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ANTHROPOMETRIC DATA FOR TANZANIA'S PRIMARY SCHOOL FURNITURE DESIGN

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ABSTRACT

Lack of anthropometric data has been reported to be primarily responsible for furniture mismatch, which has resulted in the high prevalence of musculoskeletal disorders among schoolchildren. This study is aimed at determining appropriate anthropometry dimensions that can be used in school furniture manufacturing for Tanzania's children. Anthropometric data from 12 body regions; which includes stature height, body weight, shoulder breadth, popliteal height, reaching (overhead) height, eye height, elbow height, hip breadth, arm length, thigh thickness, buttock-popliteal length and buttock-knee length; were collected from 468 children, comprising 236 boys and 232 girls. Percentile distributions of these dimensions, grouped into four age groups, 6- to 8-, 9- to 11-, 12- to 14- and 15- to 17-year-olds were presented. However, there was no significant difference in these dimensions between boys and girls, except among the 9-11-year-olds. The results from this study will provide design inputs to help furniture manufacturers to provide well fitted furniture for Tanzania's schoolchildren because it is suitable for both genders and for children from both rural and urban centres.

Keyword: anthropometry, mismatch, Tanzania, schoolchildren, school furniture.

1. INTRODUCTION

Availability of anthropometric data is essential for the design of school furniture (Adeyemi *et al*., 2014). This is necessary to prevent the children from using mismatch school furniture. Furniture mismatch and heavy backpack has been identified as major risk factors for musculoskeletal disorders (MSD), such as neck and back pain among schoolchildren (Adeyemi *et al*., 2014). MSD can also occur as a result of the sedentary nature of school work in Tanzania, where the children are expected to seat for an extended period of 3-6 hours every day. The resulting MSD effect can lead to absenteeism and distraction during learning (James *et al*., 2012; Woodcock *et al*., 2009).

Although, anthropometric data are used for design purposes, the usefulness of such data are not limited to furniture design, for anthropometry is also used in assessing growth and healthy development of children (Bundak *et al*., 2014; Konishi *et al*., 2014). Hence, most developed nations made tremendous effort not only to have an anthropometric database, but also to update it at regular intervals. However, many African and other developing countries are yet to have a reliable database for such evaluations (Alderman *et al*., 2006; Development, 2007; Moradi and Baten, 2005). This has led to the provision of school furniture using anthropometric estimates from Europe and America. The effect of this practice is the highest prevalence rate in musculoskeletal disorders among African school children. The class activities for primary school children in Tanzania require children to pursue academic work in various postures such as sitting, standing, bending, viewing, etc. for a long period of time a day. In Tanzania, children start primary school at age of 7 years and finish primary education at 13 years old. At this age the physical development of children changes to the spinal column as a result of inappropriate posture style triggered by unfitting school furniture. This fact motivates to carry out a research to help designers to develop appropriate furniture for primary school children. This study is therefore aimed at developing an anthropometric database that can be used in designing school furniture for Tanzanian schoolchildren.

2. METHODS

The application for data collection was sent to selected schools in Mpanda, Katavi region of Tanzania. Approvals were obtained from 10 schools and the school distribution was fairly representative of the urban and rural populations of Tanzania. After obtaining schools and parental consents, a total of 468 children, comprising 236 males and 232 females, assented to partake in the study. Since, it might not be possible to produce furniture for each age group because of intra and inter age variations over time, children within certain age groups are normally provided with same furniture. Hence, the primary school children were split into four groups each. Twelve body dimensions were measured. These are the major anthropometric dimensions used for furniture designs and they include stature height, body weight, shoulder breadth, popliteal height, reaching (overhead) height, eye height, elbow height, hip breadth, arm length, thigh thickness, buttock-popliteal length and buttock-knee length. In addition to weight, Figure-1 shows eleven (11) anthropometric dimensions which are necessary for the seat and desk surface design.

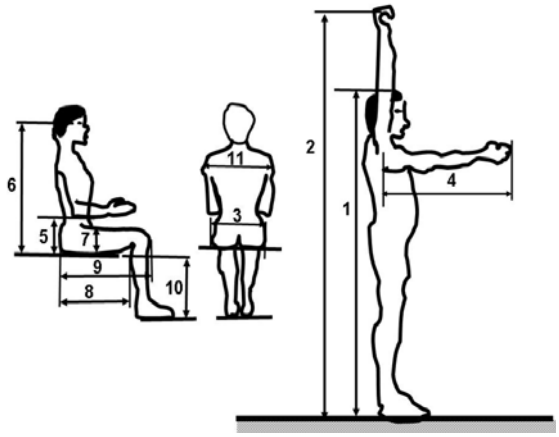

Figure-1. Anthropometric measurements of standing posture (1) Stature (2) Reaching height (3) Hip breadth (4) Arm length (5) Elbow height (6) Eye height (7) Thigh thickness (8) Buttock-popliteal length (9) Buttock-knee length(10) Popliteal height (11) Shoulder breadth.

The choice of the variables measured in this study was based on the children's safety and comfort, and their relevance to the design of school furniture and other facilities that have influence on pupils-desks interaction. The child anthropometry was measured using a wall-mounted gridlines, calibrated in millimeters, anthropometric chair and a flexible measuring tape with an accuracy of 0.1mm. The body weight was measured using a portable weight scale with an accuracy of 0.01Kg. Descriptive analysis, which includes determination of the percentile distribution, and other analysis were carried out using Statistical Package for Social Science (SPSS) version 21.

3. RESULTS

Table-1 shows the age, gender and class classification of the children that participated in the study while Tables 2 to 5 shows the 5th, 50th and 95th percentile of the four age categories in the schools. The minimum and maximum percentile of the entire group varies between age and gender. The smallest 5th and biggest 95th percentile lies within the 6 and 17 years old students.

Table-1. The age group, class classification and gender of the children.

Age group	Class							Gender		Total
	1	2	3	4	5	6	7	Male	Female	
6 to8	28	16	0	0	0	0	0	47	64	111
9 to 11	3	9	21	9	5	0	0	52	43	95
12 to 14	0	3	3	33	20	21	11	95	99	194
15 to 17	0	0	0	3	2	4	15	42	26	68
Total	31	28	24	45	27	25	26	236	101	468

Table-2. The anthropometric data of the 12 furniture dimensions for 6- to 8-year-olds children.

Age group (years)	**Percentiles** (mm)					
	Male			**Female**		
	5th	**50th**	**95th**	**5th**	**50th**	**95th**
Stature	1060.00	1125.00	1290.31	1110.00	1280.00	1504.00
Reaching height	1142.00	1390.00	1692.51	1111.70	1211.70	1686.50
Hip breadth, seated	200.00	220.00	263.11	172.25	218.00	271.95
Arm length	395.00	513.50	630.32	467.50	565.00	694.80
Elbow height, seated	102.00	142.50	204.40	105.35	137.00	228.50
Eye height, seated	403.00	468.00	543.23	405.30	483.00	642.20
Thigh thickness, seated	68.00	94.50	146.11	69.00	94.00	153.90
Buttock-popliteal	316.25	318.00	382.93	292.10	324.50	431.50
Buttock-knee length	294.80	382.00	496.21	258.70	393.00	516.25
Popliteal height, seated	218.00	300.00	358.09	229.00	295.00	342.30
Shoulder breadth	265.00	282.50	325.25	245.25	272.50	362.50
Body weight	19.00	22.50	26.23	18.35	23.00	31.30

Table-3. The anthropometric data of the 12 furniture dimensions for 9- to 11-year-olds children.

Age group (years)	**Percentiles** (mm)					
	Male			**Female**		
	5th	**50th**	**95th**	**5th**	**50th**	**95th**
Stature	1103.50	1227.50	1612.50	1195.00	1420.00	1540.00
Reaching height	1362.50	1449.50	1807.50	1320.00	1670.00	1902.54
Hip breadth, seated	181.75	245.00	379.75	203.00	250.00	344.69
Arm length	518.00	600.00	723.7	510.00	643.00	695.29
Elbow height, seated	108.25	138.00	169.50	125.00	143.00	167.17
Eye height, seated	432.00	532.50	641.50	494.00	588.00	649.77
Thigh thickness, seated	77.20	93.00	127.50	82.00	92.00	108.92
Buttock-popliteal	296.25	360.50	442.75	220.00	400.00	491.96
Buttock-knee length	282.00	511.00	546.00	327.00	457.00	524.61
Popliteal height, seated	261.50	332.50	415.00	260.00	340.00	400.45
Shoulder breadth	261.50	292.50	347.50	280.00	305.00	346.09
Body weight	20.50	28.50	35.00	23.00	31.00	39.65

Table-4. The anthropometric data of the 12 furniture dimensions for 12- to 14-year-olds children.

Age group (years)	**Percentiles** (mm)					
	Male			**Female**		
	5th	50th	95th	5th	50th	95th
Stature	1270.00	1405.00	1676.50	1195.00	1420.00	1540.00
Reaching height	1509.00	1790.00	2057.00	1465.45	1800.00	1887.25
Hip breadth, seated	229.00	275.00	320.00	209.85	276.50	350.50
Arm length	588.00	670.00	761.00	594.70	672.50	746.20
Elbow height, seated	120.00	145.00	180.70	119.95	155.50	192.15
Eye height, seated	505.90	603.00	673.80	515.90	616.00	695.20
Thigh thickness, seated	84.70	100.00	134.00	100.00	104.00	140.10
Buttock-popliteal length	345.20	420.00	513.30	300.20	417.50	472.00
Buttock-knee length	348.00	482.00	560.00	345.95	500.00	566.10
Popliteal height, seated	328.10	390.00	445.50	229.00	375.00	423.85
Shoulder breadth	265.50	325.00	390.00	289.75	330.00	365.75
Body weight	26.90	37.00	51.10	29.95	38.50	51.10

Table-5. The anthropometric data of the 12 furniture dimensions for 15- to 17-year-olds children.

Age group (years)	**Percentiles** (mm)					
	Male			**Female**		
	5th	**50th**	**95th**	**5th**	**50th**	**95th**
Stature	1380.00	1556.50	1725.73	1370.00	1557.50	1756.68
Reaching height	1765.00	1980.00	2205.29	1674.00	1870.00	1902.54
Hip breadth, seated	235.00	315.00	430.48	250.00	324.00	412.38
Arm length	680.00	760.00	813.30	665.00	722.00	813.30
Elbow height, seated	103.00	155.00	194.11	108.00	160.00	195.68
Eye height, seated	516.00	666.00	750.94	575.00	663.00	716.75
Thigh thickness, seated	98.00	120.00	137.11	120.00	124.00	149.79
Buttock-popliteal length	381.00	460.00	510.61	407.00	464.00	509.61
Buttock-knee length	440.00	520.00	589.36	510.00	550.00	585.91
Popliteal height, seated	384.00	434.00	469.80	365.00	408.00	443.87
Shoulder breadth	230.00	375.00	440.53	315.00	346.00	361.65
Body weight	34.00	49.00	62.82	42.00	50.00	58.67

3.1 Comparison of dimensions in gender and age

Figure-1 shows that there was generally no significant difference in the anthropometric dimensions based on gender (p=0.921). Although a 2-way ANOVA did not reveal significant interaction between age and gender, Marginal means profile plot in Figure-2 shows that gender difference can be pronounced at the 9-11-year-old age group.

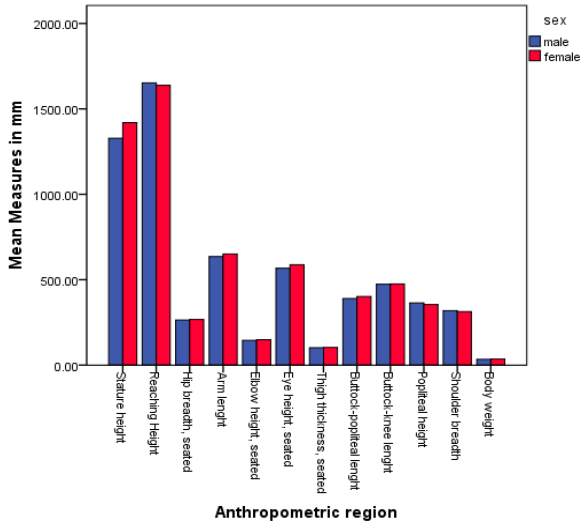

Figure-1. Gender differences in anthropometric data variations.

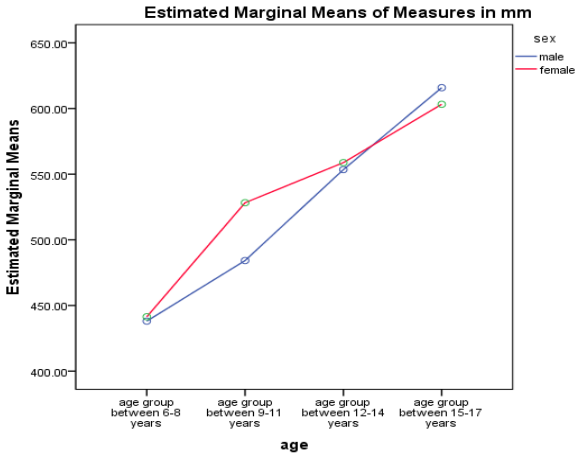

Figure-2. Marginal differences of the anthropometric dimensions of the age groups between boys and girls.

4. DISCUSSIONS

Developing anthropometric recommendation for children can be very challenging because of the inherent variability. That is why it is important to have anthropometric data which can be used to design multiple sizes to accommodate the variation in children's anthropometry (Molenbroek *et al*., 2003). The age categorisation used in this study ensures that the growth rates of the children are factored into the design process. It is common for schools to provide school furniture with the same dimensions for all ages. Some of the manufacturers of the school furniture have no alternative than to use foreign dimensions since local anthropometric data are not available. The study has revealed that there is a significant difference between the four age groups and provision of same-size furniture for the children will cause a mismatch.

Figures-3 shows the influence of age on the variation of different dimensions to male and female

children. It is shown that the dimensions of children increase with age, however, for male and female children; there is a significant discrepancy of some dimensions as their respective ages increase. It can be seen that at the age below 7 years, female pupils have small hips breadth compared to the male pupils while between 7 and 12 years female hips breadth become larger than male pupils. Hips breadth of both groups is almost the same in between the age of 12 and 15 years. Above 15 years, hip breadth dimensions for female pupils are far larger than for male pupils.

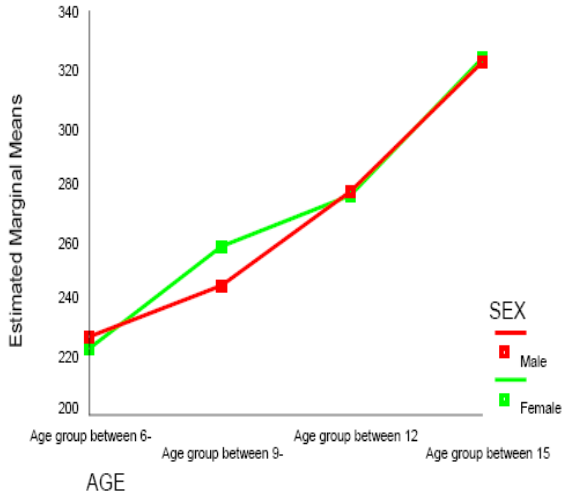

Figure-3. Variation of hip breadth dimensions and age.

The lack of significant difference between male and female dimensions is an indication that the use of the anthropometry dimensions, presented in this study for both genders, will accommodate large population. Also, classifying the recommendation into four age groups also minimise the variability due to age differences. However the larger marginal means identified in 9-to 11-year-olds children (Figure-2) is synonymous with the puberty experience during the period. This is because puberty is reported to start earlier in girls, which make them experience a growth spurt earlier than boys (Bundak *et al*., 2014; Cole *et al*., 1998). Moreover, Figure-2 also highlighted the commonly reported trend of boys catching up and eventually overtaken girls in their late teens. Furthermore, age classification is very important to accommodate the changes in children's growth, which differ with their age (Castellucci *et al*., 2015). The age group classification is similar to what has been done for similar projects in other countries (BS and EN, 2006; García-Acosta and Lange-Morales, 2007; Nurul *et al*., 2009).

Since most furniture dimensions in Africa are based on American and European standards, Comparing the 5th and 95th percentiles with these standards show that the Tanzania children anthropometry are less when compared with the children from these continents (BS and EN, 2006; García-Acosta and Lange-Morales, 2007), highlighting the possibility of mismatch when those standards are used as input for furniture design for the children. This is not unexpected since anthropometry varies with race, genetic differences, standard of living or socio-economic status and nutrition (or malnutrition) status of a population (Graham, 1972; Griffiths *et al*., 2010; McVeigh *et al*., 2004; Moradi and Baten, 2005). The analysis made in desk measurements shows that some students in class 1, 2, and 3 do not sit properly when writing, a situation which provide inappropriate posture during the study. The students of the lower class as mentioned, they stand in order to have an access of writing on the table, while those of higher class (i.e. class 6 and 7) bend when writing as shown in Figure-4.

Figure-4. Left and Right are standing and awkward sitting posture for class 1 and 7 students, respectively.

Malnutrition, which is associated with socioeconomic status, has been reported to be a risk factor for anthropometry among children from African and other developing countries (Goon *et al*., 2011; Lwambo *et al*., 2000; McVeigh *et al*., 2004; Tharakan and Suchindran, 1999). Malnutrition is associated with stunted growth, a situation common all over the continent. This is because availability and the quality of food affects growth in children (Alderman *et al*., 2006; Moradi and Baten, 2005). Tanzania is not exempted from this problem and hence, it might also be a factor responsible for the lower anthropometric dimensions observed in this study (Lwambo *et al*., 2000). This can affect variation in anthropometry across the population, especially the urban-rural divide.

This study has further highlighted the need for national standards for design inputs for Tanzanian children. However, there is a need for a more comprehensive study since this study is also limited in sample size and the number of regions covered. Such comprehensive study will also help to define the appropriate number of sizes. For example, while the European standard (BS and EN, 2006) contains four sizes of furniture for schoolchildren within 6 to 18 years, this was not suitable for Columbian children, with a wider range between 5th and 95th percentiles and bigger differences between the sizes, leading to the

recommendation of six sizes for Columbian children (García-Acosta and Lange-Morales, 2007).

5. CONCLUSIONS

The availability of anthropometric data for school furniture design will help reduce the problem of furniture mismatch presently identified in schools. The results from this study will provide design inputs to help furniture manufacturers to provide well fitted furniture for Tanzania's schoolchildren. The information is also suitable for both genders, since there is no significant difference between data from boys and girls, and also children from both the rural and urban centers.

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