertical grip reach	194.4	8.4	181.6	7.3
Fingertip reach height	206.9	8.5	193.3	7.6
Stature	166.0	6.4	156.5	6.0
Eye height	154.6	6.0	145.1	5.3
Shoulder height	138.3	5.4	129.2	5.0
Armpit height	122.3	5.5	113.3	5.2
Elbow height	102.1	5.0	95.2	5.4
Hip height	77.5	5.1	77.6	6.4
Knuckle height	68.8	3.8	64.9	3.6
Fingertip height	60.3	3.7	57.6	3.7
Tibial height	45.7	3.8	41.2	3.7
Biacromial	34.3	3.1	30.4	3.4
Bideltoid	47.1	4.2	44.2	3.8
Elbow span	85.4	4.0	79.6	4.0
Arm span	169.4	6.9	156.6	6.7
Grip reach	70.4	5.5	62.8	6.8
Sitting Posture				
Vertical reach seated	129.2	6.0	120.6	5.9
Sitting height	87.1	3.9	83.8	3.0
Sitting eye height	76.0	4.1	72.4	3.4
Sitting shoulder height	59.9	3.1	57.1	3.3
Sitting elbow height	24.4	3.3	22.7	2.9
Anthropometer				
Standing hip breadth	32.7	2.8	33.2	2.9
Chest depth	21.6	2.6	23.4	3.2
Elbow fingertip length	45.8	2.3	42.0	2.4
Shoulder elbow length	35.7	2.2	34.0	1.9
Cervical height	63.4	3.0	60.0	3.0
Buttock popliteal height	45.6	2.4	45.0	2.2
Popliteal height	40.0	1.6	37.3	1.9
Knee height	51.3	2.8	49.0	2.2
Sitting hip breadth	35.2	3.1	36.2	3.1
Thigh clearance	15.2	2.2	15.1	2.3
Thight-thight breadth	34.6	3.1	32.5	3.7
Knee-knee breadth	25.1	4.5	23.1	4.7
Ankle height	9.3	1.2	9.0	0.9
Foot breadth (right)	9.8	0.5	9.0	0.5
Foot breadth (left)	9.8	0.5	9.0	0.5
Foot length (right)	24.7	1.2	23	1.1
Foot length (left)	24.7	1.4	23	1.1
Hand length (right)	17.9	0.8	17	0.8
Hand length (left)	18.1	0.8	17	0.7
Handbreadth (right)	10.0	0.6	9.0	0.5
Handbreadth (left)	9.9	0.5	9.0	0.5

Palm length (right)	10.2	0.5	9.0	0.5
Palm length (left)	10.2	0.5	9.8	6.9
Palm breadth (right)	8.5	0.5	7.6	1.5
Palm breadth (left)	8.4	0.5	7.5	1.5
Head length	18.4	0.9	17.6	0.9
Head breadth	16.0	0.9	15.6	0.7
Static Strength Measurement (Kg)				
Handgrip strength test (left)	38.9	8.6	23.8	5.60
Handgrip strength test (right)	41.1	8.4	25.6	6.29
Pinch grip strength test (left)	8.3	1.9	5.6	1.51
Pinch grip strength test (right)	8.4	1.8	5.6	1.65
Isometric back strength test	80.0	24.6	43.8	15.0
Circumference measurement				
Bodyweight (Kg)	76.0	14.8	65.0	12.3
Head circumference	56.3	2.19	55.1	2.1
Arm circumference	30.7	3.52	28.5	3.6
Wrist circumference	18.3	2.2	17.1	2.1
Waist circumference	92.3	11.2	86.6	10.7
Hip circumference	101.6	8.8	102.4	9.1
Ankle circumference	24.0	2.2	22.9	2.2

Table 4 Percentile Values (P) of Anthropometry Dimensions of Sabah Male Workers (n=150)

	Male		
Anthropometry Dimension (cm)	**P5**	**P50**	**P95**
Standing Posture			
Vertical grip reach	181.0	194.5	209.1
Fingertip reach height	192.4	206.1	221.5
Stature	156.7	166.0	177.8
Eye height	145.1	154.5	165.4
Shoulder height	129.4	138.0	149.0
Armpit height	115.7	122.1	131.6
Elbow height	95.3	102.0	110.6
Hip height	69.8	77.0	86.7
Knuckle height	63.0	68.5	75.0
Fingertip height	54.2	60.0	66.0
Tibial height	39.0	45.7	51.5
Biacromial	29.7	33.7	40.7
Bideltoid breadth	41.0	46.5	55.1
Elbow span	79.5	85.6	92.6
Arm span	158.5	170.0	181.5
Grip reach	61.9	70.0	79.3

Sitting Posture			
Vertical reach seated	119.0	129.2	139.7
Sitting height	81.3	87.0	93.9
Sitting eye height	69.7	76.1	82.6
Sitting shoulder height	54.2	60.0	65.0
Sitting elbow height	18.9	24.2	30.8
Anthropometer			
Standing hip breadth	28.6	32.4	37.7
Chest depth	17.6	21.5	26.5
Elbow fingertip length	42.1	46.1	49.5
Shoulder elbow length	32.5	35.6	39.1
Cervical height	58.2	63.3	68.6
Buttock popliteal height	41.5	45.4	49.3
Popliteal height	36.7	40.0	42.5
Knee height	47.3	50.9	55.5
Sitting hip breadth	30.4	35.0	40.8
Thigh clearance	11.6	15.1	19.1
Thight-thight breadth	29.8	34.3	40.2
Knee-knee breadth	20.0	24.1	32.8
Ankle height	7.81	9.3	10.9
Foot breadth (right)	8.80	9.8	10.7
Foot breadth (left)	8.90	9.8	10.8
Foot length (right)	22.8	24.8	26.9
Foot length (left)	22.8	24.8	27.1
Hand length (right)	16.4	18.1	19.7
Hand length (left)	16.6	18.2	19.6
Handbreadth (right)	8.9	10.1	10.9
Handbreadth (left)	9.0	10.0	11.0
Palm length (right)	9.2	10.3	11.2
Palm length (left)	9.2	10.3	11.2
Palm breadth (right)	7.7	8.5	9.5
Palm breadth (left)	7.6	8.4	9.4
Head length	16.4	18.5	19.8
Head breadth	14.8	15.9	17.5
Static Strength Measurement (Kg)			
Handgrip strength test (left)	25.7	38.8	53.3
Handgrip strength test (right)	29.1	40.2	55.7
Pinch grip strength test (left)	5.00	8.00	12.0
Pinch grip strength test (right)	5.00	8.00	11.5
Isometric back strength test	40.0	80.0	120.0
Circumference measurement			
Bodyweight (Kg)	54.7	73.8	107.0
Head circumference	52.5	56.5	60.0
Arm circumference	26.0	30.0	36.8
Wrist circumference	15.1	18.0	22.4
Waist circumference	76.0	91.0	113.4
Hip circumference	88.1	100.6	120.0
Ankle circumference	21.0	24.0	27.8

Table 5 Percentile Values (P) of Anthropometry Dimensions of Sabah Female Workers (n=126)

	Female		
Anthropometry Dimension (cm)	**P5**	**P50**	**P95**
Standing Posture			
Vertical grip reach	169.0	181.7	194.0
Fingertip reach height	181.0	192.9	206.6
Stature	146.7	156.0	165.9
Eye height	136.7	145.5	153.7
Shoulder height	121.0	129.0	137.7
Armpit height	106.2	112.4	122.0
Elbow height	87.0	95.0	103.8
Hip height	69.2	76.5	92.9
Knuckle height	58.6	65.0	70.0
Fingertip height	51.0	58.0	63.0
Tibial height	33.5	41.5	47.3
Biacromial breadth	25.3	30.1	35.2
Bideltoid breadth	38.0	44.0	51.5
Elbow span	73.3	79.6	86.0
Arm span	146.3	156.0	167.4
Grip reach	54.3	62.0	73.8
Sitting Posture			
Vertical reach seated	110.62	121.10	130.82
Sitting height	77.66	84.00	89.44
Sitting eye height	68.00	72.50	77.66
Sitting shoulder height	52.83	56.80	63.97
Sitting elbow height	18.29	22.80	26.97
Anthropometer			
Standing hip breadth	28.5	33.4	37.9
Chest depth	18.2	22.9	29.1
Elbow fingertip length	38.0	42.0	45.4
Shoulder elbow length	30.4	33.6	36.7
Cervical height	54.4	59.9	64.4
Buttock popliteal height	40.8	45.0	48.5
Popliteal height	34.4	37.5	40.1
Knee height	44.8	49.0	51.7
Sitting hip breadth	31.6	36.3	41.8
Thigh clearance	11.0	15.2	18.8
Thight-thight breadth	26.8	32.2	40.1
Knee-knee breadth	18.0	22.2	30.6
Ankle height	7.5	9.0	10.6
Foot breadth (right)	8.2	9.0	10.0
Foot breadth (left)	8.1	8.9	10.0
Foot length (right)	21.2	22.9	24.8
Foot length (left)	21.0	22.9	24.7
Hand length (right)	15.0	16.4	17.9
Hand length (left)	15.2	16.6	17.8
Handbreadth (right)	7.9	8.7	9.6
Handbreadth (left)	8.0	8.6	9.5

Palm length (right)	8.1	9.0	10.2
Palm length (left)	8.4	9.3	10.3
Palm breadth (right)	6.8	7.4	8.4
Palm breadth (left)	6.7	7.4	8.2
Head length	16.1	17.6	19.4
Head breadth	14.53	15.6	17.0
Static Strength Measurement (Kg)			
Handgrip strength test (left)	13.5	24.2	32.2
Handgrip strength test (right)	16.1	25.5	38.0
Pinch grip strength test (left)	3.1	5.5	8.0
Pinch grip strength test (right)	3.5	5.5	8.5
Isometric back strength test	20.0	45.0	73.0
Circumference measurement			
Bodyweight (Kg)	46.2	65.5	88.4
Head circumference	51.0	55.0	58.7
Arm circumference	23.0	29.0	34.7
Wrist circumference	13.5	17.0	21.0
Waist circumference	70.0	86.0	104.0
Hip circumference	86.6	102.0	120.4
Ankle circumference	19.1	23.0	27.0

3.0 RESULTS

The results obtained from the anthropometric database collection are shown in the table above. The data analyses were 5th percentile, 50th percentile, 95th percentile, mean (M), and standard deviation (SD). The anthropometric data were collected from 276 Sabah adults comprised of 150 males and 126 females, ranging from 19 to 69 years old.

Table 2 shows the majority of respondents between 30 and 39 years of age (36.2 %). With a ratio of 54.3%, the majority of genders indicate males are higher than females (45.7 %). The marital status was dominated by the married person with (71.4%), and the marital status minority was widowed (1.8%). In terms of ethnicity, the majority of the subjects were Kadazan (20.3%), followed by Dusun (16.3%), Malaysia Sabah (13.0%), and others (0.4%). The majority of respondents worked in the power plant industry (43.5%). And most of the participants were from the category of administration (70.3 %).

Table 3 shows the mean and standard deviation of the standing and sitting postures. First, the mean and standard deviation for the stature of males was (M=166.0, SD=6.47), and the stature of females was (M=156.5, SD=6.01). Next, the mean and standard deviation of the eye height of males was (M=154.6, SD=6.06), and the eye height of females was (M=145.1, SD=5.36). Finally, the mean and standard deviation of elbow height of males was (M=102.1, SD=5.02), and elbow height for females was (M=95.2, SD=5.40).

The mean and standard deviation for a seated vertical reach of males was (M=129.2, SD=6.03) and seated vertical reach for females was (M=120.6, SD=5.93). For sitting height, the mean and standard deviation of males was (M=87.1, SD=3.99), and females were (M=83.8, SD=3.07). For circumference measurement, the mean and standard deviation of body weight for males was (M=76.0, SD=14.89), and body weight for females was (M=65.0, SD=12.34). For waist circumference, the mean and standard deviation for males was (M=92.3, SD=11.25), and waist circumference for females was (M=86.6, SD=10.73).

4.0 DISCUSSION

Malaysia is a multi-cultural nation, multi-racial and multi-ethnic. It consists of the two (West Malaysia) and (East Malaysia) separated by the South China Sea (Khan & Moorthy, 2014). East Malaysia is less populated with a landmass (Khan & Moorthy, 2014). In East Malaysia, the documentation in anthropometric research is still lacking compared to West Malaysia. Unsurprisingly, the number of dimensions between West Malaysia and East Malaysia does not have a huge difference in the anthropometric measurements around East Malaysia.

This finding supported the previous study on the Malaysian working-age population database. The male respondent in all dimensions, including stature, vertical grip, arm width, sitting height, diameter, and static strength, is higher in all dimensions as shown in Tables 3, 4, and 5. Gender is the main factor influencing workplaces, household products, and tools for industrial designers (Tittiranonda et al., 1999). Good designs and products are important for the comfort of both genders based on the current data in this study. This shows that for the adult working population at Kota Kinabalu, Sabah's gender may have an important impact on anthropometric measurements. The present study results align with the previous research in which males are higher than females in anthropometry measurement (Nurul Shahida et al., 2015).

A comparison of the findings of Hassan et al. (2015) shows that anthropometric measurement in standing position on the peninsula of Malaysia is larger in comparison with East Malaysian where the vertical grip reach of the peninsula of Malaysia male was (M=200.85, SD=10.71) and vertical grip reach of East Malaysian male was (M=194.40, SD=8.40). Same as for the female in the peninsula of Malaysia, the female was (M=184.27, SD=9.38), and the vertical grip reach of East Malaysian females was (M=181.6 SD=7.36). As the comparison of the previous study on Asian regions of Malaysia, Japan, Taiwan, China, and Korea also shows, the height value of the stature and sitting height for both male and female data are among the highest of all Asian regions (Mohamad et al., 2010).

The results of the present study indicate similar patterns with the previous studies. The measurement data is higher among males than females for standing postures such as standing knee height, arm span, and elbow span. It is because the 5th percentile value of males is greater than the 5th percentile of female respondents. According to BIFMA standard, the cover occupants up to the 95th percentile of males for safety and good performance. BIFMA G1 Ergonomic Guidelines recommend fit and comfort for the 5th percentile female to the 95th percentile male (Bellingar & Haworth, 2016). In general, it can be deduced that the anthropometric dimension differs significantly between males and females.

However, the limitation of the present study is that it used convenience sampling as a sampling method. As a result, the study respondents are mostly from the Power Plant Industry. So, the data cannot be generalized to the whole workers' population in Kota Kinabalu, Sabah. However, the data from the present study can be used as one of the data to build a comprehensive anthropometric database in the Sabah population. Consequently, anthropometry is considered one of the crucial criteria in designing products and facilities for the Malaysian population. Therefore, this study provides the latest information to construct a comprehensive anthropometric database that will fulfill this need.

5.0 CONCLUSION

Anthropometry is the measurement of body parts. Previous studies show that anthropometric data used in the workstation, equipment, and workplace design can reduce musculoskeletal injury among workers. As shown in the results section, this present study successfully constructs an extensive anthropometric database of the Sabah population. The anthropometric data gathered from this study could provide industrial designers in Malaysia with references.

The industrial designer will use this anthropometric database to develop an ergonomic product, workstation, or facility for all employees. It may help avoid long-term health problems for employees and reduce muscular-skeletal problems amongst workers in Malaysia. Therefore, all industrial designers need to include anthropometric considerations in their design. Furthermore, the workplace arrangement by the individual properties will increase productivity and life quality by decreasing the tiredness in tasks performed either in standing or sitting positions.

The authors have done the most demanding part of the work, which provides the key to a safer, healthier, and more comfortable work environment for Sabahan workers. With this project, a valuable anthropometric database for Sabahan workers is available. Further, studies should induce more respondents and more dimensions to build a comprehensive database for the Sabahan working population.

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