

ANTHROPOMETRIC MEASUREMENT OF THAI ELDERLY IN NORTHEASTERN RURAL AREA

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Abstract

Anthropometry takes part in making a difference in managing physical human needs including elderly needs in order to improve their quality of life. The objective of this study was to measure the body dimension of healthy Thai elderly living in rural areas and investigate the relationship among body dimensions. Questionnaire was given to the respondents in order to get their demographic data. Questionnaire and anthropometry measurements were taken on a total of 23 male elderly and 88 female elderly people from rural areas in Northeastern Thailand. Most respondents (49.5%) of the total elderly are in their 60s, 32.4% in their 70s, 17.2% in their 80s, and 1% in their 90s. 54.1% of them are still actively working and 96.4% of them are regularly doing body exercise in keeping their body fit and healthy. The body dimensions measured consist of 22 standing dimensions, 20 sitting dimensions, and 15 foot and hand dimensions. Positive correlations were found between some of the body dimensions. The developed anthropometric data is expected to overcome the information gap related to the dimensions of the body of the elderly and to assist the development of products and other supporting equipment to be anthropometrically compatible for elderly residents of rural areas in the future.

Keywords: Anthropometry, body dimensions, elderly, rural area

Introduction

The term “elderly” refers to persons above the age of 65, with “early elderly” referring to people aged 65 to 74 years, and “late elderly” referring to people aged 75 years or more (Orimo *et al.*, 2006). Elderly can be classified in a variety of ways, including physical appearance, major life experiences, and societal roles. Aging is an expected process that is commonly measured by chronological age and according to Kowal and Peachey (2001), most

developing countries agree that old age begins at 60 or 65 years old.

Data from World Population Prospects: the 2017 revision (United Nation, 2017) showed that the number of those aged 60 years or over is expected to be more than twofold by 2050 and triple by 2100, where it rises from 962 million globally in 2017 to 2.1 billion in 2050, and 3.1 billion in 2100. Henry *et al.* (2001) in one of their studies stated that

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the number of elderly people in developing countries has quickly extended as a result of the increased access to health and public services. They also stated that the economic growth in Thailand also plays an important role in enhancing the living conditions and extended life potentials of the Thai elderly.

The percentage of people aged over 60 years old in Thailand is around 13 percent of the whole population (UNFPA Thailand, 2006). Elderly living in rural areas has the same concerns related to healthcare access as those living in urban area. However, they may also face challenges related to housing quality, availability of home-based services, and long-term care in their communities. Srithamrongsawat *et al.* (2009) stated that Thailand's elderly needs long-term care due to its rapidly aging population. Syafinas *et al.* (2018) explained that according to WHOQOL (1994), in tandem with the nation's transition to an aging population, the quality of life of the elderly must be examined and enhanced to a higher degree. In 2004, the WHOQOL working group established quality of life guidelines for individuals aged 60 and above, which were tested in several countries (Power *et al.*, 2005). Tiraphat *et al.* (2017) confirmed the importance of age-friendly communities in terms of physical and social environments for older people's quality of life. Therefore, elderly in Thailand also need to assess and improve their quality of life status as it can be one of the indicators of a healthy life where the elderly should be part of the social development resources in the society.

Physical environment can be improved by applying anthropometry and an ergonomic approach in designing facilities for elderly. Anthropometry has been extensively proposed in order to help manage and deal with physical human needs (Hartono, 2018). Anthropometry has an essential role in designing facilities and equipment as it must fit appropriate measures into product characteristics and designs. The appropriate design will utilize the anthropometric data in order to improve productivity and decrease work-related musculoskeletal disorders (Klamklay *et al.*, 2008; Chuan *et al.*, 2010). Humans are varied in dimensions and proportions and this variability needs to be understood and applied well in designing a product or facility (Pheasant and Haslegrave, 2005). Special populations such as children and elderly could have different anthropometric dimensions compared to adults, by taking size and ratio between measures into consideration (Hartono, 2018). Human characteristics variation is also related to ethnicity, gender, and age (Jurgens *et al.*, 1990) in (Abd Rahman *et al.*, 2018). Ethnic diversity is an

important factor that influences anthropometric data as it is more prominent among races compared to nations (Abd Rahman *et al.*, 2018). Therefore, the body dimension of a population from one population, nationality, and ethnicity can be a lot more different from that of the others. The use of an appropriate anthropometric database is important to help adapt the facilities and equipment to a particular population group (Wickens *et al.*, 2004).

Knowing the body dimension of elderly in rural area can help design appropriate facilities such as handrail in washroom and toilet seat. Furthermore, this leads to improving safety in the daily activities of elderly in rural area. The objectives of this study were to: 1) measure body dimensions of Thai elderly living in rural area; and 2) investigate the relationship among body dimensions. The anthropometric data developed here was intended to address the lack of information related to the dimensions of the body of the elderly and to assist the development of products and other supporting equipment to be anthropometrically suitable for elderly residents of rural area in the future, such as the manufacture of elderly public facilities and nursing homes supporting tools.

Materials and Methods

Respondents

The respondents participating in this study were selected based on their willingness to respond and to be measured. All respondents were carefully selected corresponding to the intended main criteria which are elderly aged 60-90 years old from Northeastern Thailand. They were able to work and do activity independently. Each elderly was given informed consent which provided sufficient information about the research methodology, protocol, and compensation written in easily understood language. Elderly as research subject was given full right to make the decision in volunteering in this study after studying all aspects of the research and experiment.

A total of 111 elderly consisted of 23 male elderly and 88 female elderly people participated in this study and were measured using the standard body dimensions. All respondents were considered healthy and able to carry out daily activities including working by themselves without any help.

Anthropometric Measurements

Anthropometer was used in this study to measure the standing and sitting dimensions, with a caliper used for measuring the foot and hand dimensions. The measuring tape was used to measure some of body part's circumferences and

diameters. Respondent's weight was measured by using a digital weighing scale. The respondents measured were wearing thin clothes and without shoes. The body dimensions measured consisted of 22 standing dimensions, 20 sitting dimensions, and 15 foot and hand dimensions. The measurement was done in 3 repetitive measurements in order to minimize the error value.

The procedure of measurements was explained in detail to the elderly. The respondents were required to keep proper natural posture throughout the measurement in order to get reliable measurement results. When measuring height, the respondents stood with their heels positioned parallelly side by side and vertically in line with their shoulder blades and buttocks. Recapitulation was made for measurement results before being calculated and transformed into a list of percentiles of body dimensions and was elaborated into the form of design.

Statistical Analysis

All experiment results were subjected to a strong statistical analysis that gave a generalization of the cases studied. Anthropometric data analysis helps determine the key anthropometric characteristics that were required to obtain other related anthropometric variables. The average value of each dimension was used in the final statistical measurements. Data were analyzed using statistical software. Statistics frequency was used to see the comparison between each demographic data. Percentiles and data normality was also calculated by using statistical software.

Results and Discussion

Demographic Data Results

The respondents of this study were 23 male elderly and 88 female elderly where 49.5% of the total elderly are in their 60s, 32.4% in their 70s, 17.2% in their 80s, and 0.9% in their 90s. Out of all the elderly, 0.9% of them needed handrail help in some of their activity such as standing up from sitting position, and 4.5% of them needed walk support occasionally, such as walking stick.

Nearly half of the respondents were still actively working. As shown in Figure 1, a total of 45.95% of elderly were not working while the rest of them were working. Furthermore, 11.71% of the total elderly worked as farmer, 27.93% elderlies worked as employer, 8.11% elderly were running business, and 6.30% of them had another job as their occupations.

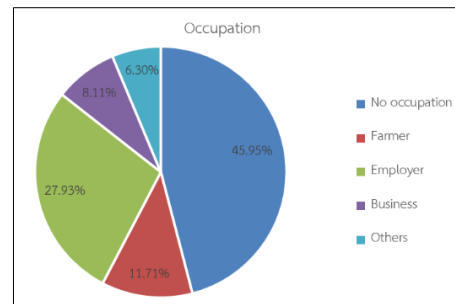


Figure 1. Percentage of subject's occupation

Figure 2 shows that most of the respondents did regular exercise in order to keep their body fit so that they were able to do daily activities and work independently. As seen in Figure 2, 96.40% of total respondents did regular exercise, where 38.74% respondents regularly did fast lane and biking exercise, 47.75% did only fast lane exercise, 4.50% did only biking exercise, 5.41% did yoga regularly, and 3.60% did not do regular exercise.

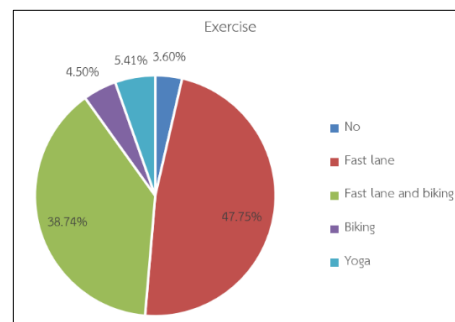


Figure 2. Percentage of subject's routine exercises

Anthropometry

The anthropometric data were analyzed in terms of descriptive statistics data such as mean, standard deviation (SD), 5th, 50th, and 95th percentile. The data obtained were used for designing workplaces, social care centers, as well as interior design. Based on the Kolmogorov-Smirnov normality test result, most body dimensions data had p-value larger than 0.05 which indicates that the data was distributed normally. The anthropometric descriptive statistic such as body dimensions, mean value, standard deviation, 5th percentile, 50th percentile, and 95th percentile of standing dimensions, sitting dimensions, and foot and hand dimensions are presented in Tables 1, 2, and 3, respectively.

Table 1. Descriptive statistics for measured standing dimensions

Male Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Chest circumference	88.35	8.19	76.20	87.00	109.60
Under chest circumference	84.39	9.68	69.20	84.00	107.20
Waistline circumference	83.65	9.94	63.40	82.00	105.40
Abdomen circumference	90.17	9.02	77.20	91.00	109.80
Hip circumference	94.70	8.47	83.20	92.00	114.00
Thigh circumference	43.78	6.13	33.00	44.00	56.00
Upper arm circumference	46.91	5.86	39.20	46.00	61.60
Elbow circumference	26.33	2.62	21.20	26.00	31.60
Wrist	18.28	1.61	15.20	19.00	21.60
Chest breadth	27.77	2.35	23.52	27.80	32.93
Waist breadth	27.02	2.59	23.46	27.00	33.60
Abdominal breadth	28.53	3.40	22.20	28.70	35.46
Hip breadth	31.34	2.17	27.70	31.00	36.56
Thigh breadth	12.05	3.14	8.50	11.00	18.96
Body height	162.16	6.12	152.30	162.00	178.80
Eye height	149.89	5.55	140.16	148.50	162.82
Shoulder height	133.80	6.05	124.04	133.00	149.36
Back armpit height	117.69	5.17	110.46	116.90	132.11
Back waist height	103.54	12.44	90.64	101.40	146.50
Elbow bending height	96.53	7.33	73.62	98.23	108.50
Crotch height	69.52	6.17	56.22	70.60	83.40
Tibial height	44.03	3.60	36.88	43.70	49.78
Female Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Chest circumference	93.16	8.85	80.00	92.50	104.58
Under chest circumference	87.23	8.53	72.75	88.00	100.55
Waistline circumference	88.06	9.37	70.45	90.00	103.55
Abdomen circumference	95.38	9.14	78.45	96.00	109.55
Hip circumference	100.82	8.37	87.90	100.50	115.55
Thigh circumference	44.10	5.58	34.00	44.00	53.42
Upper arm circumference	48.64	6.25	35.35	50.00	58.10
Female Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Elbow circumference	26.13	3.38	21.00	26.00	30.79
Wrist	17.17	1.53	14.00	17.00	19.00
Chest breadth	26.80	2.57	22.39	27.00	30.83
Waist breadth	26.77	2.86	21.60	27.13	31.06
Abdominal breadth	30.17	2.73	25.93	30.15	35.22
Hip breadth	32.69	2.60	28.89	32.50	37.35
Thigh breadth	12.26	4.09	9.00	11.80	16.97
Body height	151.46	5.68	142.25	151.00	160.00
Eye height	139.81	5.53	132.00	139.25	148.46
Shoulder height	123.71	5.04	115.79	123.25	132.14
Back armpit height	108.11	5.52	97.91	108.23	117.07
Back waist height	95.37	5.16	85.14	95.60	103.87
Elbow bending height	90.77	6.42	82.00	91.20	99.44
Crotch height	66.61	4.64	58.25	66.65	73.40
Tibial height	41.66	3.90	35.65	41.25	48.11

Table 1 shows that body height of male elderly was 162.16 ± 6.12 cm with the 5th percentile of 152.30 cm and 95th percentile of 178.80 cm. Meanwhile, female elderly's body height was 151.46 ± 5.68 cm with 142.25 cm and 160.00 cm as the 5th and 95th percentile, respectively.

The value of sitting body height was 83.35 ± 5.30 cm for male elderly and 77.67 ± 4.33 cm for female elderly. The popliteal height value was 44.19 ± 2.31 cm and 42.78 ± 3.24 cm for male and female elderly, respectively. The hip breadth value for male elderly was 34.19 ± 3.76 cm and 35.22 ± 3.35 cm for female elderly. Males and females frequently differ in body size, form and structure. The results showed that most of male elderly's body dimensions has greater value than female elderly except for some body dimensions, such as chest circumference, thigh circumference, abdominal breadth, and hip breadth. Chest circumference showed a value of 88.35 ± 8.19 cm for male elderly and 93.16 ± 8.85 cm for female elderly. Thigh circumference, abdominal breadth, and hip breadth of male elderly were 43.78 ± 6.13 cm, 28.53 ± 3.40 cm, and 31.34 ± 2.17 cm, respectively. Meanwhile the value of female elderly's was 44.10 ± 5.58 cm for thigh circumference, 30.17 ± 2.73 cm for abdominal breadth, and 32.69 ± 2.60 cm for hip breadth. The rest of the measurement details for each dimension can be seen on Table 1 for standing dimensions, table 2 for sitting dimensions, and Table 3 for foot and hand dimensions.

Table 2. Descriptive statistics for measured sitting dimensions

Male Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Sitting body height	83.35	5.30	71.12	84.00	92.96
Sitting eye height	72.13	4.46	63.40	73.00	79.00
Sitting cervicale height	59.65	3.68	52.33	60.00	64.48
Sitting shoulder height	54.75	3.81	46.66	55.17	59.52
Sitting waist height	27.68	3.28	23.04	27.70	36.20
Sitting bending elbow height	20.16	3.51	12.50	20.60	25.70
Popliteal height	44.19	2.31	39.72	43.80	48.38
Upper part knee length (sitting)	50.63	2.84	46.03	51.00	56.92
Knee height (sitting)	51.80	3.36	45.50	50.50	55.04
Shoulder biacromial breadth	31.90	2.24	28.20	31.50	35.32
Shoulder bideltoid breadth	41.36	2.74	35.56	41.50	47.76
Elbow to elbow extension breadth	82.05	5.68	73.40	82.50	91.20
Male Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Elbow to elbow breadth	42.60	6.72	28.60	42.50	57.40
Hip breadth	34.19	3.76	29.20	33.40	44.60
Elbow to center of fist length	34.42	1.65	31.60	34.30	37.84
Elbow to fingertip length	46.24	2.29	43.17	45.73	51.72
Abdomen to knee length	35.53	3.29	30.60	35.53	43.27
Buttocks to knee contact length	54.54	3.47	49.20	54.00	62.76
Bottom to popliteal length	44.22	2.49	41.06	43.80	49.86
Bottom to upper calf	44.21	2.55	40.06	44.20	50.30

Female Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Sitting body height	77.67	4.33	70.45	78.00	84.78
Sitting eye height	66.86	4.20	60.56	67.20	73.70
Sitting cervicale height	54.97	3.87	49.25	55.10	61.28
Sitting shoulder height	50.50	3.33	45.20	51.00	55.55
Sitting waist height	25.00	3.68	19.26	24.83	32.94
Sitting bending elbow height	18.31	3.38	11.89	18.67	23.11
Popliteal height	42.78	3.24	40.75	42.60	44.20
Upper part knee length (sitting)	47.75	2.80	43.33	47.95	52.78
Knee height (sitting)	49.48	2.08	45.88	49.50	52.50
Shoulder biacromical breadth	29.58	2.43	25.55	29.60	34.19
Shoulder bideltoid breadth	37.89	2.46	34.00	37.95	41.91
Elbow to elbow extension breadth	75.77	6.04	65.96	76.50	83.56
Elbow to elbow breadth	42.30	4.24	35.89	42.00	49.90
Hip breadth	35.22	3.35	29.89	34.90	40.44
Elbow to center of fist length	32.09	1.99	29.00	31.90	35.57
Elbow to fingertip length	42.85	2.26	39.64	42.70	46.67
Abdomen to knee length	30.29	4.27	24.18	29.95	36.55
Bottom to knee contact length	51.83	3.86	46.31	51.90	57.08
Female Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Bottom to popliteal length	43.02	3.26	38.38	42.75	48.64
Bottom to upper calf	42.79	3.46	37.07	42.85	47.35

Table 3. Descriptive statistics for measured foot and hand dimensions

Male Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Front foot width	11.08	1.30	9.06	10.90	13.64
Heel width	7.09	0.88	5.84	7.00	9.00
Maximum foot length	24.99	1.64	21.97	25.00	28.80
Maximum palm length	21.96	1.49	19.20	22.00	24.80
Thumb length	6.50	0.51	5.69	6.40	7.90
Index finger length	7.08	0.38	6.42	7.00	7.76
Middle finger length	7.72	0.43	7.04	7.70	8.86
Ring finger length	7.32	0.47	6.70	7.27	8.74
Little finger length	5.81	0.47	4.80	5.90	6.43
Tip of the finger-center of hand palm	18.17	0.74	16.84	18.27	19.30
Palm length	10.84	1.53	9.65	10.50	16.27
Male Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Tip of the index finger – base of the thumb	11.33	0.64	9.80	11.40	12.18
Palm width	8.48	0.45	7.75	8.50	9.28
Hand width	11.24	1.47	8.93	11.00	13.50
Largest grip diameter	6.61	1.01	4.10	7.00	8.08

Female Elderly					
Body Dimension	Mean	Std. Dev.	Percentiles		
			5	50	95
Front foot width	10.02	1.06	8.38	10.00	11.60
Heel width	6.63	1.24	5.35	6.30	9.28
Maximum foot length	23.01	1.46	20.35	23.00	25.26
Maximum palm length	19.58	1.14	18.00	20.00	21.55
Thumb length	6.01	0.67	5.20	5.90	6.96
Index finger length	6.75	0.46	6.00	6.75	7.70
Middle finger length	7.27	0.45	6.51	7.27	8.00
Ring finger length	6.77	0.46	6.00	6.78	7.60
Little finger length	5.43	0.38	4.80	5.50	6.00
Tip of the finger-center of hand palm	17.01	1.13	14.78	17.00	18.72
Palm length	9.99	1.05	8.50	10.00	11.14
Tip of the index finger - base of the thumb	10.36	0.86	8.50	10.40	11.84
Palm width	7.71	0.75	6.95	7.58	9.08
Hand width	9.68	1.08	8.18	9.52	11.67
Largest grip diameter	6.14	0.82	4.61	6.13	7.46

Correlation Among Body Dimensions

The correlation coefficients between body dimensions were calculated to explore whether these dimensions are correlated with each other. Table 4 shows the body dimensions showing correlation. The strongest correlation value was found between shoulder height and body height (0.933). Most correlation coefficient values which are greater than 0.194 showed that there is positive correlation between some body dimensions, where the correlation is significant at 0.05 level. The positive value on significantly correlated body dimensions indicates that the value of one body dimension will increase as the other body dimension increases. The greater the value of correlation coefficient, the stronger the correlation between body dimensions is. A correlation coefficient values are classified into very weak, weak, moderate, strong, and very strong correlation if the value is of 0.00-0.19, 0.20-0.29, 0.40-0.59, 0.60-0.79, and 0.80-1.00, respectively (Evans, 1996). Based on correlation calculation result, elderly's body height and shoulder height were significantly correlated with almost all measured body dimensions except for chest circumference and abdominal breadth.

Comparison with Data from Other Countries

This study presents comparison of anthropometry data of elderly between few countries. The results of anthropometry statistical analysis showed that there is difference but also similarity in body dimensions among these elderly population, especially in South East region. Table 5 shows the mean and standard deviation for present

Table 4. Correlation coefficients between each body dimensions and standing body dimension

	Chest Circ.	Thigh Circ.	Chest breadth	Abdominal breadth	Body height	Shoulder height	Sitting body height	Popliteal height	Hip breadth	Buttocks to popliteal length	Front foot width	Max. foot length	Palm length	Palm width	Largest grip diameter
Chest Circumference	1														
Thigh Circumference	.562**	1													
Chest breadth	.710**	.515**	1												
Abdominal breadth	.740**	.495**	.529**	1											
Body height	.069	.219*	.288**	.035	1										
Shoulder height	-0.008	.0131	.231*	.009	.933**	1									
Sitting body height	.088	.279**	.336**	-0.027	.689**	.640**	1								
Popliteal height	.0125	.302**	.226*	.0135	.473**	.426**	.375**	1							
Hip breadth	.676**	.633**	.601**	.665**	.289**	.217*	.223*	.329**	1						
Buttocks to popliteal length	.065	.011	-0.093	.088	.317**	.311**	.094	.056	.084	1					
Front foot width	.080	.0150	.0115	.020	.363**	.304**	.342**	.0179	.0186	.0157	1				
Maximum foot length	.0100	.0088	.199*	.092	.614**	.614**	.327**	.267**	.239**	.288**	.266**	1			
Palm length	.065	.0184	.286**	.0159	.285**	.308**	.223*	.0034	.0178	.0071	.0081	.253**	1		
Palm width	.0106	.222*	.0174	.043	.435**	.452**	.397**	.0149	.0164	.195*	.240*	.257**	.250**	1	
Largest grip diameter	-0.002	-0.083	-0.070	-0.049	.260**	.252**	.076	.0069	.0002	.267**	.103	.194*	-0.142	.214*	1

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

study, Australian (Kothiyal and Tettey, 2001), Indonesian (Rahmawati *et al.*, 2020), Singaporean (Lee *et al.*, 2019), Malaysian (Rosnah *et al.*, 2009), and Thai (Jarutat *et al.*, 2005). A comparison between the results of this study and previous study conducted by Jarutat *et al.* (2005) is also needed to see the difference between body dimensions of Thai elderly in urban area and rural area. The data set in this study does not correspond completely with those studies, therefore some of the body dimensions are removed.

A total of 15 body dimensions were summarized for the comparison between data from present study and other studies. The result on Table 5 indicates that Australian presented the greatest stature, eye height, knee height, and sitting eye height compared to those from other countries. These results also suggest that there are various body dimension differences among elderly from Asian countries. The data in present study shows that Thai elderly have greater popliteal height, hand length, and foot breadth amounted to 44.2±2.31 cm, 21.9±1.49 cm, and 11.1±1.29 cm, respectively. There were also smaller value of buttock-knee length and buttock-popliteal length compared to the other countries. The buttock to knee length of Thai elderly in present study was 54.5±3.47 cm, which was almost the same value as Australian elderly (54.9±3.8 cm) and Malaysian elderly (53.7±3.6 cm), however had smaller length compared to Singaporean elderly with the length of 57.1±1.5 cm. The obvious differences between body dimension of Thai elderly in rural area in this study and those living in urban area from previous study can be seen at the knee height and popliteal height. Present study showed that the knee height and popliteal height of elderly in rural area (51.8±3.36 cm and 44.2±2.31 cm) were greater than Thai elderly in urban area which was 47.8 cm and 40.1 cm for knee height and popliteal height, respectively.

Anthropometry Applications in Engineering Design

A design solution is created by considering the ergonomics aspect to minimize accidents and provide a safe and comfortable environment. Architects and interior designers have a social obligation to adapt and change the environment to make it more accessible to the elderly (Kurnia, 2014).

The anthropometric data is required in order to design product or facility which is specially designed for elderly. It can provide more comfort so the tools and facilities are more user friendly, and this can lead to more productivity and less stress (Lee *et al.*, 2019). The toilet design was developed

Table 5. Comparison of elderly body dimensions in different populations

Body dimensions	Mean (SD)					
	Present study	Australian ^a (2001)	Indonesian ^b (2020)	Singaporean ^c (2019)	Malaysian ^d (2009)	Thai ^e (2005)
Body height	162.2(6.12)	165.8(7.9)	156.1(7.3)	163.5(4.9)**	162.3(7.5)**	161.4
Eye height	149.9(5.55)	153.2(7.0)	143.3(7.02)	152.4(4.9)**	149.9(6.1)**	149.9
Elbow height	96.5(7.33)	104.3(5.0)	98.5(4.65)	106.0(4.8)**	97.1(5.8)**	98.9
Bideltoid breadth	41.4(2.74)	-	39.4(2.42)	42.1(1.9)**	-	43.4
Forearm (upper arm) hand length	46.9(5.86)	-	-	-	45.5(2.0)**	-
Hand length	21.9(1.49)	18.4(1.0)	-	18.1(0.7)**	17.8(1.2)**	-
Sitting body height	83.4(5.3)	84.3(5.6)	-	83.2(2.0)**	83.1(4.3)**	82.9
Sitting eye height	72.1(4.46)	72.9(4.6)	107.5(8.11)	72.1(2.4)**	71.6(5.6)**	73.4
Popliteal height	44.2(2.31)	41.6(2.5)	42.9(3.08)	39.4(1.7)**	39.6(2.4)**	40.1
Knee height	51.8(3.36)	51.5(3.1)	-	47.5(1.7)*	49.8(2.9)**	47.8
Bottom – knee length	54.5(3.47)	54.9(3.8)	-	57.1(1.5)**	53.7(3.6)*	-
Bottom – popliteal length	44.2(2.49)	45.2(3.8)	42.3(4.73)	46.2(1.3)**	45.5(2.7)**	-
Sitting hip breadth	31.3(2.17)	33.6(2.8)	34.7(3.61)	30.0(1.6)	35.0(3.5)**	35.4
Foot length	24.9(1.64)	-	-	26.1(1.0)**	24.6(1.1)**	-
Foot breadth	11.1(1.29)	-	-	10.0(0.6)*	10.2(0.7)**	-

by adjusting the proportion of body dimensions with the results of anthropometric measurements of the elderly. Designing products with proper body dimensions will help elderly people work or move comfortably and independently. The application is shown as follows.

Toilet Seat

The dimension used in the toilet seat height is 5th percentile of female popliteal height dimension in order to get most elderly population to use it conveniently. Seat heights that are excessively high (more than 120% of lower leg length) or too low (less than 80% of lower leg strength) can create instability in seating during toilet activity and might obstruct safe transfer and result in falls (Capezuti *et al.*, 2008). From this study, the 95th percentile of male hip breadth in sitting position is 44.60 cm. This value is used to set the width of toilet seat.

As for the toilet seat depth, 5th percentile of female bottom - popliteal length with the value of 38.38 cm is used. The 5th percentile of female popliteal height with the value of 40.75 cm is used for the toilet seat height. However, to be practical for the manufacturer, the value of 40.00 cm, 45.00 cm, and 40.00 cm, can be used for toilet seat width, toilet seat depth, and toilet seat height respectively. Figure 3 presents the application of anthropometry in the design of a toilet seat for the elderly.

Toilet Handrail

Some elderly might still have strength in their muscle. However, elderly will experience a decline in independence and quality of life, so as their ability to walk independently. Handrail will help support them as it bears the weight of the elderly and

helps stabilize their grip in walking, bending, or rising. The height of the handrail must be comfortable for the elderly to easily reach from sitting and standing positions. The body dimensions used in designing the handrail are 82.00 cm from the 5th percentile of female elbow height for handrail height, and 4.61 cm from the 5th percentile of female grip diameter for handrail diameter. In order to make it feasible for the manufacturer, the value is adjusted to 85 cm for handrail height and 5 cm for handrail diameter. Figure 4 shows the application of anthropometry dimensions to the elderly toilet handrail design.

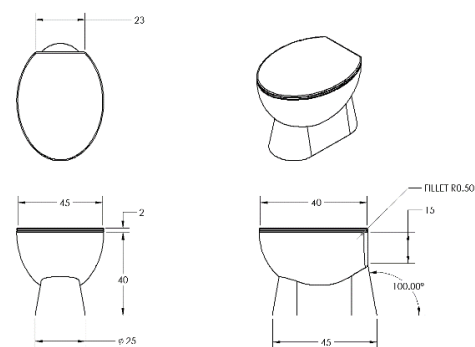


Figure 3. Anthropometry applications on the design of toilet seat

Grab Bar

Elderly are more vulnerable and some of them have difficulty keeping their balance right. Grab bar is a supporting tool to help elderly maintain their

balance to prevent falls or slip accidents. For determining the effective grab bar dimensions, 85.00 cm from the 5th percentile of female standing elbow height for the grab bar minimum height and 4.61 cm from the 5th percentile of female largest grip diameter for the bar diameter are to be considered. The female hand dimension is used to design to make sure both genders can have a full grasp on the grab bar in order to get more strength to move. If the diameter is too big in size, the lower population might find it difficult to grasp the bar properly. To be practical for the manufacturer, the value of 90 cm can be used for grab bar height and 5 cm for bar diameter. The anthropometry applications in the design of grab bar for elderly is shown in Figure 5.

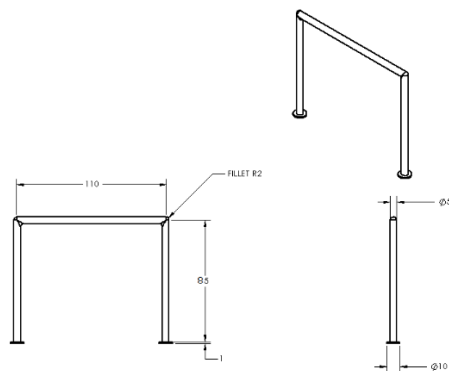


Figure 4. Toilet handrail for elderly

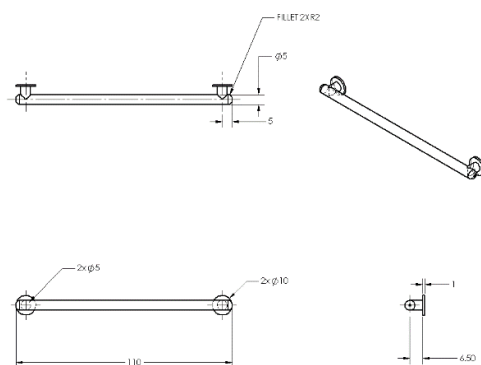


Figure 5. Grab bar for walking support

Conclusions

The conclusions from this study are as follows:

1. A total of 57 body dimensions of Thai elderly consisted of 22 standing dimensions, 20

sitting dimensions, and 15 foot and hand dimensions were measured.

2. The important body dimensions to design elderly's facilities are sitting body height, popliteal height, hip breadth, and buttock to popliteal height for toilet design, also elbow height and grip diameter for handrail design.

3. The relationship among body dimensions showed that elderly's body height and shoulder height were strongly correlated with nearly all measured body measurements except chest circumference and abdomen breadth, according to the correlation calculation results.

4. The anthropometry data of Thai elderly from this study was resulting in a similar result to the previous study conducted by Jarurat *et al.* (2005).

A wider data collection will be necessary as it can be more representative for a bigger population. It is also highly recommended to conduct similar studies in other states or regions of the country so that more databases of anthropometric measurements can be obtained. These anthropometric databases will help to assist product designers in developing and finding the proper user characteristics in the products needed by the elderly in the future.

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