

ANTHROPOMETRIC DATA OF ASEAN ADULTS AND CHILDREN FOR ASEAN NCAP

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1 Introduction

1.1 Background of Project

Anthropometry is the study of the human body dimension, usually measured in static or dynamic position to assess the proportion and composition of the human body (Petruk & Naglic, 2017). Static anthropometry is referring to the standard measurement taken when body parts are held in a static position and fixed points, whereas dynamic anthropometry is a measurement of human body parts taken with the body at work, in motion or specific posture (Institute of Industrial Engineers, 2006). Anthropometric data can be obtained via manual measurement or using body scanner technologies, where the data acts as a compendium of human body dimension for a specific population. The anthropometric data is universally applicable for various fields of works such as industrial and automotive design, including vehicle safety assessment. It is essential to obtain the anthropometric data for ergonomic design guidelines as well as to improve the comfortability, safety, performance, and efficiency of a product (Pheasant, 1998; Dawal et al., 2012).

The New Car Assessment Programme for Southeast Asian Countries (ASEAN NCAP) is using Hybrid III 50th percentile male (HIII-50M), and Q1.5 & Q3 dummies, as adults and children surrogates in their frontal-impact crash testing. Similar dummies (representing children aged between 6 and 10 years old) are also used for Child Restraint System (CRS) installation assessment procedure (ASEAN NCAP, 2019a & 2019b). Historically, the Hybrid III adult dummy represents the anthropometry parameters (stature & body weight) of the US adult population in the 1970s. A follow-up study indicated a substantial change in the distribution of body weights among the US adult population.

With the rapid growth of human populations throughout the globe, physical characteristics of human body composition may have significant variation, particularly in height and weight (Pheasant & Haslegrave, 2006; Tesedo Nieto et al., 2011; Dawal et al., 2012;). These variances are subjected to human diversity factors such as age, genetics, ethnicity, health, diet intake and lifestyle (Hsu et al., 2016; Taifa & Desai, 2017). Another survey conducted on the Chinese population found that both the statures and body weights were relatively lower than the reference values of these dummies – indicating a mismatch of anthropometric measures between the populations of the USA and China (Cao et al., 2016). Anthropometric variations may result in several design issues related to ergonomics, safety, and comfort level of vehicle occupants. Furthermore, without the use of accurate anthropometric data, the performance of product design is limited. Therefore, the need to establish ASEAN anthropometric data for ASEAN NCAP is significant since it involves the safety aspect of vehicle design.

1.2 Problem Statement and Literature Review

Table 1 shows previous anthropometric studies performed particularly in ASEAN countries. Based on these studies, it can be concluded that there are limited works on the anthropometric database that can represent the ASEAN population. Therefore, it is useful to develop a more comprehensive database covering Malaysia, Indonesia, and Thailand to represent the ASEAN's adult and children population. ASEAN NCAP, as a well-known champion of vehicle safety in the ASEAN region, could benefit significantly from this study especially in fulfilling specific considerations towards the ASEAN NCAP requirements. The developed database would help in the development of test manikins for installation checks and other relevant purposes. It may also add another dimension in the human anthropometric study in ASEAN. Besides, relevant stakeholders may want to consider the findings when developing new products (especially related to vehicle safety applications such as child safety seats, restraint system, etc.) in the future. Nonetheless, it is also essential to utilise the anthropometric database in the ergonomic design of products, design for vehicle safety (such as blind-spot reduction), and general vehicle design applications.

Table 1: Study on anthropometry, particularly in ASEAN countries.

Title/Author	Subjects	Age	Location	Dimension	Equipment	Major Finding	Critical Review
Anthropometric Measurements Among Four Asian Countries in Designing Sitting and Standing Workstations. <i>Rahman et al. (2018)</i>	Malaysian - 314 samples Thai - 400 samples Indonesian - 377 samples Filipinos - 1805 samples (Gender not reported)	18 - 45 years old	Malaysia, Thailand, Indonesia, and Philippines	36 anthropometric dimensions	Measuring tape, weighing scale, measuring chair, Scientific Martin pelvimeter, TTM bone calliper)	<ul style="list-style-type: none"> The results indicated that the Indonesians were the tallest among the four countries, whereas the Filipinos were the shortest for both male and female Filipinos and Malaysian data were almost similar and appear to have the smallest values for eye and elbow height 	<ul style="list-style-type: none"> The study focuses on comparison in anthropometric dimensions of four ASEAN countries (gender), where the anthropometric database developed is used to improve industrial workstation and facilities ergonomically
An Anthropometric Comparison of Current Anthropometric Test Devices (ATDs) with Malaysian Adults. <i>Isa et al. (2016)</i>	708 male samples 613 female samples	15 - 80 years old	Malaysia	Stature and body weight	Human body measuring kit, anthropometer	<ul style="list-style-type: none"> The results revealed that the current Malaysian midsize male population differs from the ATD's statures and body weights by about 35 and 40 percentile points The statures of both Chinese and Malaysian populations are slightly shorter than the reference ATDs, while US adults are larger than reference ATDs 	<ul style="list-style-type: none"> The anthropometric parameter selected for this study focus only on stature and body weight Current ATDs used in automotive crash test not fully represent current Malaysian adult.
Incorporating Malaysian's Population Anthropometry Data in the Design of an Ergonomic Driver's Seat. <i>Deros et al. (2015)</i>	1405 male and female (anthropometric data) 100 male and female (driver's seat discomfort)	Not reported	Malaysia	8 sitting anthropometric dimension	Direct measuring method (i.e. anthropometer, ruler, callipers and measuring tape)	<ul style="list-style-type: none"> Questionnaire surveys used to gather respondents' awareness level and their perception towards parameter that influence driver's seat design Driver's seat adjustability is the most influential parameter in determining driver's seat comfort, followed by cushion, and back rest New driver's seat design is established using 3D Digital Human Modelling (DHM) software, CATIA. 	<ul style="list-style-type: none"> The anthropometric data are used to develop and design an ergonomic driver's seat. The parameters are selected with consideration to optimize comfort level and safety of driver's seat
Anthropometric Data of Malaysian Workers. <i>Hassan et al. (2015)</i>	863 - male samples 261 - female samples	Not reported	NIOSH, Malaysia	23 static anthropometric dimensions	Anthropometer and anthropometric grid	<ul style="list-style-type: none"> The result found that there are significant different of anthropometric dimensions between gender. The anthropometric dimensions for each gender is established to be used for designing safer and healthier workplace for Malaysian worker 	<ul style="list-style-type: none"> Covers only 10 industrial sectors classified under the Law of Malaysia Occupational Safety and Health Act 514

<p>Anthropometric Database for the Learning Environment of High School and University Students. <i>Dawal et al. (2012)</i></p>	<p>41 high school students (21 male samples, 20 female samples) 143 university students (74 male samples, 69 female samples)</p>	<p>13 - 17 years (high school students) 18 - 28 years (university students)</p>	<p>Kuala Lumpur</p>	<p>20 static anthropometric dimensions</p>	<p>Measuring tape, weighing scale, measuring chair, pelvimeter, TTM bone calliper)</p>	<ul style="list-style-type: none"> • There are significant differences between gender of high school and university students for several parameters • All data for male students are relatively higher than female students. However, mean BMI for female high school students are greater than for male high school student 	<ul style="list-style-type: none"> • The study compares anthropometric measurement of high school and university students in context of designing products, devices, and equipment for ergonomic learning environments.
<p>Comparison of Malaysian and SAE J833 Anthropometric Proportions for Vehicle Package Design. <i>Rashid et al. A (2013)</i></p>	<p>105 male samples 105 female samples</p>	<p>17 - 60 years old</p>	<p>Malaysia</p>	<p>23 anthropometric dimensions</p>	<p>Measurement taken using manual measurement methods as described in the ISO 3411:2007</p>	<ul style="list-style-type: none"> • Comparison made between anthropometric data of Malaysian population with SAE J833 database for each gender • Malaysian population has longer dimension for upper body segment, whereas data from SAE J833 indicated longer dimension for lower body segment 	<ul style="list-style-type: none"> • Comparison only cover 5th Female, 50th Male and 95th Male percentiles and the anthropometric data collected are for designing ergonomic driver cockpit area for Malaysian population
<p>Incorporating Anthropometrics Data in Designing Driver's Seat for Malaysian Made Compact Cars. <i>Deros et al. (2014)</i></p>	<p>26 males, 19 females (for survey of driver's seat comfort); 1216 Malaysian (anthropometry data)</p>	<p>20 - 30 years old (survey); 15-65 years old (anthropometry data)</p>	<p>Malaysia</p>	<p>62 anthropometric dimensions</p>	<p>L-shape ruler, measuring tape anthropometer</p>	<ul style="list-style-type: none"> • Measured maximum and minimum values of seat adjustment horizontal sliding distance (SLD) and Accelerator Heel Point (AHP) for driver's seat comfort (based on the chosen compact cars) • All the cars studied are able to accommodate 90 % of car drivers from the Malaysian population, except for extreme population (5th and 95th percentile) may experience discomfort 	<ul style="list-style-type: none"> • Only popliteal height parameter is chosen for anthropometric data comparison between car models
<p>Three-Dimensional (3D) Anthropometry Study of the Malaysian Population. <i>Bong et al. (2014)</i></p>	<p>160 - female samples</p>	<p>18 - 65 years old</p>	<p>Malaysia</p>	<p>6 anthropometric dimensions (circumference)</p>	<p>Measuring tape, Holtain skinfold callipers) and 3D body scanner</p>	<ul style="list-style-type: none"> • The anthropometric measurement (circumference) taken with manual and 3D body scanner (Size USA and ISO 8559 size reference) are compared using paired sample t-test analysis • Result shows that mean \pm standard deviations of SizeUSA is higher than manual measurements, compare to ISO 8559 	<ul style="list-style-type: none"> • Covers only Malaysian females and limited to circumference parameters, hence the result cannot be generalized to represent whole body anthropometric measurement for Malaysian population

Anthropometric Study Among Adults of Different Ethnicity in Malaysia. <i>Karnegam et al. (2011)</i>	150 - male samples 150 - female samples	18 - 24 years	Sultan Azlan Shah Polytechnic in Perak	33 anthropometric dimensions	Harpenden standard anthropometer	<ul style="list-style-type: none"> • There are significant differences in most of the anthropometric measurement taken for each three ethnics. • The post-hoc Scheffe test indicated that the majority of the parameters of anthropometry of Malay males have the largest body size compared to the Chinese and Indian. Meanwhile, Chinese females have the largest body size compared to the Malay and Indian population. 	<ul style="list-style-type: none"> • The respondent participate in this study are students age 18-24 years which does not represent each ethnic population in Malaysia
Anthropometry of Malaysian Young Adults. <i>Karnegam et al. (2011)</i>	595 - male samples 437 - female samples	18 - 24 years	Sultan Azlan Shah Polytechnic in Perak	34 anthropometrical dimensions	Harpenden standard anthropometer	<ul style="list-style-type: none"> • Malaysian anthropometric data collected in this study are presented according to each gender (1st, 5th, 50th, 95th and 99th percentile) • The Malaysian anthropometric data are compared with Thailand adults (South), where the results revealed that there are 11 and 12 significant differences between the male and female adults respectively 	<ul style="list-style-type: none"> • The study only covers young adult age 18-24 years. The comparison of anthropometric measurement between Malaysian and Southern Thai adults only cover for 15 parameters
Malaysian Sitting Anthropometry for Seat Fit Parameters. <i>Darus et al. (2010)</i>	216 males and females	18 - 40 years old	Malaysia	16 anthropometrical dimensions	Direct measuring method (i.e. anthropometer, ruler, callipers and measuring tape)	<ul style="list-style-type: none"> • The anthropometric data collected for each gender are compared with previous studies (local anthropometric studies, Thailand, Filipino and Swedish) • There are some differences between current anthropometric data with other local studies for Malaysian (sitting height, sitting elbow height, etc.) • The current findings are found to be significantly larger than the Filipino, but smaller compared to the Thailand and Swedish 	<ul style="list-style-type: none"> • The anthropometric dimension selected for this study are mean to fit parameter dimension for Malaysian automobile driver seat design • The comparison between current study and previous studies only made for few anthropometric dimensions due to different method of measurement and limited data.

1.3 Project Aim and Objectives

This project aims to develop an anthropometric database covering at least three ASEAN countries (i.e., Malaysia, Indonesia, and Thailand) to represent ASEAN's adults and children population.

Specific objectives:

1. To establish anthropometric data of ASEAN adults and children for ASEAN NCAP
2. To compare and analysed developed anthropometric data with other ASEAN countries
3. To develop 3D-model manikin using collected anthropometry data for future ASEAN NCAP use

2 METHODOLOGY

2.1 Research Methodology

Research methodology incorporated four phases as demonstrated in Figure 1 which include:

- Phase 1: Determination of anthropometric parameter
- Phase 2: Data collection
- Phase 3: Data analysis
- Phase 4: Development of ASEAN manikin model

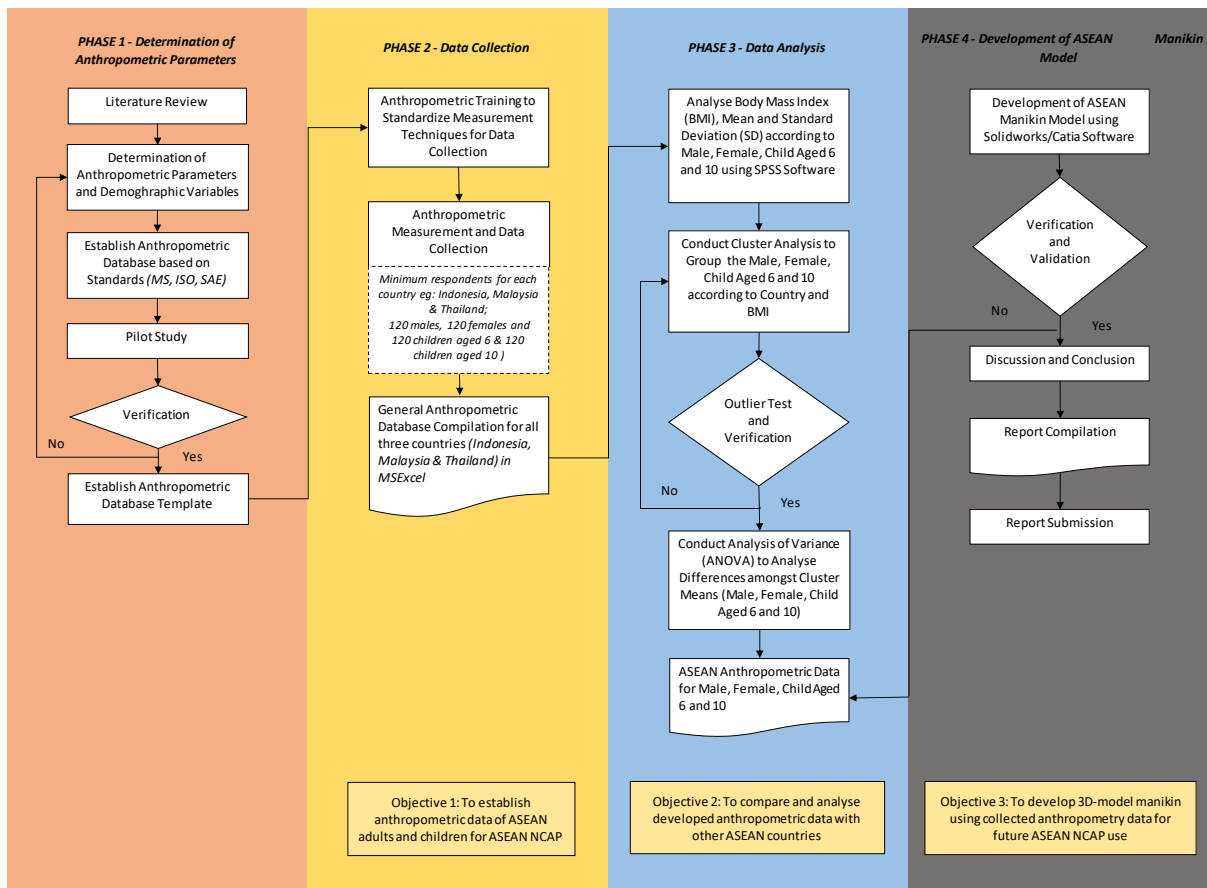


Figure 1: Flowchart for Methodology of Anthropometric Data for ASEAN

Based on Figure 1, three objectives of this study – i) to establish anthropometric data of ASEAN adults and children for ASEAN NCAP; ii) to compare and analyse developed anthropometric data with other ASEAN countries; and iii) to develop 3D-model manikin using collected anthropometry data for future ASEAN NCAP use, are achieved after completing Phase 2, Phase 3 and Phase 4, subsequently. The details for each phase are as follows:

Phase 1: Determination of Anthropometric Parameters

The procedure starts from determination of anthropometric database based on standards including ISO 7250 (Basic Human Body Measurements For Technological Design), and SAE J833 (Standard Human Physical Dimension) to ensure the comparability of the anthropometric database created with all measurements taken as per standard. Several steps were taken to ensure the validity and reliability of anthropometric parameters. Initially, the human body has divided into five segments, comprises the head, body, and torso for sitting, arm and hand, leg and foot as shown in Figure 2. Anthropometric parameters for each segment are identified, with an overall total of 42 anthropometric parameters as

presented in Figure 3. Table 2 shows the body description for each anthropometric parameter. Then, the anthropometric database template was established after the verification process.

Phase 2: Data Collection

This project requires a collection of anthropometric data for adults and children in Malaysia, Thailand, and Indonesia. The 42 anthropometric parameters were measured using direct measuring methods (i.e. height and weighting scale, ruler and measuring tape). Anthropometry measurement was performed with the basic sitting posture, where the subjects sit straight with feet together, shoulders relaxed, while arms and hand are in 90-degree positions as shown in Figure 2. The respondents are required to sit straight on the chair with minimal movement to ensure the body is not moving during the measurement activity. The sampling size was calculated based on the population taken from Department Statistics of Malaysia (Department of Statistics Malaysia, 2019).

In this study, the probability sampling method was used to reach out to the population. The main benefit of using this method is that there will be an equal probability of selection for all respondents in the population without bias (Ross K. N., 2005). Derived from the calculation of measurement sample size (Raosoft, 2004); a minimum recommended sampling size of 68 respondents was needed with a margin of error was 10% with 90% confidence level and response distribution for each category was 50%. To achieve the required sample size, a minimum of 120 respondents to participate in this measurement was set for each category. Before the actual data collection was conducted, a pilot test was carried out to ensure the measurement of the anthropometric parameters followed the ISO 7250-1:2017 Basic Human Body Measurements for Technological Design requirement.

Table 3 summarises the number of respondents participated in this study for each category. Figure 4 shows the data collection activities performed by the team.

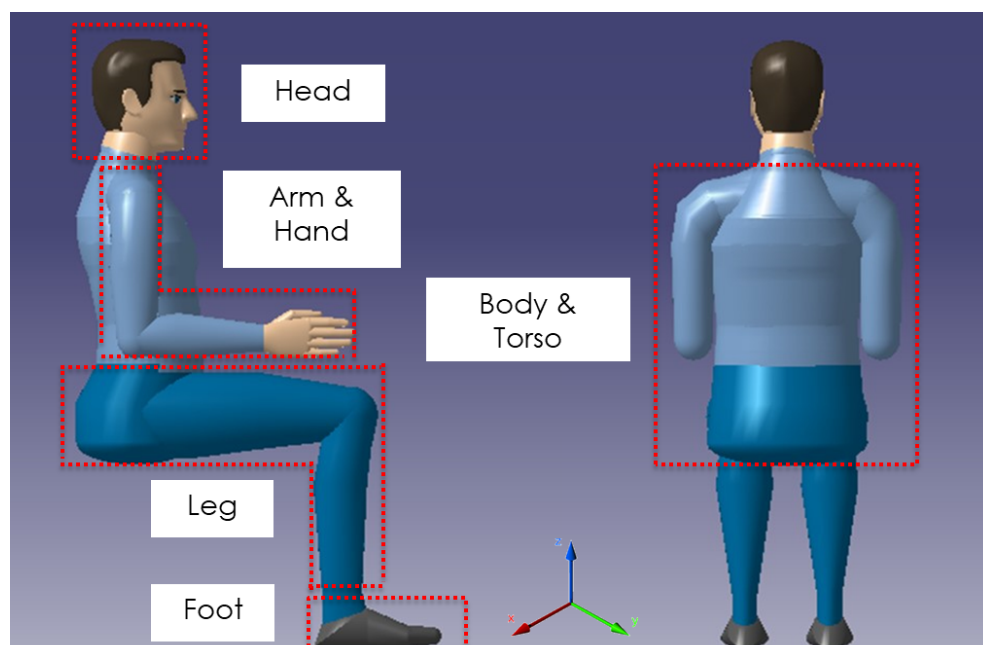


Figure 2: Sitting Posture with Five Segments of Body Measurement

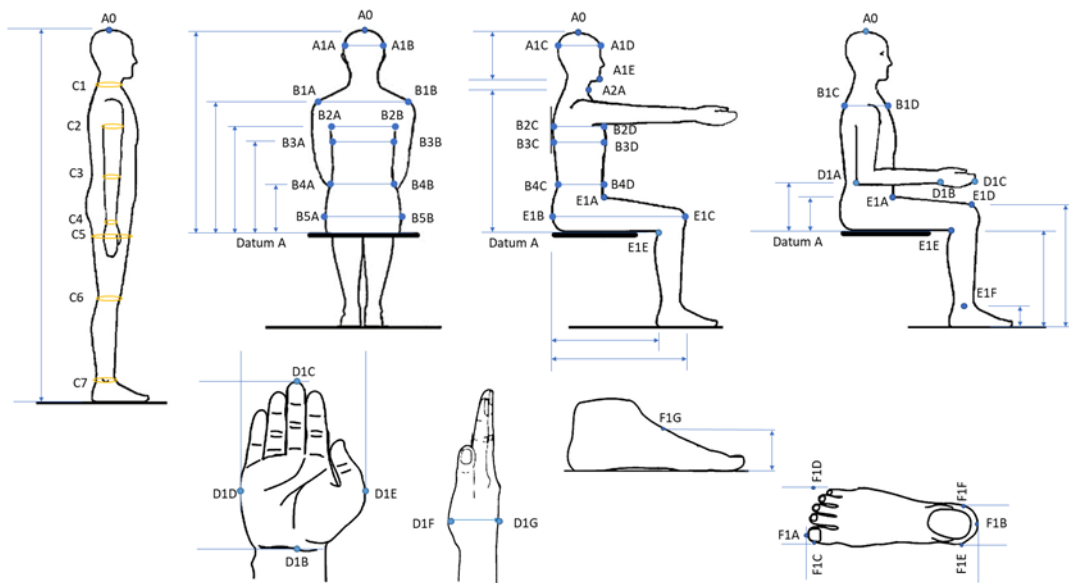


Figure 3: Illustration of 42 Body Dimensions

Table 2: Description of 42 Anthropometric Parameters

Standing Posture (Weight, Stature and Circumferences)			
No	Parameter	Description	Coordinates
1	Weight	Body weight	
2	Stature	Vertical distance from a standing surface to the top of the head.	Base - A0
3	Neck circumference	Circumference of the neck at the infra-thyroid landmark (Adam's apple).	C1
4	Axillary arm circumference (upper arm)	Circumference of the upper arm perpendicular to its long axis at the level of the anterior scye landmark on the upper arm.	C2
5	Elbow circumference	Circumference of the elbow in a plane perpendicular to the long axis of the arm at the level of the olecranon center landmark, with the arm straight at the side.	C3
6	Wrist circumference	Circumference of the wrist perpendicular to the long axis of the forearm at the level of the stylium landmark.	C4
7	Thigh circumference (crotch level)	Circumference of the thigh at its juncture with the buttock.	C5
8	Knee circumference	Horizontal circumference of the knee at the level of the mid-patella landmark (standing).	C6
9	Ankle circumference	Minimum horizontal circumference of the ankle.	C7
Sitting Posture (Head and Neck, Body and Torso, Arm and Hand, Leg, and Foot)			
No	Parameter	Description	Coordinates
10	Sitting Height	Vertical distance between the sitting surface and the top of the head.	Datum A to A0
11	Head Height	Vertical distance between the menton landmark at the bottom of the chin and the horizontal plane tangent to the top of the head.	A0 to A1E
12	Head Breadth	Maximum horizontal breadth of the head above the attachment of the ears.	A1A to A1B
13	Head Length	Maximum length of the head between the glabella landmark and the opisthocranium.	A1C to A1D
14	Sitting Neck Height	Vertical distance between the sitting surface and the infrathyroid landmark (Adam's apple).	Datum to A2A

15	Sitting shoulder height (acromial)	Vertical distance between the sitting surface and acromion landmark on the tip of the shoulder.	Datum A to B1A
16	Sitting shoulder breadth (biacromial)	Posterior distance between the right and the left acromion landmarks on the tips of the shoulders.	B1A to B1B
17	Sitting shoulder depth (acromial)	Horizontal distance between the front and the back at the same shoulder acromial level.	B1C to B1D
18	Sitting interscye height	Vertical distance between the sitting surface and axillary fold posterior landmarks.	Datum A to B2A
19	Sitting intescye breadth	Distance across the back between the top of the right and left axillary fold posterior landmarks.	B2A to B2B
20	Sitting intescye depth	Horizontal distance between the front and back at interscye level	B2C to B2D
21	Sitting chest height	Vertical distance between the sitting surface and the bust point on women and the nipple on men.	Datum A to B3A
22	Sitting chest breadth	Maximum horizontal breadth of chest at the level of the bust point/thelion.	B3A to B3B
23	Sitting chest depth	Horizontal distance between the chest at the level of the bust point on women and the nipple on men, and the back at the same level.	B3C to B3D
24	Sitting waist height	Vertical distance between the sitting surface and the centre of the navel (omphalion).	Datum A to B4A
25	Sitting waist breadth	Horizontal breadth of the waist at the level of the centre of the navel (omphalion).	B4A to B4B
26	Sitting waist depth	Horizontal distance between the front and back of the waist at the level of the centre of the navel (omphalion).	B4C to B4D
27	Sitting hip breadth	Lateral maximum hip or thigh breadth (whichever is broader) of a seated subject.	B5A to B5B
28	Sitting elbow height	Vertical distance between the sitting surface and radial landmark below the elbow.	Datum A to D1A
29	Sitting elbow - wrist forward length	Horizontal distance between the back of the tip of the elbow to the wrist	D1A to D1B
30	Hand length	Length of the hand between the stylium landmark on the wrist and the tip of the middle finger.	D1B to D1C
31	Hand breadth (across thumb)	Maximum breadth of the hand between the metacarpal I and the metacarpal V.	D1D to D1E
32	Hand thickness	Vertical distance between the standing surface and top of hand.	D1F to D1G
33	Sitting thigh clearance height	Vertical distance between the sitting surface and the highest point on the top of the thigh.	Datum A to E1A
34	Sitting knee length (hip to knee)	Horizontal distance between the most posterior point on buttock and the front of the knee as measured in the sitting position with the knees flexed 90 degrees.	E1B to E1C
35	Sitting knee height (top of knee)	Vertical distance between the bottom of the planted foot and the suprapatellar landmark (located standing).	E1D to Base
36	Sitting popliteal height = datum A	Vertical distance between the foot surface and the bottom of the thigh just behind the knee. The subject is seated with the thighs parallel and the knees flexed 90 degrees.	Datum A to Base
37	Sitting popliteal length	Horizontal distance between the most posterior point on the buttock and the back of the knee as measured in the sitting position with the knees flexed 90 degrees.	E1B to E1E
38	Sitting ankle height (ankle to base)	Vertical distance between the standing surface and the lateral malleolus on the outside of the ankle.	E1F to Base
39	Foot length	Distance between the tip of the longest toe and the back of the heel of the standing foot.	F1A to F1B
40	Foot breadth	Maximum breadth of the standing foot between the first and the fifth metatarsophalangeal landmark protrusions.	F1C to F1D
41	Heel breadth	Maximum horizontal distance between the medial and lateral points on the inside and outside at the heel.	F1E to F1F
42	Foot thickness	Vertical distance between the standing surface and top of foot.	F1G to Base

Table 3: Number of Respondents Participated in the Project

	Children 6 Years Old	Children 10 Years Old	Adult Male	Adult Female
Malaysia	143	128	130	123
Thailand	124	120	121	120
Indonesia	140	124	125	134
ASEAN	407	372	376	377



Figure 4: Data Collection Activities

Phase 3: Data Analysis

Anthropometric data for each country (i.e., Malaysia, Indonesia, and Thailand) were sorted and analysed using Microsoft Excel and SPSS software version 25. For screening, Microsoft Excel was used to select the range of weight and height, while the SPSS software was used to calculate the accuracy of collected data by trimming the outliers and also to conduct statistical analysis as described in Section a.

a) Statistical analysis

To trim the outliers, two-steps cluster analysis was used, and the results are displayed using the Q-Q plot and matrix scatter plot. The statistical data analyses for basic descriptive statistics (including mean, standard deviation, 5th percentile, 50th percentile and 95th percentile) for 42 anthropometric parameters were tabulated. These descriptive statistics for body dimensions were calculated to determine the characteristics and measurements of the subjects. The Statistical Package for the Social Science (IBM SPSS Statistics Ver.25, 2017) was used for data entry and descriptive statistical analysis.

b) Anthropometric database for Malaysia (MY), Indonesia (ID) and Thailand (TH)

Anthropometric database for each of the countries are developed consisting of the mean values of 42 anthropometric parameters specified earlier. The findings are presented in Section 3 of this report.

c) Anthropometric database for ASEAN

Anthropometric data of Malaysian, Indonesian and Thai are combined, sorted and re-analysed using Excel and SPSS. Statistical analysis was performed in the combined data to establish the ASEAN anthropometric database comprises the 42 anthropometric parameters. This database is utilized further in Phase 4 for the development of digital 3D-models using SolidWorks. The findings for ASEAN anthropometric database are presented in Section 4.

Phase 4: Development of ASEAN Manikin 3D-Models

ASEAN manikin 3D-models are developed using SolidWorks software. ASEAN 3D-model for each percentile are illustrated in Section 4.

3 ANTHROPOMETRY DATABASE OF MALAYSIAN, THAI, AND INDONESIAN

3.1 Malaysia

Anthropometric database of selected parameters for **Malaysian children aged 6 years old** are tabulated in Table 4.

Anthropometric database of selected parameters for **Malaysian children aged 10 years old** are tabulated in Table 5.

Anthropometric database of selected parameters for **Malaysian adult male** are tabulated in Table 6.

Anthropometric database of selected parameters for **Malaysian adult female** are tabulated in Table 7.

Table 4: Mean, Standard Deviation, and Percentile of Selected Parameters for Malaysian Children Aged 6 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	18.66	2.74	14.88	18.30	24.50
2	Stature (Height)	109.52	6.59	96.00	111.00	119.00
3	Sitting Height	59.80	2.97	54.38	60.00	64.50
4	Head Breadth	14.62	1.31	13.00	14.50	17.13
5	Head Length	16.96	1.08	15.00	17.00	19.00
6	Sitting shoulder breadth (acromial)	25.96	2.16	23.00	26.00	30.00
7	Sitting hip breadth	22.78	2.29	19.38	22.50	28.00
8	Sitting knee length (hip to knee)	36.10	2.09	32.75	36.00	39.75

Table 5: Mean, Standard Deviation, and Percentile of Selected Parameters for Malaysian Children Aged 10 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	33.38	9.54	23.40	31.45	55.10
2	Stature (Height)	136.43	7.03	126.00	135.00	150.95
3	Sitting Height	70.70	3.89	65.03	70.00	78.95
4	Head Breadth	15.62	1.14	14.00	15.50	17.98
5	Head Length	17.68	1.06	16.00	17.75	19.50
6	Sitting shoulder breadth (acromial)	32.31	3.01	28.00	32.00	37.00
7	Sitting hip breadth	28.59	3.18	23.53	28.00	34.95
8	Sitting knee length (hip to knee)	45.63	2.93	42.00	45.00	50.98

Table 6: Mean, Standard Deviation, and Percentile of Selected Parameters for Malaysian Adult Male

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	73.55	15.97	49.86	72.00	103.20
2	Stature (Height)	169.38	6.37	158.00	169.00	180.00
3	Sitting Height	86.35	4.31	78.00	86.00	95.00
4	Head Breadth	16.63	1.55	14.00	17.00	19.00
5	Head Length	18.63	1.28	16.50	18.50	21.00
6	Sitting shoulder breadth (acromial)	42.58	3.71	37.00	42.00	49.60
7	Sitting hip breadth	37.89	3.64	31.70	38.00	44.30
8	Sitting knee length (hip to knee)	56.78	3.46	51.70	56.50	63.00

Table 7: Mean, Standard Deviation, and Percentile of Selected Parameters for Malaysian Adult Female

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	60.38	12.81	44.36	57.10	85.00
2	Stature (Height)	156.14	5.61	146.35	155.00	165.00
3	Sitting Height	80.18	3.96	73.35	80.00	87.00
4	Head Breadth	14.77	1.34	12.50	15.00	17.00
5	Head Length	17.37	1.35	15.00	17.50	19.65
6	Sitting shoulder breadth (acromial)	38.81	3.49	33.85	38.00	47.00
7	Sitting hip breadth	37.82	3.81	32.00	37.50	46.00
8	Sitting knee length (hip to knee)	54.07	3.23	49.00	54.00	59.65

3.2 Thailand

Anthropometric database of selected parameters for **Thailand children aged 6 years old** are tabulated in Table 8.

Anthropometric database of selected parameters for **Thailand children aged 10 years old** are tabulated in Table 9.

Anthropometric database of selected parameters for **Thailand adult male** are tabulated in Table 10.

Anthropometric database of selected parameters for **Thailand adult female** are tabulated in Table 11.

Table 8: Mean, Standard Deviation, and Percentile of Selected Parameters for Thailand Children Aged 6 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	23.23	3.53	18.00	23.00	31.30
2	Stature (Height)	123.27	5.38	115.00	124.00	131.65
3	Sitting Height	64.25	3.73	58.70	64.00	71.00
4	Head Breadth	15.38	0.99	14.00	15.00	17.00
5	Head Length	16.40	1.03	14.00	16.00	18.00
6	Sitting shoulder breadth (acromial)	30.07	2.77	25.00	30.00	35.00
7	Sitting hip breadth	25.73	2.51	22.00	25.00	30.30
8	Sitting knee length (hip to knee)	36.35	2.57	32.00	36.00	40.00

Table 9: Mean, Standard Deviation, and Percentile of Selected Parameters for Thailand Children Aged 10 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	32.78	6.87	23.80	31.00	47.00
2	Stature (Height)	139.50	6.23	130.00	139.00	153.20
3	Sitting Height	71.80	3.83	67.00	71.00	80.20
4	Head Breadth	15.96	1.56	14.00	15.00	19.00
5	Head Length	16.40	1.44	14.00	16.00	19.00
6	Sitting shoulder breadth (acromial)	33.84	2.22	30.00	34.00	38.00
7	Sitting hip breadth	30.32	3.31	25.00	30.00	35.00
8	Sitting knee length (hip to knee)	45.83	3.46	40.00	46.00	50.00

Table 10: Mean, Standard Deviation, and Percentile of Selected Parameters for Thailand Adult Male

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	65.89	10.28	50.00	65.00	89.00
2	Stature (Height)	170.57	7.75	159.90	170.00	180.00
3	Sitting Height	87.52	3.73	82.00	87.00	94.00
4	Head Breadth	17.44	1.06	16.00	17.00	19.00
5	Head Length	18.42	1.52	16.00	18.00	21.00
6	Sitting shoulder breadth (acromial)	44.57	3.67	40.00	44.00	53.00
7	Sitting hip breadth	36.41	3.11	30.90	38.00	40.00
8	Sitting knee length (hip to knee)	53.38	2.74	48.00	54.00	57.00

Table 11: Mean, Standard Deviation, and Percentile of Selected Parameters for Thailand Adult Female

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	50.26	5.28	41.50	50.00	58.00
2	Stature (Height)	160.11	5.30	153.00	159.00	167.50
3	Sitting Height	84.26	3.97	76.00	85.00	89.00
4	Head Breadth	16.40	1.53	14.00	16.00	19.00
5	Head Length	18.00	0.96	16.00	18.00	19.25
6	Sitting shoulder breadth (acromial)	39.11	1.98	35.50	39.50	42.00
7	Sitting hip breadth	33.71	2.98	28.50	34.00	38.00
8	Sitting knee length (hip to knee)	51.83	3.78	45.00	52.00	57.00

3.3 Indonesia

Anthropometric database of selected parameters for **Indonesian children aged 6 years old** are tabulated in Table 12.

Anthropometric database of selected parameters for **Indonesian children aged 10 years old** are tabulated in Table 13.

Anthropometric database of selected parameters for **Indonesian adult male** are tabulated in Table 14.

Anthropometric database of selected parameters for **Indonesian adult female** are tabulated in Table 15.

Table 12: Mean, Standard Deviation, and Percentile of Selected Parameters for Indonesian Children Aged 6 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	19.81	4.00	14.68	19.05	29.15
2	Stature (Height)	113.30	7.15	101.00	112.00	126.00
3	Sitting Height	60.44	3.96	55.00	60.00	68.00
4	Head Breadth	16.08	1.55	14.00	16.00	18.63
5	Head Length	17.61	1.60	15.50	17.50	20.50
6	Sitting shoulder breadth (acromial)	29.13	3.01	24.38	29.00	35.25
7	Sitting hip breadth	26.41	3.28	21.00	26.50	32.00
8	Sitting knee length (hip to knee)	34.83	3.44	30.00	34.25	40.13

Table 13: Mean, Standard Deviation, and Percentile of Selected Parameters for Indonesian Children Aged 10 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	31.93	7.41	22.56	29.50	47.24
2	Stature (Height)	136.62	7.33	124.00	136.00	149.15
3	Sitting Height	71.07	4.27	64.00	71.00	79.00
4	Head Breadth	17.15	1.74	14.93	17.00	20.00
5	Head Length	18.47	1.56	16.00	18.25	21.00
6	Sitting shoulder breadth (acromial)	34.74	4.05	27.00	35.00	41.00
7	Sitting hip breadth	30.71	4.77	25.00	31.00	39.08
8	Sitting knee length (hip to knee)	44.20	4.85	37.00	44.00	51.50

Table 14: Mean, Standard Deviation, and Percentile of Selected Parameters for Indonesian Adult Male

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	66.90	8.83	54.13	67.30	84.44
2	Stature (Height)	170.78	5.20	164.00	170.00	182.85
3	Sitting Height	86.95	4.31	80.58	87.00	95.93
4	Head Breadth	17.37	1.63	15.00	17.00	20.85
5	Head Length	18.53	2.05	15.00	19.00	21.85
6	Sitting shoulder breadth (acromial)	42.76	3.31	37.00	43.00	47.00
7	Sitting hip breadth	37.76	4.54	30.08	38.00	43.85
8	Sitting knee length (hip to knee)	58.55	3.42	52.00	59.25	63.00

Table 15: Mean, Standard Deviation, and Percentile of Selected Parameters for Indonesian Adult Female

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	52.83	6.65	45.00	51.00	65.00
2	Stature (Height)	157.47	4.79	150.00	157.00	167.40
3	Sitting Height	82.07	3.16	76.60	82.00	87.00
4	Head Breadth	17.16	1.58	15.00	17.00	20.00
5	Head Length	18.05	1.53	15.10	18.00	21.00
6	Sitting shoulder breadth (acromial)	39.53	3.15	35.00	39.50	45.00
7	Sitting hip breadth	36.42	4.24	30.50	36.00	42.40
8	Sitting knee length (hip to knee)	54.72	3.49	48.30	54.50	60.50

4 ANTHROPOMETRY DATABASE OF ASEAN

Anthropometric database of selected parameters for **ASEAN children aged 6 years old** are tabulated in Table 16, while Figure 5 depicts the 3D-model representation of this category in 5th, 50th and 95th percentile.

Anthropometric database of selected parameters for **ASEAN children aged 10 years old** are tabulated in Table 17, while Figure 6 depicts the 3D-model representation of this category in 5th, 50th and 95th percentile.

Anthropometric database of selected parameters for **ASEAN adult male** are tabulated in Table 18, while Figure 7 depicts the 3D-model representation of this category in 5th, 50th and 95th percentile.

Anthropometric database of selected parameters for **ASEAN adult female** are tabulated in Table 19, while Figure 8 depicts the 3D-model representation of this category in 5th, 50th and 95th percentile.

Table 16: Mean, Standard Deviation, and Percentile of Selected Parameters for ASEAN Children Aged 6 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	20.33	3.96	15.00	19.60	28.00
2	Stature (Height)	114.95	8.5	101.00	114.50	130.00
3	Sitting Height	61.31	4.05	55.00	61.00	69.00
4	Head Breadth	15.35	1.46	13.00	15.00	18.00
5	Head Length	17.01	1.3546	15.00	17.00	19.50
6	Sitting shoulder breadth (acromial)	28.29	3.17	24.00	28.00	34.00
7	Sitting hip breadth	24.89	3.18	20.63	24.50	30.00
8	Sitting knee length (hip to knee)	35.74	2.83	31.00	36.00	40.00

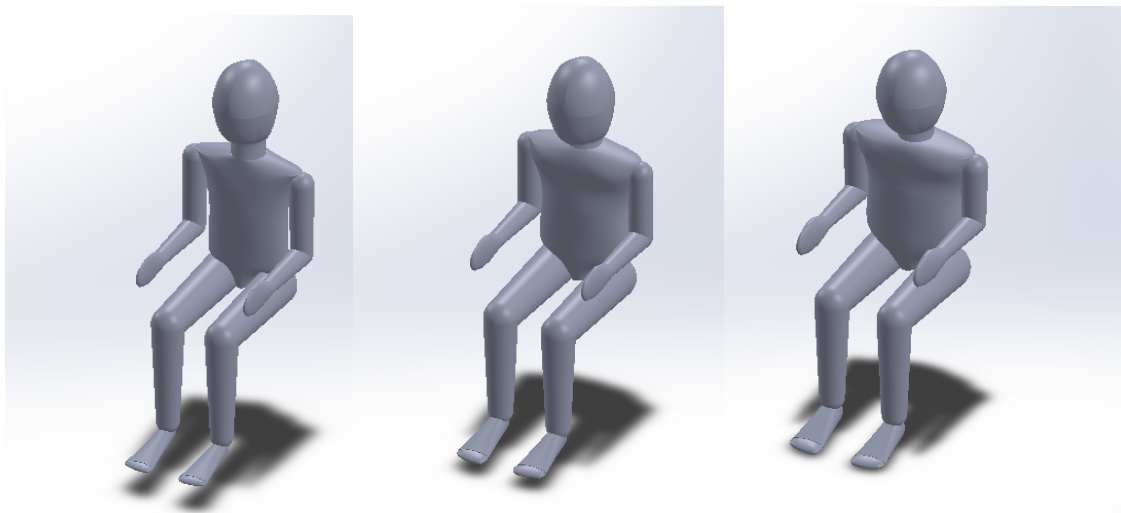


Figure 5: 3D-model of ASEAN children aged 6 years old (5th, 50th and 95th percentiles)

Table 17: Mean, Standard Deviation, and Percentile of Selected Parameters for ASEAN Children Aged 10 Years Old

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	31.66	7.17	22.65	30.00	45.90
2	Stature (Height)	137.16	7.05	125.5	137.0	149.5
3	Sitting Height	71.00	4.03	65.00	70.50	78.50
4	Head Breadth	16.21	1.62	14.00	16.00	19.00
5	Head Length	17.49	1.59	15.00	17.50	20.00
6	Sitting shoulder breadth (acromial)	33.39	3.32	28.00	33.50	38.75
7	Sitting hip breadth	29.60	3.89	24.25	30.00	36.00
8	Sitting knee length (hip to knee)	44.95	3.86	39.00	45.00	50.00

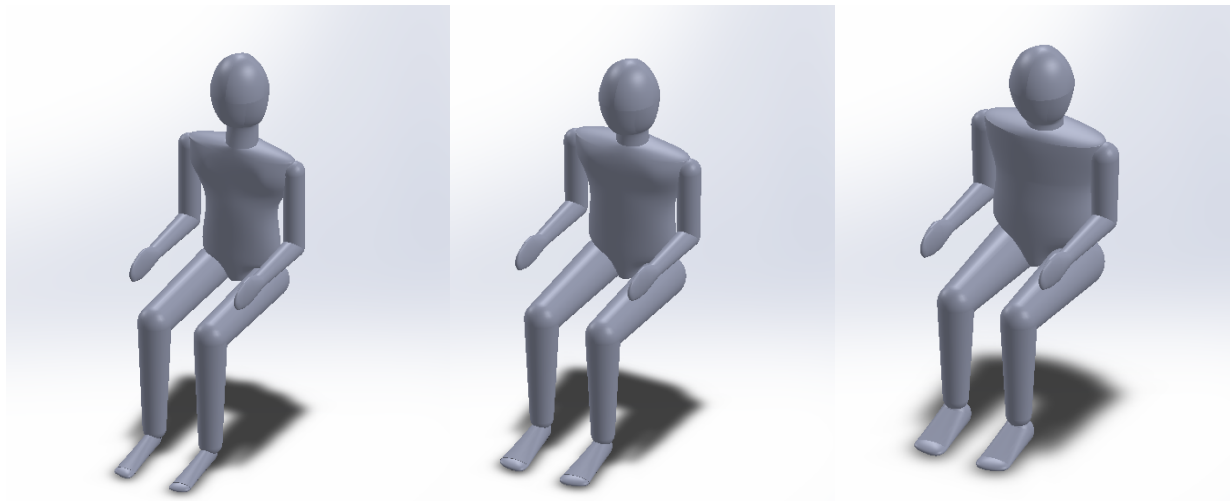


Figure 6: 3D-model of ASEAN children aged 10 years old (5th, 50th and 95th percentiles)

Table 18: Mean, Standard Deviation, and Percentile of Selected Parameters for ASEAN Adult Male

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	68.05	11.49	51.00	69.00	89.00
2	Stature (Height)	170.36	6.49	160.00	170.00	180.00
3	Sitting Height	86.94	4.15	80.50	87.00	95.00
4	Head Breadth	17.12	1.48	14.50	17.00	19.50
5	Head Length	18.51	1.67	16.00	18.50	21.00
6	Sitting shoulder breadth (acromial)	43.16	3.60	37.00	43.00	50.00
7	Sitting hip breadth	37.21	3.77	31.00	38.00	43.00
8	Sitting knee length (hip to knee)	56.14	3.77	49.00	56.00	62.00

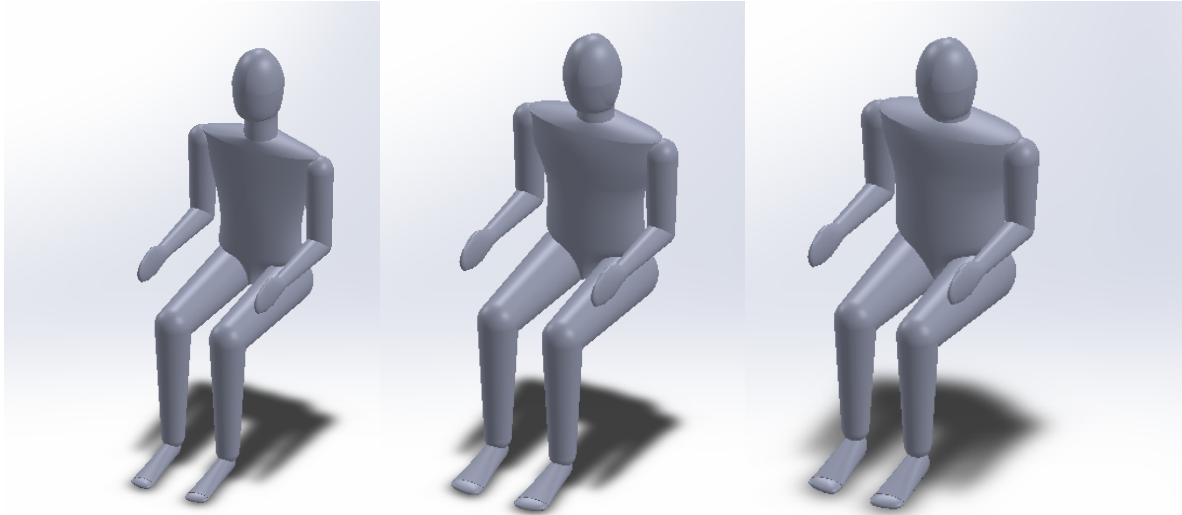


Figure 7: 3D-model of ASEAN adult male (5th, 50th and 95th percentiles)

Table 19: Mean, Standard Deviation, and Percentile of Selected Parameters for ASEAN Adult Female

No.	Parameters	Mean	SD	5 th Percentile	50 th Percentile	95 th Percentile
1	Weight	52.74	7.32	41.58	52.00	65.00
2	Stature (Height)	157.99	5.35	150.00	158.00	167.00
3	Sitting Height	82.18	4.08	76.00	82.00	89.00
4	Head Breadth	16.15	1.79	13.50	16.00	19.00
5	Head Length	17.79	1.36	15.50	18.00	20.00
6	Sitting shoulder breadth (acromial)	38.94	2.80	35.00	39.00	44.00
7	Sitting hip breadth	35.59	3.82	30.00	36.00	42.00
8	Sitting knee length (hip to knee)	53.44	3.69	46.00	54.00	59.50

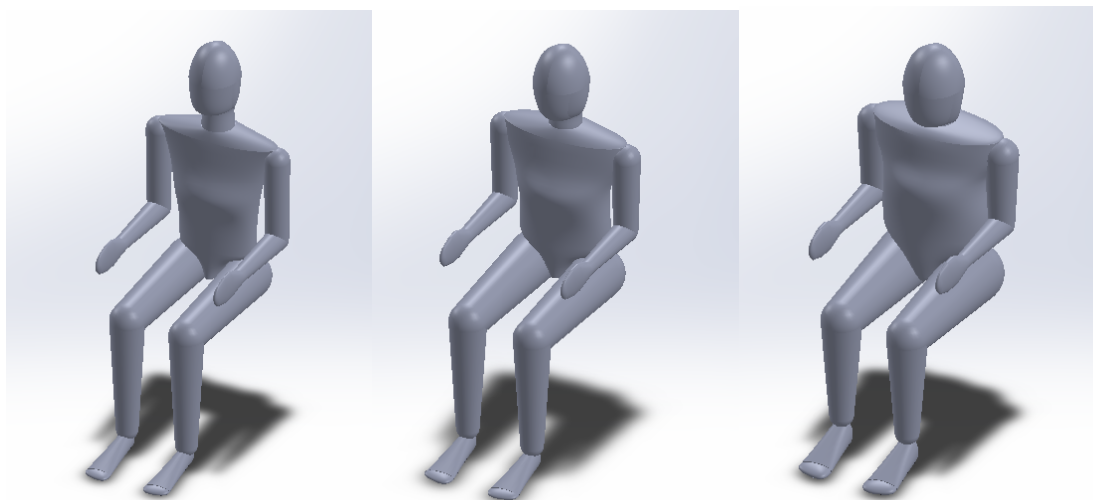


Figure 8: 3D-model of ASEAN female (5th, 50th and 95th percentiles)

5 LIST OF OUTPUT

5.1 Publication

- i. Mohd. Zaki, N. I., Che Husin, S. M., Abu Husain, M. K., Abu Husain, N., Ma'aram, A., Jusuf, A., Carmai, J., Ahmad, Y. and Abu Kassim, K. A., (2019). *Development of Anthropometric Database for ASEAN NCAP: A Case Study of Malaysian Children Aged 6 Years Old*, presented at ICSM2019, Bali, Indonesia.
- ii. Anthropometric data of ASEAN adults and children for ASEAN NCAP (completed – ISBN 978-983-40842-0-2)

5.2 Intellectual Property Rights

- i. 3D Model Sitting Position for Malaysian Children Anthropometry (AR2019007049)
- ii. Anthropometry Database for Malaysian Children (LY2019007048)
- iii. Anthropometry Survey Form (LY2019007050)
- iv. Anthropometry Database for Malaysian Adult Male (filing process, pending registration completion)
- v. Anthropometry Database for Malaysian Adult Female (filing process, pending registration completion)
- vi. Anthropometry Database for ASEAN Children Aged 6 Years Old (filing process, pending registration completion)
- vii. Anthropometry Database for ASEAN Children Aged 10 Years Old (filing process, pending registration completion)
- viii. Anthropometry Database for ASEAN Adult Male (filing process, pending registration completion)
- ix. Anthropometry Database for ASEAN Adult Female (filing process, pending registration completion)

5.3 Human Capital

- i. Three (3) intern students (Completed)
- ii. One (1) Master student (Ongoing)

6 CONCLUSION

The project was successfully conducted with good collaboration between Malaysia, Thailand, and Indonesia team. Anthropometric database for MY, TH and ID are established in Section 3, which are then combined and analysed to form the ASEAN Anthropometric database (as detailed in Section 4). 3D-models representing ASEAN children aged 6 years old, 10 years old and adults (both male and female) have also been developed and shown in Section 4.

To summarise, all research objectives have been accomplished. Two (2) publications have been produced, nine (9) IPRs have been registered, and four (4) human capitals have been developed throughout the project duration.

The outputs from this project have significant value for further development. It is hoped that ASEAN NCAP and relevant stakeholders will benefit much from the work.

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