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Analysis of the most relevant anthropometric dimensions for school furniture selection based on a study with students from one Chilean region

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ABSTRACT

Most of the worldwide standards used for furniture selection suggest the use of the Stature of the school children, assuming that all the other anthropometric characteristics will also be appropriate. However, it is important to consider that students' growth differ with age. The aim of this study is to determine if Popliteal Height can be used as a better, or more adequate, measure for classroom furniture selection when comparing with Stature. This study involved a representative group of 3046 students from the Valparaíso Region, in Chile. Regarding the methodology, eight anthropometric measures were gathered, as well as six furniture dimensions from the Chilean standard. After assigning the level of school furniture using Stature and Popliteal Height to each of the students, six mismatch equations were applied. The results show that when using Popliteal Height, higher levels of match were obtained for the two more important furniture dimensions. Additionally, it also presents a better cumulative fit than Stature. In conclusion, it seems that Popliteal Height can be the most accurate anthropometric measure for classroom furniture selection purposes.

1. Introduction

School work requires students to spend long hours sitting down. Considering this, as well as the potential inadequate use of school furniture, it is likely that some anatomical-functional changes and problems in the learning process may occur (García-Acosta and Lange-Morales, 2007; Trevelyan and Legg, 2006; Milanese and Grimmer, 2004; Hira, 1980). This situation causes an increased concern about the school classrooms, particularly about the study and design of school furniture suitable to the needs of the students and the appropriate dimensions according to the students' anthropometrics characteristics. Worldwide, it is possible to observe a great number of studies regarding the students' anthropometric characteristics, with the aim of generating safer school furniture (Agha, 2010; Dianat et al., 2013; Evans et al., 1988; García-Acosta and Lange-Morales, 2007; Musa, 2011; Oyewole et al., 2010; Savanur et al., 2007). Furthermore, there is an increase in the number of standards regarding school furniture in different countries, such as: Chile (INN, 2002), Colombia (ICONTEC, 1999), the European Union (CEN, 2012), Japan (JIS, 2011) and United Kingdom (BSI, 2006).

Anthropometric information for chair design is mainly concerned with providing data on the Stature of the people for whom the seats are designed (Evans et al., 1988; Kayis, 1991). Furthermore, most of the standards that are published worldwide for furniture selection tend to use, as a reference, Stature (S) as the anthropometric dimension of the school children, assuming that all the other anthropometric characteristics are also appropriate. However, it is important to remember that student growth differ with ages. For example, before puberty, the legs grow more rapidly than the trunk and in adolescents, the growth spurt is largely in the trunk (Bass et al., 1999). Also, Lueder and Berg Rice (2008) recommended that for designing school furniture it may be useful to consider how children develop and mature, as well as to incorporate features that accommodate a wide range of ages in

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good postures. The body proportion, i.e., the proportions related to the S between different segments of the body, may be helpful for this situation since it is a scaling relation calculated with a ratio of one body dimension to a specific reference dimension. The most common reference dimension is the Stature (Roebuck et al., 1975).

Some authors (Cho, 1994; Hibaru and Watanabe, 1994; Molenbroek et al., 2003; Noro and Fujita, 1994) suggest that the furniture selection can be done more efficiently if the Popliteal Height (PH) is used instead of S. Molenbroek et al. (2003), demonstrated, by using ellipses, that the seat height proposed in the standard PrEN 1729 is too high for most of the children with S of 1200 mm. Hibaru and Watanabe (1994) found that the chair size selection was strongly correlated with the PH in 124 students from 4th grade. Another, more complex system was also developed to allocate school furniture by Noro and Fujita (1994). This system is based on the physical images of students and it considered the different variables like PH, S, school grade and physical condition (slim, average and obese). However, there is a controversial point raised between the authors that proposed PH for allocation to the school furniture, namely the fact that, as reported by Noro and Fujita (1994), there is the need to make accurate measurement of PH and this requires experience and skills. On the other hand, Molenbroek et al. (2003) suggested that current knowledge about the use and the measurement of PH in a school class is absent. Nevertheless, the authors assumed that this is not necessarily more difficult and/or time consuming compared to the measurement of S if some measurement strategies are applied, such as the example shown in Fig. 1 (Molenbroek et al., 2003).

The aim of this study is to determine if PH can be used as a better and most accurate measure for classroom furniture selection rather than using S.

2. Methodology

2.1. Participants

It is important to mention that, in Chile, growth seems to be clearly influenced by socio-economic aspects, where it has been observed that children from higher socio-economic levels are taller than those of lower and medium socio-economic levels (Castellucci et al., 2010; Muzzo, 2003). On this basis, the selection used a stratified random sample regarding the three types of elementary school administrations in Chile (public, semi-public and private), as well as the corresponding financial situation of the students.

The estimated student population of basic and secondary schools in the Valparaíso Region during 2010 was 243,490 students. Considering a 50% prevalence of school furniture mismatch ($p = 0.5$ to obtain the largest sample), with 3% accuracy, 95% confidence intervals, and 15% of loss, the theoretical sample size is 1251 students. However, based on the Chilean school education system, every school has 12 grades, with students ranging from the age of 6 to 18 years old. In order to cover all of them, it was decided to use a random sample of at least 20 students per grade, keeping the proportionality of each cluster. This cross-sectional study involved a representative group of 3046 participants (1382 female and 1664 male students), with ages ranging from 6 to 18 years old (11.7 ± 3.5), from 18 schools that were randomly selected from a list given by the Regional Ministerial Secretary of Education.

The study started after its approval by the Committee of Ethics at the School of Medicine from the Universidad de Valparaíso. Permission to conduct this research was obtained also from the Regional Ministerial Secretary of Education and from the headmaster of each of the considered schools. Additionally, written consent was obtained from parents and students before starting the measurement procedures.

Fig. 1. Evaluation of Popliteal Height with the “Peter lower leg meter”.

2.2. Furniture reference dimensions

Table 1 presents the furniture dimensions from the five levels of furniture dimensions indicated in Chilean Standard 2566 (INN, 2002), which were utilized in the current study. Also, Fig. 2 shows a representation of the furniture dimensions.

2.3. Anthropometric measure

The anthropometric dimensions were collected from the right side of the subjects while they were sitting in an erect position on a height-adjustable chair with a horizontal surface, with their legs flexed at a 90° angle, and with their feet flat on an adjustable footrest. During the measurement process, the subjects were without shoes and were wearing shorts and T-shirts (ISO, 2008).

All measurements were taken with a portable anthropometer (Holtain), with an exception made to subjects' Stature, which was measured with a stadiometer.

The anthropometric measures considered and collected during this study are presented and defined in Table 2 and Fig. 3.

2.4. Mismatch equations

Fig. 4 shows the procedure for assigning the level of school furniture and analyzes the level of mismatch. The level of school furniture was assigning using S – “Selection by Stature” (SbS) – as the Chilean standard recommend following different intervals for example. For example, if the student's stature is 167 cm the school furniture level will be the 4th. The school furniture was also assigned using PH – “Selection by Popliteal Height” (SbPH) – it is important to mention that 2 cm were considered for SC, as an