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ELEMENTARY SCHOOL STUDENT'S ANTHROPOMETRY FOR THE PURPOSE OF SCHOOL FURNITURE

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ABSTRACT

This study aims to present anthropometric dimensions of Indonesian Elementary school students for the design of school furnitures. The research was conducted in Metropolitan Area of Jakarta, Indonesia. A number of 1,214 students age between 6–11 years old was participated in this study. Eight anthropometric data in the sitting posture of the subject were measured. The mean, standar deviation (SD), percentile value of such anthropometric dimensions were calculated. Results of t-test showed that there was a significant difference of popliteal height of students between age group and gender. Results also showed differences for some other sitting dimensions among age group. Further, these differences among age group and gender should be very important and should be taken into consideration in designing the school furniture to be used by students.
***Keywords**: Anthropometric dimensions, sitting postures, elementary school students.*

1. INTRODUCTION

Anthropometry refers to the measurement of human body. Anthropometric measurements are essential as basic descriptive information on body composition and nutritional status (Mokdad and Al-Ansari, 2009). Anthropometric data are also essential for design of equipment and workplaces (Bolstad et al., 2001). For children, anthropometric data of students could be used for correctly designing school furniture, clothing as well as needed for determining and evaluating health status of the students.

Most anthropometric data of elementary school children were used for school furniture design. These anthropometric data become basis to determine dimensions of school furniture. Student's sitting posture is influenced by the activities performed in the classroom, the anthropometric dimensions of school children and the measures and design features of school furniture (Yeats, 1997). Uncomfortable postures could be painful due to the prolonged periods children spend at school (Aagaard-Hansen and Storr-Paulsen, 1995; Murphy et al., 2004) and several researchers have reported posture-related syndromes in students (Knight and Noyes, 1999; Milanese and Grimmer, 2004; Troussier et al., 1999).

To design ergonomics school furniture for elementary school students, their anthropometric dimensions were needed. However, literature study indicated that very few studies have been conducted in the past to study anthropometric dimensions of Indonesian population in general and children dimensions in particular. Therefore, this study was conducted to develop anthropometry of Indonesian elementary school student in the sitting posture which can be used for the design of school furnitures. Anthropometric dimensions obtained from this study could be used by designer and school authorities to evaluate the existing school furniture provided for the students as well as for the new or improved design.

2. METHODOLOGY

2.1 Subjects

There were 1.214 children participated in this study. Their age varied between 6 and 12 years old. They were taken from seven elementary schools in Metropolitan Area of

Jakarta (five are public school and two are private school).

2.2 Anthropometric Dimensions measured

For the design of school furniture, at least six dimensions need to consider i.e popliteal height, buttock-popliteal length, hip breadth, shoulder height, elbow height and knee height (Gouvali and Boudolos, 2006; Mokdad and Al-Ansari, 2009; Panagiotopoulou et al, 2004). Popliteal height is needed to design seat height. Buttock-popliteal length is used to design seat depth while hip breadth for seat width. Shoulder height is used to design backrest height. Elbow rest height is used to design desk height and arm rest and knee height for below-table height.

Eight student's body dimensions in the sitting posture were identified and presented in this study. Two anthropometric characteristic (stature and weight) were used for description only while the other six dimensions were considered to be useful for school furniture design. The measurement illustrations were defined by Pheasant and Haslegrave (2006) and Kroemer (2006). The measurement illustrations were as follows:

Stature: The Vertical distance from the floor to the top of the head, when standing.

Shoulder height, sitting: The vertical distance from the sitting surface to the tip (acromion) of the shoulder, when sitting.

Elbow rest height, sitting: The vertical distance from the sitting surface to the lowest point of the right elbow, when sitting, with the elbow flexed at 90^0.

Popliteal height: The vertical distance from the floor to the underside of the thigh directly behind the right knee; when sitting, with the knees flexed at 90^0.

Knee height: The vertical distance from the floor to the top of the right knee cap, when sitting, with the knees flexed at 90^0.

Buttock-popliteal length: The horizontal distance from the back of the buttocks to back of the right knee just below the thigh, when sitting with the knee flexed at 90^0.

Hip Breadth: The maximal horizontal breadth across the hips or thighs, whatever is greater, when sitting.

Weight of subject.

2.3. Instruments

In order to measure student's dimensions in the sitting posture, a self design simple anthropometer together with adjustable chair was used. Stature of students was taken with a ruler attached to the wall and a staff to help measurer pointing body landmark. A digital weighing scale was used to take the body weight of subjects. For data analysis, statistical package Minitab 16 was used.

2.4. Procedure

Fifteen university students were recruited to help in the study. They helped to get permit from school authorities, to do and to record anthropometric measurement activity, and to manage subjects during measurement. Before beginning the measurement of students, the measurers spent one day standardising and refining the measurement techniques in the Laboratory for Work Sistem Design and Ergonomics, Industrial Department, Faculty of Engineering, Atma Jaya University Jakarta. During training, they were provided with some materials so that they became familiar with the body landmark for each body dimension, the equipments, measurement technique and subjects organization during measurement.

3. RESULTS

Eight anthropometric dimensions of elementary students are presented in Table 1. This table shows the mean and standard deviation of student within age group and gender. Table 2 presents the 5^{th} and 95^{th} percentile values of six anthropometric dimensions for the purpose of school furniture design. The percentile values are usefull to determine school furniture based on student's anthropometry. These anthropometric data become basis to determine dimensions of school furniture.

Table 1 Anthropometry of elementary school students for school furniture design use.

Dimension	Gender	6 years		7 years		8 years		9 years		10 years		11 years		12 years	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature	Boys	117.52	5.64	122.85	5.63	125.12	5.74	131.09	7.07	136.19	7.06	140.52	7.56	147.17	8.35
	Girls	115.86	7.58	121.11	5.57	125.64	7.27	130.56	6.92	139.16	8.02	143.39	7.80	146.05	6.61
Sitting shoulder height	Boys	39.08	3.71	41.19	3.14	42.28	3.55	44.92	3.88	46.56	4.15	48.32	4.14	50.37	3.29
	Girls	39.70	6.45	40.52	3.50	41.99	3.41	44.57	3.65	47.83	3.71	50.03	4.50	50.81	3.32
Sitting elbow height	Boys	13.45	2.41	15.79	2.40	16.27	2.51	17.38	2.74	17.88	2.60	18.52	2.65	18.85	2.28
	Girls	15.57	2.14	16.26	2.34	16.85	2.55	17.70	2.52	18.67	2.71	19.60	2.36	19.39	2.34
Buttock-popliteal height	Boys	28.77	2.38	31.52	2.02	32.45	1.94	34.29	2.22	35.29	2.16	36.52	2.29	37.96	2.24
	Girls	29.79	2.98	30.93	2.46	32.83	2.61	33.96	2.39	35.91	2.79	36.78	2.49	37.70	2.06
Sitting knee height	Boys	35.56	2.24	36.30	2.66	37.21	2.44	39.42	3.25	41.46	3.15	41.23	3.67	43.18	3.42
	Girls	35.58	3.36	36.39	2.24	37.55	3.33	38.99	3.09	41.99	3.29	42.03	3.18	42.15	2.19
Buttock-popliteal length	Boys	30.41	2.24	34.94	2.94	35.40	2.38	38.04	2.93	39.24	3.60	40.47	3.02	41.25	2.79
	Girls	31.63	3.07	34.53	2.98	36.46	2.84	38.24	2.99	40.07	3.63	41.46	3.24	41.82	2.60
Hip breadth	Boys	22.94	3.32	23.01	3.35	23.10	3.12	25.18	3.49	25.11	5.06	25.11	3.96	25.73	3.64
	Girls	19.56	2.76	21.52	2.91	22.91	3.06	23.98	4.06	25.43	3.82	26.48	4.19	26.12	3.28
Weight	Boys	23.70	7.39	24.89	7.03	25.37	6.84	30.84	9.77	33.77	11.67	34.50	9.57	38.33	10.02
	Girls	22.07	5.79	23.76	5.66	25.51	7.11	28.71	7.64	34.83	10.20	37.16	8.85	38.69	9.17

Table 2. Summary percentile values of sitting anthropometric dimensions for design purposes

Anthropometric dimensions	Percentiles	6 years		7 years		8 years		9 years		10 years		11 years		12 years	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Sitting shoulder height	5	32.97	29.10	36.03	34.76	36.44	36.38	38.53	38.58	39.73	41.72	41.51	42.63	44.97	45.35
	95	45.18	50.31	46.35	46.28	48.12	47.60	51.31	50.57	53.38	53.94	55.13	57.42	55.78	56.27
Sitting elbow height	5	9.48	12.05	11.85	12.41	12.15	12.66	12.87	13.56	13.60	14.21	14.15	15.72	15.09	15.55
	95	17.42	19.09	19.74	20.11	20.40	21.04	21.89	21.85	22.16	23.13	22.88	23.48	22.61	23.23
Buttock-popliteal height	5	24.85	24.89	28.19	26.88	29.27	28.54	30.64	30.03	31.73	31.33	32.75	32.68	34.28	34.32
	95	32.69	34.69	34.85	34.98	35.64	37.11	37.94	37.88	38.85	40.50	40.30	40.88	41.64	41.09
Sitting knee height	5	31.88	30.06	31.93	32.71	33.19	32.07	34.08	33.91	36.27	36.58	35.18	36.80	37.55	38.54
	95	39.24	41.10	40.67	40.08	41.23	43.03	44.75	44.08	46.65	47.40	47.27	47.26	48.81	45.75
Buttock popliteal length	5	26.73	26.57	30.11	29.62	31.48	31.79	33.23	33.32	33.32	34.11	35.51	36.14	36.65	37.54
	95	34.09	36.69	39.77	39.43	39.32	41.13	42.86	43.16	45.16	46.03	45.44	46.78	45.84	46.10
Hip breath	5	17.47	15.02	17.50	16.74	17.96	17.88	19.43	17.31	16.79	19.15	18.60	19.59	19.74	20.73
	95	28.40	24.11	28.51	26.30	28.23	27.95	30.92	30.65	33.43	31.71	31.62	33.37	31.73	31.51

4. DISCUSSION AND CONCLUSIONS

Most anthropometric data of elementary school children were used for school furniture design. These anthropometric data become basis to determine dimensions of school furniture (Mokdad and Al-Ansari, 2009). For the design of school furniture, at least six dimensions need to consider i.e popliteal height, buttock-popliteal length, hip breadth, shoulder height, elbow height and knee height (Gouvali and Boudolos, 2006; Mokdad and Al-Ansari, 2009; Panagiotopoulou et al, 2004). Referring Table 2, percentile values can be used for the design of school furniture.

Popliteal height could be used to determine seat pan of school furniture. In accordance to popliteal height, Gouvali and Boudolos (2006) declares that seat height should be lower than popliteal height so that (1) the lower leg constitutes a 5–30^0 angle relative to the vertical and (2) the shin-thigh angle is between 95 and 120^0. Referring Table 2, the 5th percentile of popliteal height should be used to achieve an optimum seat height (Evans et al., 1988; Helander, 1997). In addition, an allowance from 2cm to 4.5 cm for shoes should be considered.

Seat depth of school furniture could be design based on popliteal length of students. Most researchers report that seat depth should be designated for the fifth percentile of buttock-popliteal length distribution, including even the shorter users (Pheasant & Haslegrave, 2006; Sanders and McCormick, 1993). Parcells et al. (1999) defined a mismatch when depth was either < 80 % or >95 % of buttock-popliteal length. Gouvali and Boudolos (2006) recommend seat depth should be between 80% until 99% of popliteal length. The 5th percentile of buttock-popliteal length as presented in Table 2 is used to achieve optimum seat depth (Evans et al., 1988; Helander 1997) so that it can accommodate children with short buttock. By using the 5th percentile, it will naturally

accommodate children with long buttock-poplieal length.

Hip breath could be used to determine seat width of student's chair. According to Corlett and Clark (1995), seat width should be enough to support ischial tuberosities in order to achieve stability and allow space for lateral movements. Seat width should be large enough to accommodate even the users with the largest hip breadth (Sanders and McCormick, 1993). Gouvali and Boudolous (2006) proposed that seat width should be at least 10% (to accommodate hip breadth) and at the most 30% larger than hip breadth (for space economy). Hip breadth is used to design seat width and for optimum design, 95th percentile should be used (Evans et al., 1988; Helander, 1997). In addition, seat width should be at least 10% (to accommodate hip breadth) and at most 30% larger (for space economy) than hip breadth (Gouvali and Boudolous, 2006).

Shoulder height of students could be used to determine backrest height of student's chair. Gouvali and Boudolos (2006) recommended that the backrest should be lower than the scapula, or at most on the upper edge of the scapula (60–80% of shoulder height). Elbow rest could be used to determine table height of school furniture. Most researchers consider elbow rest height as the major criteria for table height (Milanese and Grimmer, 2004; Sanders and McCormick, 1993), based on the fact that there is a significant reduction in the load on the spine when arms can be supported on the table. Parcells et al. (1999) and Gouvali and Boudolous (2006) consider elbow rest height and shoulder height to determine table height. Parcells et al. (1999) suggested that table height should be adjusted to elbow-floor height, so that it would be minimum when shoulders are not flexed or abducted, and maximal when shoulders are at 25^0 flexion and 20^0 abduction (elbow rest height x 0.8517 + shoulder height x 0.1483). By modifying equation by Parcells et al. (1999), Gouvali and Boudolos (2006) propose that table height should be lower than *0.8517Elbow rest height + 0.1483 Shoulder height* and greater than *seat height plus elbow rest height*.

Knee height could be used to determine underneath table height of school furniture. According to Sanders and McCormick (1993) underneath table height should be enough so that there is space between the knees and the underneath surface of the table (Sanders and McCormick, 1993). Parcells et al. (1999) proposed that the table clearance should be at least 2 cm. The equation proposed by Gouvali and Boudolos (2006) considered as appropriate the case that underneath table height was at least 2 cm higher than clearance from seat height (with clearance is defined as knee height - popliteal height).

Results of f-test indicated that there was a significant *popliteal height* difference of students within age groups and between gender (p-value=0.000). This result indicated that providing students with the same seat height for all grade is not suitable. Providing different sizes chair for different grade level is appropriate for ergonomically design.

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