

An Anthropometric Measurement Of Cerebral Palsy Children For Developing Product Design

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Abstract: In ergonomics fields, anthropometric data can be used and applied in product design and used to develop design process. The research was conducted to study application of anthropometric data in product design for children with special needs. The research focused on anthropometric measurement of the children's hand with cerebral palsy. However, no specific data of cerebral palsy (CP) children in Malaysian that could be obtained. The objective of this research is to apply and analyze an anthropometric database of cerebral palsy children (aged 12 month – 15 years old) for product design. The data analyze is using descriptive statistic method producing mean, percentiles and standard deviation (S.D) value for anthropometric variables. 30 children with cerebral palsy are involved in this study and 19 hand dimensions have been measured. The subject was informed before data collection started, that the study was to develop an anthropometric database which can be used to improve product design or other ergonomic consideration for cerebral palsy. The result of the study will provide guidelines for product design process.

Index Terms: Anthropometric data, Ergonomic, Cerebral Palsy Children

1 INTRODUCTION

Anthropometry is a key element in ergonomics for identifying and addressing a product's problems according to user characteristics [2]. For example, features of users with physical disabilities such as cerebral palsy require an ergonomic product design that can help them do things comfortably and easily. Anthropometry in ergonomics includes product designs and workplaces that involve humans to understand and control things such as turning on doorknobs, ability to grasp, pressing light switches, and so on [2]. For example, features of users with physical disabilities such as cerebral palsy (CP) require a product design that can help them do things comfortably and easily.

2 LITERATURE REVIEW

Anthropometry is an important element in many different fields. It is widely used in product design primarily to determine the product design that is appropriate and safe for users [1]. Hand anthropometry data can be obtained by measuring every hand dimensions and hand posture of spread hand [3]. Hand anthropometry consist of measurement of fingers length and width, palm width, grip diameter etc. [8]. Hand dimensions measurement can be considered when designing a product which focusing on hand usage. Purpose of ergonomic design for hand related tools are to optimize hand function to be more effective in doing activities which can minimize burden to the muscle, tendon etc. So, hand anthropometry measurement is very crucial in producing databased which can be refer when designing a product. This is because every human hand posture and size is different especially cerebral palsy children. Cerebral palsy children are generally smaller and thinner compared to normal children, especially cerebral palsy quadriplegics [4].

2.1 Cerebral Palsy

The most common cases of disability among children in a developing country are cerebral palsy (CP), and it often associated with poor growth approximately 2 per 1000 live births. Cerebral palsy (CP) can be defines as a group of disorders in the development of movement and posture which can cause limited activities. Cerebral palsy disorder often accompanied by disturbances of sensation, cognition, communication, perceptions or behavior by epilepsy disorder [5]. Cerebral palsy (CP) can be separated into 4 categories; which is monoplegia, hemiplegia, diplegia and quadriplegia.

Differences between these four categories are which part of the body is affected [6]. Special needs children such as cerebral palsy children which have physical disabilities requires more specific attentions in all aspect, especially their sensory ability development which cover gross and fine motor skills development and sensory integration. All this skill is correlated to each other and vital to allow cerebral palsy children to explore surrounding to play with their friends and to adapt new routine. It is crucial in order to improve physical and attention abilities together with their learning capability.

2.2 Significance of anthropometric database in design

Anthropometry data that has been measured can be compile into one database, and it is called anthropometric database. Anthropometric database can be widely used by engineer, architect, designer and product manufacturer which can allow special needs people to undergo their life comfortably [7]. Collected anthropometry measurement can be made as a guideline for designer in various application such as product design. It also can be used to design facilities that can help people especially special needs people, in order to improve their mobilities which cause by their limitation compared to normal people. For example, Asian population need to have their anthropometry measurement to ease designer to design an ergonomic furniture which can result to comfortability, safety and increase satisfaction level and ultimately reduce Musculoskeletal disorders (MSDs) [8].

3 RESEARCH METHODOLOGY

This research is carried out at various location around Sarawak. The study and data collection were carried out for about 12 months. Limitation of funds and resources had limited the location to obtain the subject; which is only at Sarawak. The next limitation is no collectable information of whereabouts the location for the cerebral palsy children. Hence, only 30 people of subject is obtained; age ranging from 12 month to 15 years old. For comparison, 30 normal children also obtained; age ranging from 4 to 6 years old. As for the gender, 15 male and 15 females are obtained for both normal and cerebral palsy children.

3.1 Measurement Procedure

A total of 19 anthropometric dimensions were chosen. These dimensions were chosen on the basis that they were standard anthropometric used for design purpose as specified by

Yogyakarta, Stephen Pheasant and Chandra [9] [10] [11]. Refer to Figure 1 for the detailed image of the anthropometric dimensions.

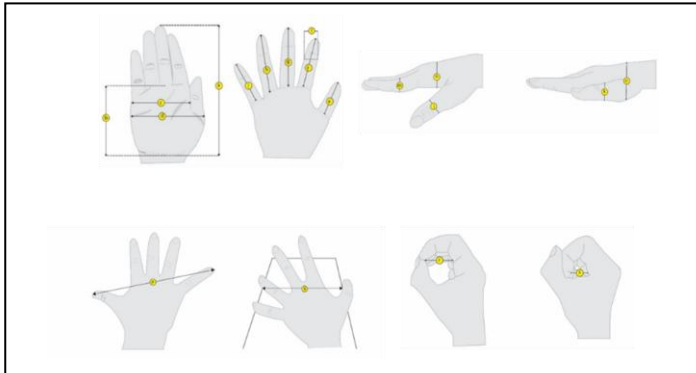


Fig. 1. Hand Anthropometry Measurement.

[a: Hand length, b: Palm length, c: Palm width (Metacarpal), d: Thumb length, e: Index finger length, f: Middle finger length, g: Ring finger length, h: Pinkie finger length, i: Thumb width, j: Thumb thickness, k: Index finger width, l: Index finger thickness, m: Palm thickness (Metacarpal), n: Palm thickness (until thumb), o: Max width (thumb until pinkie finger), p: Maximum functional width (thumb to other finger), q: Maximum grip diameter, r: Minimum grip diameter]

19 selection hand dimensions were measured using anthropometer standard professional kit consist of Vernier caliper for length, breadth and depth measurement of hand, slim guide skinfold caliper for measurement of palm and finger thickness, measuring tape for circumferential measurement, a sponge cylinder and cone to measure internal grip and inner caliper to measure grip span. Respondents and caretaker were explained about the objectives of the study measurement procedures and confidentiality of the personal data taken. Each dimension was measured three times and average was taken.

4 RESEARCH FINDING

4.1 Anthropometric Data for Cerebral Palsy (CP) (Male and Female)

Table 1 shows complete data of hand dimension for children having cerebral palsy (CP). All of 19 dimensions are listed inside the Table 1.

TABLE 1

ANTHROPOMETRIC DATA FOR CEREBRAL PALSY (MALE AND FEMALE)

Dimension	Male		Female	
	Mean	SD	Mean	SD
Hand length	183.0	15.0	170.0	12.0
Palm length	100.0	8.0	95.0	7.0
Palm width (Metacarpal)	75.0	5.0	70.0	4.0
Palm width (until thumb)	110.0	10.0	105.0	9.0
Thumb length	50.0	4.0	48.0	3.5
Index finger length	65.0	5.0	62.0	4.5
Middle finger length	70.0	5.5	67.0	5.0
Ring finger length	75.0	6.0	72.0	5.5
Pinkie finger length	80.0	6.5	77.0	6.0
Thumb width	45.0	3.5	43.0	3.0
Index finger width	55.0	4.5	53.0	4.0
Index finger thickness	15.0	1.5	14.0	1.4
Palm thickness (Metacarpal)	18.0	1.8	17.0	1.7
Palm thickness (until thumb)	22.0	2.2	21.0	2.1
Max width (thumb until pinkie finger)	130.0	13.0	125.0	12.0
Maximum functional width (thumb to other finger)	120.0	12.0	115.0	11.0
Maximum grip diameter	95.0	9.5	90.0	8.5
Minimum grip diameter	75.0	7.5	70.0	7.0

4.2 Anthropometric Data of Normal and Cerebral Palsy (CP) Children (Male and Female)

Table 2 showed mean, standard deviation and percentile for all 60 respondents; 30 normal children's and 30 children with

cerebral palsy. Based on the data comparison, for the normal male, 11 of the measurement taken have the higher mean compared to normal female. The list of dimension that normal male having higher value compared to normal female are hand length, palm length, palm width (metacarpal), palm width (until thumb), thumb length, middle finger length, ring finger length, pinkie finger length, thumb width, index finger width, and max width (thumb until pinkie finger). As for the rest of measurement, normal female has higher mean compared to normal male. Same pattern can be observed when comparing between male cerebral palsy children and female cerebral palsy children; with 10 of the measurements are higher compared to female cerebral palsy. When comparing between normal male and cerebral palsy male, the hand dimension is majorly shifted to normal children having higher hand dimension as 18 of the dimensions, normal male having higher dimension compared to children with cerebral palsy. Same result of observation also obtained for the female; normal

TABLE 2

ANTHROPOMETRIC DATA OF NORMAL AND CEREBRAL PALSY CHILDREN (MALE AND FEMALE)

Dimension	Normal Male		Normal Female		CP Male		CP Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hand length	182.0	15.0	170.0	12.0	180.0	14.0	168.0	11.0
Palm length	100.0	8.0	95.0	7.0	102.0	8.5	97.0	7.5
Palm width (metacarpal)	75.0	5.0	70.0	4.0	78.0	5.5	73.0	4.5
Palm width (until thumb)	110.0	10.0	105.0	9.0	112.0	10.5	107.0	9.5
Thumb length	50.0	4.0	48.0	3.5	51.0	4.2	49.0	3.8
Index finger length	65.0	5.0	62.0	4.5	66.0	5.2	63.0	4.8
Middle finger length	70.0	5.5	67.0	5.0	71.0	5.7	68.0	5.3
Ring finger length	75.0	6.0	72.0	5.5	76.0	6.2	73.0	5.9
Pinkie finger length	80.0	6.5	77.0	6.0	81.0	6.7	78.0	6.4
Thumb width	45.0	3.5	43.0	3.0	46.0	3.8	44.0	3.3
Index finger width	55.0	4.5	53.0	4.0	56.0	4.8	54.0	4.3
Index finger thickness	15.0	1.5	14.0	1.4	16.0	1.6	15.0	1.5
Palm thickness (metacarpal)	18.0	1.8	17.0	1.7	19.0	1.9	18.0	1.8
Palm thickness (until thumb)	22.0	2.2	21.0	2.1	23.0	2.3	22.0	2.2
Max width (thumb until pinkie finger)	130.0	13.0	125.0	12.0	135.0	14.0	130.0	13.0
Maximum functional width (thumb to other finger)	120.0	12.0	115.0	11.0	125.0	13.0	120.0	12.0
Maximum grip diameter	95.0	9.5	90.0	8.5	98.0	10.0	93.0	9.0
Minimum grip diameter	75.0	7.5	70.0	7.0	78.0	8.0	73.0	7.3

female has higher hand dimension compared to female children with cerebral palsy.

4.3 Comparison of Mean Values between Male and Female

Table 3 shows the percentage difference between male and female for both normal and children with cerebral palsy. Based on the observation data in Table 1, normal male has bigger hand dimension compared to normal female; same observation found for children with cerebral palsy. The average difference of hand dimension for normal male and normal female is 3.1% and as for children with cerebral palsy, the average difference is 5.2%. Based on the data collected, it

TABLE 3

COMPARISON OF MEAN VALUES BETWEEN MALE AND FEMALE

Dimension	Normal			CP		
	Male	Female	Difference (%)	Male	Female	Difference (%)
Hand length	180.6	129.9	0.5%	121.5	117.0	3.8%
Palm length	74.2	73.5	0.0%	65.2	64.7	0.8%
Palm width (metacarpal)	61.7	59.5	3.7%	61.2	59.1	3.6%
Palm width (until thumb)	71.1	72.3	1.2%	68.2	65.9	3.5%
Thumb length	44.3	42.8	3.4%	41.3	42.2	2.3%
Index finger length	50.9	51.0	0.3%	50.2	48.8	2.9%
Middle finger length	58.5	56.4	3.7%	56.0	52.3	7.0%
Ring finger length	52.1	51.1	2.1%	50.6	51.0	0.8%
Pinkie finger length	41.0	39.3	4.2%	44.3	42.2	4.9%
Thumb width	17.0	16.3	7.4%	12.8	12.9	0.5%
Thumb thickness	13.7	14.3	4.4%	12.9	12.5	3.2%
Index finger width	15.4	14.4	6.9%	11.6	11.7	1.1%
Index finger thickness	12.5	12.9	3.7%	11.6	12.0	3.4%
Palm thickness (metacarpal)	21.3	21.3	0.3%	15.9	14.5	9.2%
Palm thickness (until thumb)	24.5	25.5	4.1%	21.8	23.9	9.8%
Max width (thumb until pinkie finger)	147.7	145.7	2.1%	127.2	133.8	5.2%
Max functional width (thumb to other finger)	128.5	134.9	4.9%	93.5	130.8	18.5%
Max grip diameter	28.7	29.1	1.2%	21.9	23.5	7.6%
Min grip diameter	13.9	14.4	3.3%	10.0	9.0	11.1%
Average			3.1%			5.2%

shows that the difference is more obvious for children with cerebral palsy.

4.4 Comparison of Mean between Normal and Cerebral Palsy Children

Table 4 shows the percentage difference between normal and cerebral palsy children for both genders, male and female. Based on the in table 1, normal children have a higher hand dimension compare to children with cerebral palsy (CP). The statement its true for the both male and female children. The average difference of hand dimension for normal male children with cerebral palsy is 16.2%. As for the normal children and female children with cerebral palsy, the average difference of

compared to cerebral palsy children. Same observation found for female comparison. Inside Table 4, average percentage difference was made between normal and cerebral palsy children. From the Table 4, it shows that average percentage difference between normal and cerebral palsy children is around the same range for both gender; 16.2% for male and 15.5% for female. As stated in previous discussion, children which having cerebral palsy have uneven growth compared to normal children. The statement remains true in any gender. Every child with cerebral palsy has their own characteristic [13]. This difference in characteristic causing them to have varied dimension compared to normal children, such as hand posture, finger condition etc. This uneven growth among cerebral palsy children also present among female, causing the average percentage difference to be around the same range. When designing a product, anthropometric data can be used as a guideline for designer. The suitable range that can be used in designing is the value between the 5th percentile until 95th percentile. This is because of the total amount of people below the range of 5th percentile and above 95 percentiles are too small to be consider. For example, refer to table 1, the value for 5th percentile for hand length is 100.9 mm, while 95th percentile is 136.1 mm. Based on the table 1, 30 cerebral palsy respondents which have hand length to be lower than 5th percentile is only 1 people, whereas the total amount of people which having hand length more than 95th percentile is 3 people only. Based on this data, it clearly shows that the total amount people that is below than 5th percentile and more than 95th percentile is too small compared to total amount people within the range of 5th percentile until 95 percentiles. It proves that the data from 5th percentile until 95th percentile is most suitable to be considered when designing the product.

TABLE 4

COMPARISON OF MEAN VALUES BETWEEN MALE AND FEMALE

Dimension	Male			Female		
	Normal	CP	Difference (%)	Normal	CP	Difference (%)
Hand length	130.6	121.5	7.5%	129.9	117.0	11.1%
Palm length	74.2	65.2	13.8%	73.5	64.7	13.7%
Palm width (metacarpal)	61.7	61.2	0.8%	59.5	59.1	0.7%
Palm width (until thumb)	73.1	68.2	7.2%	72.3	65.9	9.7%
Thumb length	44.3	41.3	7.3%	42.8	42.2	1.4%
Index finger length	50.9	50.2	1.3%	51.0	48.8	4.5%
Middle finger length	58.5	56.0	4.4%	56.4	52.3	7.8%
Ring finger length	52.1	50.6	3.0%	51.1	51.0	0.1%
Pinky finger length	41.0	44.3	8.0%	39.3	42.2	7.3%
Thumb width	17.5	12.8	36.5%	16.3	12.9	26.4%
Thumb thickness	13.7	12.9	6.2%	14.3	12.5	14.4%
Index finger width	15.4	11.6	32.8%	14.4	11.7	22.7%
Index finger thickness	12.5	11.6	7.5%	12.9	12.0	7.8%
Palm thickness (metacarpal)	21.3	15.9	34.0%	21.3	14.5	46.8%
Palm thickness (until thumb)	24.5	21.8	12.5%	25.5	23.9	6.7%
Max width (thumb until pinky finger)	148.7	127.2	16.9%	145.7	133.8	8.9%
Max functional width (thumb to other finger)	128.5	93.5	37.4%	134.9	110.8	21.7%
Max grip diameter	28.7	21.9	31.4%	29.1	23.5	23.5%
Min grip diameter	13.9	10.0	39.3%	14.4	9.0	60.0%
	Average		16.2%	Average		15.5%

hand dimension is 15.5%. Based on the data the difference is more dominant for male children.

5 DISCUSSIONS

As stated inside the result section, Table 2 shows that male have higher mean of hand dimension compared to female. Same observation found for children with cerebral palsy. Inside Table 3, average percentage difference was made between male and female. From Table 3, it shows that average percentage difference between male and female among cerebral palsy children is more obvious compared to normal children. This major difference may due to uneven growth among children which having cerebral palsy [12]. As for normal children, the growth among them is more even, causing the average difference between male and female to become smaller. Another possible reason for this finding is age range for the respondent of cerebral palsy is huge; 12 months until 15 years old. 12 months is considered as infant as for 15 years old can be considered as teens, surely the difference is vast. Whereas the normal children age range is 4 until 6 years old; smaller age range causing smaller difference. This differ in age range among respondent caused by limitation to obtain respondent for cerebral palsy children. Lack of cooperation from caretaker and children also making it difficult to obtain respondents. Fund limitation also one of the difficulties in obtaining respondents. As stated in result section, Table 2 shows that normal children have higher mean of hand dimension

6 CONCLUSIONS

As a conclusion, it clearly shows that children which having cerebral palsy (CP) have a smaller hand dimensions compared to normal children. This is because of uneven growth among the children which having cerebral palsy. It's clearly aligned with the research that has been done previously by [12]. As for the cerebral palsy children there is no significant different between male and female. As for designing procedure, anthropometric database can be used as a guideline. the suitable value that can be used as a guideline is the value of 5th percentile until 95th percentile. however, this study of anthropometric database is still far from complete. Few recommendations need to be done the result can be more accurate if the age range for the respondent to be closer.

REFERENCES

- [1] R. ed steinfeld IDEA, The Anthropometrics of Disability. 2002.
- [2] I. Dianat, J. Molenbroek, and H. I. Castellucci, "A review of the methodology and applications of anthropometry in ergonomics and product design," Ergonomics. 2018.
- [3] M. S. Rogers, A. B. Barr, B. Kasemsontitum, and D. M. Rempel, "A three-dimensional anthropometric solid model of the hand based on landmark measurements landmark measurements," no. May 2014, 2008.
- [4] R. Rajikan et al., "Special Issue THE EFFECT OF FEEDING PROBLEMS ON THE GROWTH OF CHILDREN AND."
- [5] F. Soleimani, R. Vameghi, M. Rassafiani, N. Akbarfahimi, and Z. Nobakht, "Cerebral palsy: Motor types, Gross

- Motor function and associated disorders,” Iran. Rehabil. J., vol. 9, no. Specialissue, pp. 21–31, 2011.
- [6] P. Eunson, “Aetiology and epidemiology of cerebral palsy,” Paediatr. Child Heal. (United Kingdom), vol. 26, no. 9, pp. 367–372, 2016.
- [7] K. M. Robinette, “Anthropometry for Product Design,” in Handbook of Human Factors and Ergonomics: Fourth Edition, John Wiley and Sons, 2012, pp. 330–346.
- [8] I. W. Taifa and D. A. Desai, “Anthropometric measurements for ergonomic design of students’ furniture in India,” Eng. Sci. Technol. an Int. J., vol. 20, no. 1, pp. 232–239, 2017.
- [9] K. S. Yogyakarta, “PENGUKURAN ANTROPOMETRI TANGAN USIA 18 SAMPAI 22 TAHUN KABUPATEN SLEMAN YOGYAKARTA Hari Purnomo Jurusan Teknik Industri, Fakultas Teknologi Industri Universitas Islam Indonesia,” 2014, no. 2004, pp. 106–112.
- [10] Bodyspace: Anthropometry, Ergonomics And The Design Of Work. 2017.
- [11] A. Chandra, “Analysis of Hand Anthropometric Dimensions of Male Industrial Workers of Haryana State,” Int. J. Eng., no. January, 2011.
- [12] M. Al-Mendalawi, “Anthropometry of children with cerebral palsy at the Lagos University Teaching Hospital,” J. Clin. Sci., vol. 14, no. 2, p. 104, 2017.
- [13] P. Morgan and J. L. McGinley, “Cerebral palsy,” in Handbook of Clinical Neurology, 2018.