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Evidence for the need to update the Chilean standard for school furniture dimension specifications

H.I. Castellucci [a,*], M. Catalán [a], P.M. Arezes [b], J.F.M. Molenbroek [c]

[a] Escuela de Kinesiología, Facultad de Medicina, Universidad de Valparaíso, Valparaíso, Chile
[b] Research Center for Industrial and Technology Management, School of Engineering, University of Minho, 4800-058, Guimarães, Portugal
[c] Delft University of Technology, Faculty of Industrial Design Engineering Section Applied Ergonomics and Design, Landbergstraat 15, 2628 CE, Delft, The Netherlands

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ABSTRACT

Some countries decide to use standards to define the type of furniture dimensions that should be used according to students' anthropometric characteristics. The aim of this paper is to generate data to update the standard for Chilean school furniture using student anthropometric data. The sample used involved 3078 students. Data collection included eight anthropometric dimensions. A strict procedure was followed to define six furniture school dimensions. The definition of the compatibility between students' characteristics and furniture dimensions was done using the concept of mismatch computed through a set of equations. The results showed differences in mismatch levels between the two compared approaches, with lower mismatch found using the new proposed approach – the updated standard (UpS). Seat depth presents the greatest difference in mismatch, with values of 43% for the current Chilean standard (ChS) and 17% for the UpS. Also, seat height match values are almost the same (100%); however, it is important to mention that the level of match could drop to 82% in the ChS if the furniture selection was already carried out, as suggested in the standard itself, by using the Stature. Finally the UpS presents a higher covered range in the six furniture dimensions. The obtained results reflect the need to update the data and the procedure for school furniture selection presented by the current Chilean standard. Relevance for industry: this paper presents relevant data to be used by both school furniture designers, as well as by those responsible for the furniture selection at schools. In addition, proof is presented that school furniture standards need to be updated periodically in order to better fit the students' anthropometric characteristics.

1. Introduction

Students take part in one of the most sedentary occupations – school attendance – where permanent sitting habits are formed (Lueder and Berg Rice, 2008; Zacharkow, 1987). Being seated for a long period of time on school furniture is being associated with reports of musculoskeletal discomfort and pain (Fallon and Jameson, 1996). School furniture is a key factor for the adoption of proper posture and consequently, greater productivity for the individual. For example, the high level of mismatch between students and school furniture is being associated with adolescent low back pain (Milanese and Grimmer, 2004). Other authors, such as Linton et al. (1994), verified that the use of a chair with a curved seat and a desk with an inclination produced a reduction in musculoskeletal symptoms in comparison to the use of a desk with a flat top (parallel to the floor) and a detached chair with a straight back and seat placed at a 90° angle.

While it is acknowledged that there is a multifactorial nature of causality of adolescent spinal symptoms, it is contended that the degree of mismatch between child anthropometry and school furniture set-up should be further examined as being a strong and plausible factor in the occurrence of adolescent lower back pain (Milanese and Grimmer, 2004).

To avoid the mismatch problem, Van Niekerk et al. (2013) shows that there is no one-size-fits-all solutions. Furthermore, one of the best possible solutions to minimize mismatch is to adopt furniture with adjustability, as suggested by Jung (2005). Yeats (1997) argues that it is difficult to encourage proper posture early in life without

* Corresponding author.
E-mail address: hector.castellucci@uv.cl (H.I. Castellucci).

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the support of adjustable chairs, desks and tables in the classroom. However, scalability, i.e. having the furniture available in many sizes, became a more real and cheaper solution. This is reflected in the increase in the number of published standards regarding school furniture in different countries, such as Chile (INN, 2002), Colombia (ICONTEC, 1999), the European Union (CEN, 2012), Japan (JIS, 2011) and the United Kingdom (BSI, 2006).

A recently published study concluded that the Chilean student population has increased in Stature over the past two decades (Castellucci et al., 2014b). The authors also pointed out that this positive secular trend was observed in other anthropometric measures, such as popliteal height, hip width and buttock-popliteal length. Accordingly, they concluded that using Chilean Standard 2566 (ChS) data for furniture size selection will result in a high level of mismatch regarding desk height and seat depth.

Due to the mentioned evolution of the students' anthropometric characteristics, it is of paramount importance that the considered values for student anthropometrics in furniture standards are able to be monitored and updated to reflect the observed changes in the student population, namely to reflect the so-called secular growth observed in several populations. Considering this, the aim of the current paper is to generate data for updating the existing standard for Chilean school furniture, while taking into account the students' anthropometric data.

2. Methods and procedure

2.1. Sampling technique

The sample was defined using the principles defined in ISO 15535 (2012). In Chilean students, growth seems to be influenced by socio-economic status. It has previously been observed that children of higher socio-economic status are, on average, taller than those of lower and medium socio-economic status (Castellucci et al., 2010; Muzzo, 2003). Furthermore, in Chile there is a strong relation between family income and school administration type, i.e. children of lower, medium and high socio-economic status are more likely to attend to public, semi-public and private schools, respectively (González et al., 2004). Due to this, the selection strategy considered a stratified random sample design regarding the three types of elementary school administrations in Chile: (1) public school, where parents do not have to pay for their children's studies; (2) semi-public, where both the parents and the government pay for the education; and (3) private school, where all involved costs must be assumed by parents.

The estimated student population of basic and secondary schools in the Valparaíso Region during 2010 was 243,490 students, where 26.2%, 64.6% and 9.2% of the students went to public, semi-public and private schools, respectively. Considering a 50% prevalence of school furniture mismatch ($p = 0.5$ to obtain the largest sample), with 3% accuracy, 95% confidence intervals and 15% loss, the theoretical sample size is 1251 students. However, based on the Chilean education system, every school has 12 grades, with students ranging from the age of 5–19 years old, and 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. The final sample involved a group of 3078 students (1397 females and 1681 males).

2.2. Procedure before data collection

The measurements process was carried out by two survey teams composed of four people in each team: a measurer, a recorder, an organizer and another person to support the measurer. To avoid fatigue and monotony, the team members were able to switch from measurer to organizer and from recorder to measurer support.

Before starting the survey, the measurement teams underwent a two-week training session, including a theoretical approach about anthropometrics as well as practical instructions. They spent considerable time practicing the measurements to achieve high consistency between measurers. At the end of the training session, a sample of 30 volunteers was measured twice by the four measurers and both inter- and intra-measurer reliability were assessed using the Intraclass Correlation Coefficient (ICC) model's "two-way mixed" and "absolute agreement" types. Correlations were interpreted according to the ranges suggested by Portney and Watkins (2008): $ICC \geq 0.50$ was interpreted as moderate and $ICC \geq 0.75$ was interpreted as strong. The results from Table 1 shows that measurers have a strong value of inter- and intra-reliability.

2.3. Data collection procedure

The data collection 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 from the headmaster of each of the considered schools. Additionally, written consent was obtained from parents and students before starting the measurement procedures.

The data collection was carried out during the 2012 Chilean academic year (March to December), the range of days spent in each school ranged from 1 to 4 days, depending on the number of students at each location.

A standard procedure was followed to collect the anthropometric measurements. The procedure indicates that the anthropometric measures need to be performed from the right side of the subjects while they are 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. The following anthropometric measures (Table 2) from ISO 7250 (1996) need to be considered in order to estimate the most important furniture dimensions.

2.4. Defining the levels of the new school furniture standard

To determine the dimensions and characteristics of different sizes of school furniture, seat height should be the starting point and the design needs to be based on a bottom-up approach considering the following principles:

Seat height (SH): Most of the researchers have concluded that popliteal height (PH) should be higher than seat height (Dianat et al., 2013; Mokdad and Al-Ansari, 2009; Molenbroek and Ramaekers, 1996; Parcells et al., 1999); otherwise, most students will be unable to rest their feet on the floor properly, thus causing compression of vascular and neural structures going along the popliteal space (Milanese and Grimmer, 2004) and a less stable position for writing. However, if seat height is significantly lower than popliteal height, at more than 4 cm (UNESCO, 2001), this will increase the compression in the buttock region (García-Molina et al., 1992). Eq. (1) shows that seat height has to be higher than cos30° of popliteal height plus the shoe correction (SC) to avoid an extension of the knee of more than 30° relative to the vertical. This is relevant since with more extension the feet will not be placed flat on the floor and the thighs would not be sufficiently supported, causing discomfort. On the other hand, seat height has to be lower than cos5° of popliteal height plus SC to ensure that the student will sit in a chair high enough so that both feet are placed entirely on the floor, while also avoiding compression in the buttock region (García-Molina et al., 1992).