The Development of Standard Size for Clothes of Indonesian Boys Based on Anthropometric Data as a Reference to Formulate RSNI 0555:2013

Erlinda Muslim erlinda@eng.ui.ac.id
Department of Industrial Engineering
Universitas Indonesia
Depok, Indonesia - 16424

Boy Nurtjahyo Moch. boymoch@eng.ui.ac.id
Department of Industrial Engineering
Universitas Indonesia
Depok, Indonesia – 16424

Nauli Dwi Fileinti nauli_tiui09@yahoo.com
Department of Industrial Engineering
Universitas Indonesia
Depok, Indonesia – 16424

Maya Arlini Puspasari maya@ie.ui.ac.id
Department of Industrial Engineering
Universitas Indonesia
Depok, Indonesia – 16424

Triasni M. L. Sibarani triasni_ti2011@yahoo.com
Department of Industrial Engineering
Universitas Indonesia
Depok, Indonesia – 16424

Deo G. N. Laksana deo_ti2011@yahoo.com
Department of Industrial Engineering
Universitas Indonesia
Depok, Indonesia – 16424

Abstract

In order to increase the market share of garment products in local market, the Ministry of Industry pointed out the need to provide added value to the garment products. One of the options is to implement standard sizing system for clothes. Standard sizing system is substantial especially for children, since there seem to be unique anthropometric differences among each child. This study aims to develop a standard size of clothes for Indonesian boys based on anthropometric data, which is expected to be a national standard and a recommendation for the design of SNI. The anthropometric data are gathered from 155 boys aged 7-12 years old using 3D Body Scanner. Factor analysis and two stage cluster analysis were performed in this study and 8 groups of size for boys' clothes were established with a coverage rate of 95.48%.

Keywords: Standard Size for Clothes, Garment Industry, Anthropometry, Indonesian Children, Factor Analysis, Two Stage Cluster Analysis.

1. INTRODUCTION

Garment industry is one of the most important industries in Indonesia. Currently, garment industry is rapidly growing. Together with textile and other textile products, the Ministry of Industry considered garment industry as one of the most contributing sector to national's income. Based on the data from Ministry of Industry, the export rate of garment from Indonesia is significantly increasing each year, and reached US$13.2 billion in 2011.

Contradictory to the export rate, the market share of local garment in Indonesia is still low. Asep Setiaharja as one of the staff of Asosiasi Petekstilan Indonesia (API) said that in 2013, the market share of garment in local market was only about 50%. Therefore, the Ministry of Industry considered the need to increase added value in local garment product in order to compete with imported products. One of the efforts that could be done to increase added value is by implementing standard sizing system to local product, which means that the product will be designed based on the anthropometric data of consumers.

The important thing to be noticed while developing the standard sizing system is that there has been an anthropometric difference among people caused by ethnic/race, age, gender, and the dimension of time. The anthropometric difference caused by ethnic/race has been studied in several researches. T.K. Chuan et al conducted one of them in 2010 that successfully showed the anthropometric differences between Singaporean and Indonesian people in several body dimensions. Whereas anthropometric differences caused by age are significant if we compare the anthropometry of adult and children. Children are considered to be people who are still growing, both mentally and physically. Each child will be experiencing rapid growth until the age of 18, causing anthropometric differences between children from different group of ages and even among children in the same group of age. Therefore, 50% of children are not able to wear clothing size based on ages (Otieno, 2008). Gender and the dimension of time also contribute in anthropometric differences. Several researchers have found that the anthropometry of children in England and America are growing in the past three decades. This change has proved that the anthropometry of children is changing from time to time. Therefore, the anthropometric database should always be updated.

In Indonesia, several SNI have been formulated by Badan Standardisasi Nasional (BSN) in order to standardize the sizing system for clothes, such as SNI 08- 4985-1999 which contains about the characteristic of anthropometry for designing clothes, and other SNI which contains the standard for specific type of clothes, such as SNI 08-0555-1995 about standard size of shirts for Indonesian boys. However, SNI 08-0555-1995 has been abolished by BSN since it no longer fits with the anthropometry of children nowadays.

Based on the introduction explained above, the statement of problem in this research is the need of the development of standard size of clothes for Indonesian boys based on the updated database of anthropometry. Therefore, the objective of this research is to develop a standard size of clothes for Indonesian boys that could be used as a reference to formulate RSNI 0555:2013 to revise SNI 08-0555-1995. In addition to that, this research is conducted to add more variety in anthropometric researches in Indonesia, especially about the anthropometry of children, since until now the researches of anthropometry in Indonesia are focused on the anthropometry of adult.

2. METHOD

This section explains about the material and method used in this research.

Subject of Research

The subject of this research are Indonesian boys aged 7-12 years old, with the race of Southeast Asiatic, since the objective of this research is to develop a standard size of clothes for Indonesian boys, especially for shirts. Boys of age 7-12 were chosen as the subject of this research because several researchers have found that there has been some different type of growth between the children under 13 years old and children above 13 years old. Both male and female children have rapid changes in both vertical and horizontal dimensions. The total of subject in this research is 155 boys.

Tools Used in Research

The main tool used in this research is 3D Body Scanner or Anthroscan. By using Anthroscan, 151 variables of body dimension can be accurately determined in 10-15 seconds. Thus, this tool is the appropriate tool to gather anthropometric data.

Basic Rules for Collecting Research Data

One of the contributing factors that affect the successfulness of using Anthroscan is the type of clothes that the subjects of the research wear. The clothes used for the scanning should be tight enough and shows the real body shape of the subject. The clothes should also be in light colors, since Anthroscan could not identify dark colors. The other important factor is the body posture of the subject. The subject should stand straight with eyes straight to the front and remain with the same posture as the scanning process goes on.

Collecting Anthropometric Data

3D Body Scanner or Anthroscan can be used in several steps that are quite simple. The steps of using Anthroscan are:

- Calibrate the Anthroscan
- Set the laser
- Prepare the subject of the research
- Scan the subject using Anthroscan

Variables Used in Research

The result of scanning using Anthroscan provides 151 variables of body dimensions from head to toe. However, based on the objective of the research, only 28 dimensions of upper body are used in this research. Those 28 variables are listed in Table 1 as follows:

No.	Variables
1	Body height
2	Mid neck girth
3	Neck at base girth
4	Cross shoulder
5	Shoulder width left
6	Shoulder width right
7	Across front width
8	Bust/chest girth
9	Across back width
10	Waist girth
11	Buttock girth
12	Hip girth
13	Maximum belly circumference
14	Arm length left

15	Arm length right
16	Upper arm length left
17	Upper arm length right
18	Forearm length left
19	Forearm length right
20	Upper arm girth left
21	Upper arm girth right
22	Elbow girth left
23	Elbow girth right
24	Forearm girth left
25	Forearm girth right
26	Wrist girth left
27	Wrist girth right
28	Weight

TABLE 1: Variables Used in Research.

3. RESULTS AND DISCUSSIONS

This section will discuss about steps of processing the data, establishing the standards size of clothes, and also analyzing of the end result.

Factor Analysis

The main requirement in using factor analysis is each variable has to be correlated to each other. The correlation between each variable can be tested using Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's test of sphericity. The higher the KMO obtained from the research, shows the higher level of correlation among each variable. Bartlett's test of sphericity is used to test the hypothesis that all of the variables do not have correlations among each other in the population. The Table 2 below shows KMO and Bartlett's test obtained in this research:

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.887
Bartlett's Test of Sphericity	Approx. Chi-Square	6737.217
	Df	378
	Sig.	.000

TABLE 2: KMO and Bartlett's Test.

Based on the KMO and Bartlett's test, we can conclude that each variable has a strong correlation to each other. Thus, factor analysis can be used in this research. The next step is to determine the amount of factors extracted in this research, based on eigen value greater than 1. In this research, 6 factors are extracted based on eigen value. Each factor has its own members based on the correlation among variables. The members of each factor are shown in the rotated component matrix in **Table 3** as follows:

	Component					
Variables	1	2	3	4	5	6
Forearm girth right	**0,917**	0,268	-0,04	0,12	0,022	0,156
Forearm girth left	**0,908**	0,292	-0,06	0,129	0,016	0,155
Elbow girth left	**0,907**	0,33	-0,04	0,101	0,021	0,148
Elbow girth right	**0,893**	0,36	-0,04	0,104	0,044	0,12
Upper arm girth right	**0,766**	0,532	-0,01	0,162	0,086	0,157
Upper arm girth left	**0,755**	0,564	-0,01	0,135	0,088	0,147
Across back width	**0,514**	0,239	0,21	0,085	0,38	-0,352
Max belly circumference	0,293	**0,881**	0,059	0,132	0,095	0,13
Across front width	0,239	**0,854**	-0,05	-0,043	0,079	0,169
Waist girth	0,338	**0,837**	0,108	0,195	0,171	0,131
Hip girth	0,368	**0,823**	0,195	0,088	0,102	0,181
Buttock girth	0,336	**0,807**	0,269	0,108	0,098	0,161
Cross shoulder	0,386	**0,741**	0,034	0,004	0,277	-0,123
Bust/chest girth (horizontal)	0,519	**0,704**	0,17	0,23	0,199	0,126
Weight	0,038	**0,696**	0,314	0,343	0,089	0,043
Arm length left	0,038	0,158	**0,931**	-0,034	0,06	-0,009
Arm length right	-0,09	0,121	**0,907**	0,038	-0,009	0,048
Forearm length left	-0,27	-0,06	**0,86**	0,067	0,077	-0,109
Body height	0,359	0,177	**0,846**	0,026	0,164	0,055
Forearm length right	-0,37	-0,07	**0,836**	0,044	0,02	-0,082
Upper arm length right	0,287	0,247	**0,745**	-0,053	0,169	0,036
Upper arm length left	0,604	0,12	**0,627**	-0,038	0,054	0,064
Neck at base girth	0,249	0,192	-0,12	**0,804**	-0,061	0,014
Mid neck girth	0,117	0,196	0,155	**0,784**	0,285	0,131
Shoulder width left	-0,09	0,232	0,263	0,065	**0,749**	-0,011
Shoulder width right	0,156	0,158	0,019	0,086	**0,733**	0,181
Wrist girth right	0,408	0,387	-0,03	0,128	0,157	**0,73**
Wrist girth left	0,389	0,426	0,016	0,122	0,161	**0,726**

TABLE 3: Rotated Component Matrix.

Considering the factor loadings in each factor, the name of each factor can be identified. Thus, factor 1 was named as arm girth factor. Similarly, factor 2 was named as body girth factor, factor 3 was named as arm length factor, factor 4 was named as neck girth factor, factor 5 was named as shoulder width factor, and factor 6 was named as wrist girth factor.

Two-Stage Cluster Analysis

The next step in this research is conducted using two-stage cluster analysis. The variables used in this method are 6 body dimensions that represent the 6 factors that have been formed before. Those 6 variables are upper arm girth right, maximum belly circumference, arm length left, neck at base girth, shoulder width left, and wrist girth right.

Hierarchical cluster analysis provides several alternative solutions in terms of forming the clusters. Based on the level of homogeneity among the members in one cluster, the level of heterogeneity between members from different clusters, and also the characteristics of cluster members, the optimal solution obtained from hierarchical cluster analysis is three clusters solution. After obtaining the optimal amount of cluster solution, non-hierarchical cluster analysis is used in order to find the final cluster centers for each variable in each cluster that later will be the main basis in establishing standard size. In this research, K-Means is used to form the final cluster. The **Table 4** below is the final result obtained from non- hierarchical cluster analysis:

Variable	Cluster		
	1	2	3
Neck at base girth	41.07	38.64	35.68
Shoulder width left	11.64	10.84	10.35
Max belly circumference	95.64	71.51	58.59
Arm length left	44.24	43.04	41.29
Upper arm girth right	29.50	25.28	20.05
Wristh girth right	18.05	15.45	13.38

TABLE 4 Final Cluster Center.

Establishing Standard Size of Clothes for Indonesian Boys

The final result obtained from two- stage cluster analysis cannot be directly used as a standard sizing system, since there appears to be some size intervals problem. In general, the optimal size interval for girth dimensions is 4 to 6 cm (Eberle and Kilgus, 1996; Chung et al, 2007). Based on the standardized size intervals and also final cluster centers, the standard size of clothes for Indonesian boys is shown in **Table 5** below:

Body Dimension	S			M	L			
	1	2	3	1	1	2	3	4
Neck at base girth	26	30	34	38	42	46	50	54
Shoulder width	8	9	10	11	12	13	14	15
Belly circumference	54	60	66	72	78	84	90	96
Arm length:								
Long	37	39	41	43	45	47	49	51
Short	22	23	24	25	26	27	28	29
Upper arm girth	13	17	21	25	29	33	37	41
Wrist girth	10	12	13	15	17	19	21	23

TABLE 5: Establishment of Standard Size of Clothes for Indonesian Boys.

Analysis

The establishment of standard size of clothes for Indonesian boys in this research shows that the control dimensions used are neck at base girth, shoulder width, maximum belly circumference, arm length, upper arm girth, and wrist girth. Whereas, the size interval used in this research is based on literature review and also the standardized intervals that are written in ISO/TR 10652 and has been implemented in SNI 08-0555-1995. Moreover, the size interval used in this research is constant from one size to another, in order to make the production system more efficient and also make the consumers easier to find the appropriate size.

The cover factor obtained in this research is 95.48% which means that the standard sizing system obtained from this research is able to accommodate 95,48% of population. The cover factor should typically range 65-80%, meaning that the sizing system is able to accommodate 65-80% of the sample population with the size given (Zakaria, 2011). Hence, the result of this research shows a valid cover factor since it is able to accommodate more than 80% of the population.

The result of this research shows some significance differences compared to ISO 3636:1977 and also SNI 08-0555-1995 in terms of size interval and control dimension. It is clearly written in ISO 3636:1977 that the control dimensions for sizing system for boys are body height, chest girth, and hip girth. These differences are actually normal, since ISO is a global standard that does not consider a specific anthropometric data of a certain country. In addition to that, ISO does not consider the anthropometric differences caused by different ethnic and race. Another reason for the differences is that ISO 3636 is formulated in 1977, and obviously anthropometric data of people have been significantly changing since then.

The differences between the result of this research and SNI 08-0555-1995 are mostly caused by the dimension of time. Not only that, the anthropometric tools used to conduct the research is different than the tools used to formulate SNI, since this research used a 3D Body Scanner to collect all of the anthropometric data. The differences also could also be affected by the amount and characteristics of respondents used in this research.

4. CONCLUSION

This research has been able to prove that there are some anthropometric differences between children from different groups of age and also among children in the same group of age. Moreover, this research also proved that there are some anthropometric differences caused by the dimension of time. Hence, anthropometric database should always be updated from time to time especially if the database is used for product design.

The result of this research shows 8 groups of size for Indonesian boys that have the advantage of high coverage rate of 95.48%. The result of this research also shows significance differences compared to ISO 3636:1977 and SNI 08-0555-1995 in terms of size interval and control dimension. The differences of size interval and control dimension obtained from this research compared to SNI 08-0555-1995 show that SNI needs to be updated from time to time. Whereas the differences compared to ISO 3636:1977 show that ISO could not be directly adopted in terms of designing a certain product in a specific country.

For the future research, authors suggest to add more respondents in the study and compare the study to another standard of clothing.

5. REFERENCES

[1] Boden, et al. (2004). *New Consumer? The social and cultural significance of children's fashion consumption. Culture of Consumption Programme Working Paper.*

[2] Chuan, T.K., Hartono, Markus., & Kumar, Naresh. (2010). *Anthropometry of the Singaporean and Indonesian populations.*International Journal of Industrial Ergonomics 40 : 757-766.

[3] Chung, M. J., Lin, Hai-Fen., & Wang, M. J. (2007). *The Development of Sizing Systems for Taiwanese Elementary and Highschool Students.* International Journal of Industrial Ergonomics: 37, 707-716.

[4] Coon S.C., S.M.Garn, J.B. Birdsell. (1950). *Races : A Study of Race Formation in Man.*

[5] Eberle, H., Kilgus, R., (1996). *Clothing Technology: From Fibre to Fashion.*English ed. Europa-Lehrmittel, Germany.

[6] Gumilar, Dwiki D. (2012). “Perhitungan Luas Tubuh Manusia Indonesia dengan Metode Interpolasi”. *Skripsi.* Fakultas Teknik, DepartemenTeknik Industri Universitas Indonesia, Depok.

[7] Hair, J., Black, W., Babin, B., & Anderson. (2009). *Multivariate Data Analysis 7th Edition.* Prentice Hall.

[8] Hidayat, Taufik.dan Nina Istiadah. (2011). *Panduan Lengkap Menguasai SPSS 19 untuk Mengolah Data Statistik Penelitian.* Jakarta: Penerbit Media Kita.

[9] Hsu, Chih-Hung. (2009). *Data Mining to improve industrial standards and enhance production and marketing: An empirical study in apparel industry*. Expert Systems with Application : 36, 4185-4191.

[10] ISO 3636. (1997). *Size Designation of Clothes – Men’s and Boy’s Outerwear Garments.* International Organization for Standardization, Geneva.

[11] ISO 8559. (1989). *Garment Construction and Anthropometric Surveys – Body Dimensions.* International Organization for Standardization, Geneva.

[12] ISO/TC 133, 1991. *Size Systems and Designation for Clothes*. International Organization for Standardization, Geneva.

[13] ISO/TR 10652, 1991. *Standard Sizing Systems for Clothes*. International Organization for Standardization, Geneva.

[14] Kang, Y., Choi, H S., & W.H. Do. (2001). *A Study of the Apparel Sizing of Children’s Wear : An Analysis of the Size Increments Utilized in Children’s Wear Based on an Anthropometric Survey.* J Korean HomeEco Assoc Eng, 2(1) 96.

[15] Mustafa, P. (1992). *Fundamental of Industrial Ergonomics*. Englewood Cliffs, NewJersey: Prentice Hall.

[16] Nurmianto, Eko. (1998*). Ergonomi : Konsep Dasar dan Aplikasinya*. Surabaya: Penerbit Guna Widya.

[17] Nurtjahyo, Boy M., Yanto, Mangido, D. (2012). *Pengukuran Antropometri Siswa SDN 02 Ujung Menteng, Cakung Jakarta Timur Menggunakan Anthroscan.* Seminar Nasional Ergonomi 2012, Jakarta.

[18] Otieno, R. (2008). *Approaches in Researching Human Measurement: MMU Model of Utilising Anthropometric Data to Create Size Charts*. EuroMed J Business : 3 (1) 63.

[19] Pheasant, S. (1997). *Bodyspace: Anthropometry, Ergonomics, and the Design of Work*. London: Taylor & Francis.

[20] Pheasant, S., Haselgrave, C.M. (2006). *Body Space : anthropometry, ergonomics and design 3rd edition.* London: Taylor and Francis.

[21] Purnomo, Hari. (2013). *Antropometri dan Aplikasinya*. Jakarta: Penerbit Graha Ilmu.

[22] SNI 08-0555-1995. (1995). *Ukuran kemeja pria anak*. Badan Standardisasi Nasional, Jakarta.

[23] SNI 08-4985-1999. (1999). *Karakteristik tubuh manusia (antropometri) untuk pembuatan pakaian jadi.* Badan Standardisasi Nasional, Jakarta.

[24] Widyanti, A., dan Mahachandra. (2012). *Indonesian Workers Anthropometry : An Overview of Past and Present.* Proceedings of the Asia pacific Industrial Engineering & Management Systems Conference.

[25] Widyanti, A., dan Mahachandra. (2012). *On the Development of Indonesian Anthropometry Database : Does Occupation of Subjects Really Matter?.* Proceedings of the Asia pacific Industrial Engineering & Management Systems Conference.

[26] Workman, J. E. (1991). *Body Measurement Specification for Fit Models as a Factor in Apparel Size Variation*. Cloth Text Res. J., 10(1): 31-36.

[27] Zakaria, Norsaadah. (2011). *Sizing system for functional clothing – Uniforms for Chilren.* Indian Journal of Fibre & Textile Research : 36, 348-357.