Level of Implementation of Ergonomic Based School furniture for Malaysian Children

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Introduction: The provision of ergonomically designed school furniture, based on the anthropometric dimensions of the children, is essential for comfort and prevention of musculoskeletal disorder that may arise from the use of mismatched furniture. This is because school furniture and backpack has been identified as a major risk factor for back pain and other Musculoskeletal Disorder (MSD) among schoolchildren (Nurul, Shamsul, Mohd Shahrizal, et al. 2009, Ghazilla et al. 2010). Such discomforts are bound to distract children from concentrating in class and can result in indiscipline among children as pain makes them less tolerant (Woodcock et al. 2009). This study is therefore aimed at investigating the degree at which different furniture used in Malaysian schools conforms to the basic ergonomic requirement for school furniture.

Method: Stature heights and weights of 615 schoolchildren from three schools in Skudai area of Johor, Malaysia were measured. The two dimensions were used to estimate the appropriate anthropometric body dimensions required for furniture design. The body dimensions; which include popliteal height, buttock to popliteal length, hip breadth, shoulder height, elbow height and knee height were estimated from stature height and body mass index as defined by (Ghazilla et al. 2010, Oyewole et al. 2010, Musa and Ismaila 2011). The permissible variation of the chair and table dimensions were also computed as defined by (Gouvali and Boudolos 2006, García-Acosta and Lange-Morales 2007, Musa and Ismaila 2011). Different classrooms and canteen furniture from five schools were measured to determine their suitability for use in both lower and upper primary schools. A 2-way ANOVA was carried out to investigate if there is an interaction effect between age and race so as to determine the suitability of a single design for the entire population. The analysis was carried out using SPSS 18 at a significant level of 0.05.

Results: 
Stature height as well as other body dimensions increases with age in the children. The 2-way ANOVA did not identify significant interaction between age and race for the stature height of the children. Two of the chairs were found to be appropriate for the children while the canteen furniture shows high level of mismatch for the children.

Discussion: There is significant anthropometric variation among the primary school pupils and a single design for the entire school is not suitable, especially in the classrooms where children spend most of their time in school. Two group classifications of lower and upper primary are more appropriate as it reduces the degree of variation. Although it is virtually impossible to fit the furniture to all individuals, effort must be made to ensure it fits a large percentage of the population. There is the need to increase awareness on the need for designers and manufacturers of school furniture to conform to ergonomic recommendations.

Practitioner Summary: The study investigated the ergonomic suitability of primary school furniture among Malaysian school children. The findings highlight the need for further enlightenment towards the provision of primary school furniture that is designed based on children’s anthropometry.

Keywords: Malaysia Schoolchildren, Anthropometry, Ergonomic, Musculoskeletal Disorder.
1. Introduction
The issue of appropriate furniture for school children has been well researched and recommendations published. Yet there is still little implementation of the findings in these research in many countries. School furniture design based on comfortable body posture aids learning. This is because school furniture and backpack have been identified as the two major risk factors for back pain and other Musculoskeletal Disorder (MSD) among schoolchildren (Nurul, Shamsul, Mohd Shahrizal, et al. 2009, Ghazilla et al. 2010). Such discomforts are bound to distract children from concentrating in class and can result in indiscipline among children as pain makes them less tolerant (Woodcock et al. 2009).

The effect of these pains as it affects children’s performance is not limited to distraction during learning, but can also lead to absenteeism if not treated on time. All these can also affect productivity of the parents who may be psychologically disturbed and may have to meet extra financial demand for health bill (James et al. 2012). The long term effect in children cannot be over emphasised as MSDs among children has been associated with MSDs in adults. This justifies why developed countries have established standards for manufacturing of school furniture (Molenbroek et al. 2003, BS and EN 2006)

While literature abounds with research reports related to this problem for 2-3 decades, the recent reports of the existence of mismatch reveals that the issue has not been completely resolved by concern stakeholders. This study seeks to identify the level of implementation of ergonomically based school furniture for primary schoolchildren in skudai area of Johor, Malaysia. Unlike other related research, furniture evaluation in this study will not be limited to classroom furniture but will also consider canteen furniture where children are expected to eat or take a break.

2. Methods

2.1 Participants
The study was conducted in Skudai area of Johor, the southernmost state in Malaysia. Anthropometric data from children in three schools were collected while school furniture in five schools was inspected for the study. Three sets of furniture were identified to be commonly used in all the schools. 615 children from these schools indicated their interest in participating in the anthropometric survey. Heights were measured with a SECA 213 Standiometer having an accuracy of 0.01cm while body weight was measured with a Beurer diagnostic scale BF 20 with an accuracy of 0.01kg. The children were required to remove their shoes and stand erect during measurement.

2.2 Anthropometric data

Body dimension such as Popliteal height, buttock to popliteal length, hip breadth, shoulder height elbow height and knee height were used in this study as defined by (Ghazilla et al. 2010, Oyewole et al. 2010, Musa and Ismaila 2011). Since there is yet to be a published anthropometric database for Malaysian children, the body dimensions were determined from the stature height (H) and Body Mass Index (BMI) based on the following regression relations as used by (Oyewole et al. 2010) which falls within the ratio in (Milanese and Grimmer 2004)

\[
\begin{align*}
    \text{Popliteal Height (PH)} & = 0.2705 + 0.24^*H \\
    \text{Buttock-Popliteal length (BPL)} & = 0.7188 + 0.2426^*H \\
    \text{Hip Breadth (HB)} & = 0.6444 + 0.4729^*BMI \\
    \text{Shoulder Height (SH)} & = 0.4416 + 0.3274^*H \\
    \text{Elbow height (EH)} & = -0.4142 + 0.21645^*H \\
    \text{Knee Height (KH)} & = 0.4416 + 0.3274^*H
\end{align*}
\]

The permissible variation of the chair and table dimensions as defined by (Gouvali and Boudolos 2006, Garcia-Acosta and Lange-Morales 2007, Yanto et al. 2008, Agha 2010, Ghazilla et al. 2010, Musa and Ismaila 2011) is as follows:
Seat height (SH) is related to the popliteal height (P) by \((P + 2)\cos 30^0 \leq SH \leq (P + 2)\cos 5^0\)

Seat depth (SD) should be within \(0.8PB \leq SD \leq 0.99PB\)

Seat width (SW) should be large enough to accommodate lateral movements i.e. \(1HB \leq SW \leq 1.3HB\)

The table height (TH) should be maximum when the shoulder is flexed at \(25^0\) and should be within \(EH + \min(SH) \leq TH \leq \max(SH) + 0.85EH + 0.148S\)

Under-Table height (UH) or clearance should provide enough space between the knee height (K) and the lower edge of the table top should be within \((KH + 2) + 2 \leq UH \leq \max(SH) + 0.85EH + 0.148S - A\)

Where A denote table thickness

To calculate the required anthropometric dimension, the children were classified into lower primary (age 7 to 9) and upper primary (age 10 to 12), the 5th, 50th and 95th percentiles for each age were calculated and the average of the percentile for each group was used to determine the maximum and minimum requirements from equations above. These were used to determine the suitability of the chairs and tables in the classrooms and the canteen

2.3 Statistical analysis

Analysis of variance (ANOVA) was carried out to investigate if there is an interaction effect between age and race so as to determine the suitability of a single design for the entire population. The analysis was carried out using SPSS 18 at a significant level of 0.05.

3. Results

Fig. 1 shows the boxplot capture of the variation in stature height (in centimetres) of the children based on their ages. The figure shows that stature height as well as other body dimensions increases with age in the children \((r = 0.826, p < 0.001)\). ANOVA also shows a significant difference in stature height \((F(5, 609) = 269.685; p < 0.0001)\) which was revealed to be across all ages by the poc hoc analysis.
Table 1 provides a side by side basis for comparing the expected dimensions with the existing designs in the schools. Three sets of classroom and canteen furniture were identified during the study. The most commonly used class furniture is the plastic chair (Chair 1) with table 1 and 2. Table 1 shows that only two chairs (1 and 2) is appropriate for upper primary and none for lower primary.

Table 1: Comparison of the dimension of school furniture with expected dimensions in centimetres.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Classroom Furniture [cm]</th>
<th>Canteen Furniture [cm]</th>
<th>Lower Requirement</th>
<th>Primary Requirement</th>
<th>Upper Primary Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat height</td>
<td>Chair 1 plastic</td>
<td>Chair 3 wood</td>
<td>43</td>
<td>30.65</td>
<td>34.59</td>
</tr>
<tr>
<td></td>
<td>2 plastic</td>
<td>3 (wood)</td>
<td>37.5</td>
<td>32.9</td>
<td>37.41</td>
</tr>
<tr>
<td>Seat depth</td>
<td>Chair 1 Plastic</td>
<td>Chair 2 Fibre</td>
<td>43</td>
<td>25.14</td>
<td>28.32</td>
</tr>
<tr>
<td>Back rest height</td>
<td>Chair 1 Wood</td>
<td>Chair 3 Wood</td>
<td>46</td>
<td>28.43</td>
<td>30.41</td>
</tr>
<tr>
<td></td>
<td>All length</td>
<td>All length</td>
<td>35</td>
<td>28.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Table 1 Plastic</td>
<td>Table 3 wood</td>
<td>15.25</td>
<td>18.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with metal frame</td>
<td></td>
<td>16-31</td>
<td>16.66</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>74.5</td>
<td>72.5</td>
<td>67</td>
<td>57</td>
<td>65.5</td>
</tr>
<tr>
<td>Width</td>
<td>56</td>
<td>71</td>
<td>50</td>
<td>59.2</td>
<td>68</td>
</tr>
<tr>
<td>Knee clearance</td>
<td>17</td>
<td>20.5</td>
<td>16</td>
<td>15.25</td>
<td>16.66</td>
</tr>
</tbody>
</table>

4. Discussion

Although it is virtually impossible to fit the furniture to all individuals, effort must be made to ensure it fits a large percentage of the population. This virtually makes ergonomic consideration for furniture design complex (Oyewole et al. 2010). The large deviation from the safe range should be a cause for concern because of the effect on the children’s health and development. Hence, the level of mismatch observed shows there is still need to increase the conformance to previous recommendations on the school furniture among Malaysian schoolchildren (Nurul, Shamsul, Mohd Shahrizal, et al. 2009, Nurul, Shamsul, Shahrizal, et al. 2009, Ghazilla et al. 2010, Afzan et al. 2012). Schools are not expected to be using single furniture dimensions for all children since there is high anthropometric variability among the children (Ghazilla et al. 2010). Also, there is a high possibility that some manufacturers are using dimensions for foreign population such as chair and table 1 conforming for upper primary of UK children (SchoolFurniture n.d.).

The observed furniture mismatch is major risk factor for musculoskeletal disorder among the children. The excessive seat height, which are higher than the popliteal heights will not permit the children to rest their feet properly on the floor, thereby leading to the compression along the popliteal space and in the buttock region (Milanese and Grimmer 2004, Castellucci et al. 2014). The significant difference between the observed and recommended seat depth will also prevent the children to effectively utilise the back rest, a major risk factor for back pain. The high table height has also been identified as a major contributor of spinal loading (Castellucci et al. 2014). The study also shows that the canteen furniture were not suitable for the children. However, they were suitable for adult workers in the school. While it is not out of place to have furniture suited to teachers and other workers in the school, the present arrangement where the furniture, especially those in canteens, suited only adult and not the schoolchildren who are the focus of the system is inadequate.

Figure 1 reveals the wide variety in the entire primary school population and why a single design for the entire school is not suitable especially in the classrooms where children spend most of their time in school. Two group classifications of lower and upper primary are more appropriate as it reduces the degree of
variation. Emphasise should be place in the lower primary school since present design does not adequately consider their anthropometry. Although Malaysia is a multi-racial society, the single design recommendation will be adequate since race was not found to interact with the children’s age as their stature height increases (p=0.151). The availability of a comprehensive anthropometric data base for the country will also serve as a better medium for a nationwide analysis. Although the dimensions were based on estimated value from established relationship, the dimensions were within the range recorded by Nurul et al. (2009) considering that their dimensions were for 11 years alone (Nurul, Shamsul, Mohd Shahrizal, et al. 2009).

4. Conclusion

This study shows that furniture mismatch still exist in primary school. Worse affected are children in the lower primary schools with more tender structure. None of the canteen furniture was suitable for the entire schoolchildren. A major question to be asked is what should be done for school administrators to see the furniture mismatch as an issue that needs urgent attention? This has further demonstrated the existing poor implementation of ergonomic recommendations and the need for stakeholders to step-up actions to alter the trend.

References


