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Anthropometric mismatch between furniture height and anthropometric measurement: A case study of Korean primary schools

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ABSTRACT

This study analyzed the anthropometric mismatch between the height systems of the primary school furniture and children in Korea. The results revealed that the height systems of present desks matched the height of only half of the children. The cause of this was a drawer attached underneath the desk board. In case of the height system of present chairs, almost all children matched; however, some levels were of no use to the students. To increase the degree of matching, new height systems were developed for the desks and chairs via an algorithmic approach. It was confirmed that the new height system for desks could significantly increase the degree of matching, whereas the new height system for chairs comprised five levels that could be matched to all children. The proposed algorithmic approach is expected to be applied to the development of size systems for other products.

1. Introduction

Most children spend a considerable amount of time at school (Kumar, 1994; Troussier et al., 1999). In fact, they spend more than one quarter of a day in schools, of which 80% of the time involves sedentary activities (e.g., lessons). However, adopting awkward postures during prolonged sitting hours can cause musculoskeletal diseases (Pynt et al., 2001; Takemitsu et al., 1988). In particular, the lumbar disorder that occurs during childhood can inhibit the physical development of children in the growing phase (Tanner et al., 1976), and even if treated, it is expected to recur in adulthood (Troup et al., 1987). Furthermore, the poor postural habits formed in childhood are not easily corrected in adulthood (Yeats, 1997). Therefore, it is important to encourage children to maintain good posture while sitting.

The adoption of inappropriate sitting postures by children can be attributed to various factors such as preference, physical defects, lacking knowledge of good postures, defective sight, and fatigue (Elliott and Morrison, 1946; Hummel, 1943). One of the major factors is the use of anthropometrically mismatched furniture (Oyewole et al., 2010). In particular, the mismatched height of a desk or chair can force children to sit awkwardly. Agha (2010) found that children posed abnormally, such as by sliding forward on a seat or placing a leg between the seat surface and the buttock when the seat height was extremely high for them. It was observed that if the height of the desk was extremely low, the children bent their upper body forward. They also adopted inappropriate sitting postures such as excessive shoulder flexion or abduction when the desk height was very high. Additionally, Panagiotopoulou et al. (2004) confirmed that the mismatched heights of desks and chairs caused children to sit with poor posture. When the height of a seat was very high, children placed their buttocks forward on the front edge of the seat. Moreover, if the desk height was higher than the elbow rest height, children adopted awkward sitting postures such as elevating their arms and shoulders. Therefore, the heights of school desks and chairs should be carefully determined by considering the anthropometric characteristics of children.

The International Organization for Standardization (ISO) published the ISO 5970 standard in 1979. This is a guideline for the design of school furniture (ISO, 1979). Additionally, various countries such as the United Kingdom (BSI, 1980, 2006), Chile (INN, 2002), and Indonesia (NSAI, 1989a; b) have their own standards with regard to the anthropometric characteristics of children in each country. In Korea, the KSG-2010 standard (KIS, 2015) was published based on the ISO 5970 standard. Consequently, in Korea, the fabrication of school furniture must comply with this standard. KSG-2010 suggests seven levels for desk and chair height systems. However, in 2001, these height systems were revised based on the Korean anthropometric data obtained in 1997. Even though the height systems were developed to reflect the anthropometric characteristics of Korean children, 16 years have passed since their last revision. With regard to the secular trend of significantly increasing body size (Moon, 2011), it is uncertain whether the desks

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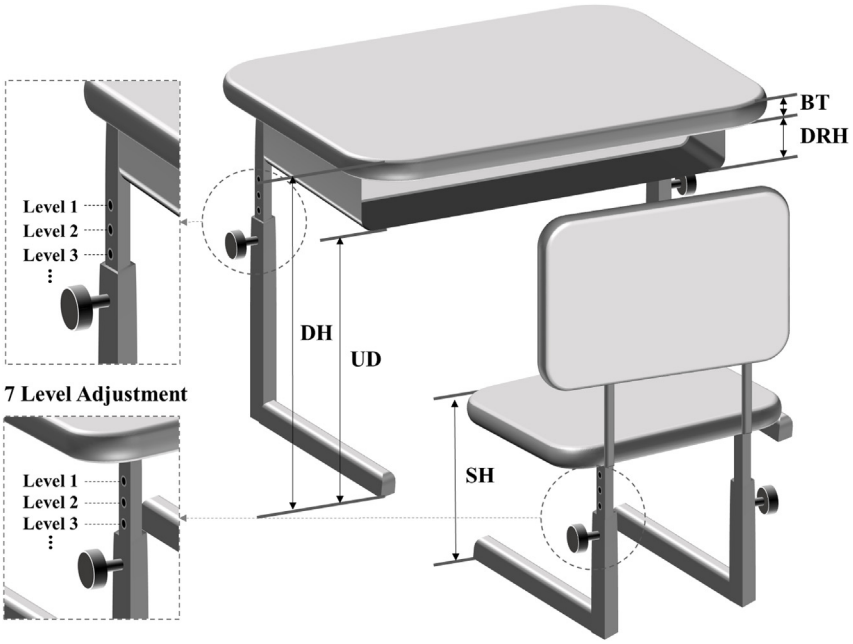

Fig. 1. Illustration of present school furniture and dimensions considered in this study. Desk height (DH): vertical distance from the floor to the tip of the front edge of the board of the desk; underneath desk height (UDH): vertical distance from floor to lowest point below the drawer; board thickness (BT): thickness of the front edge of the board of the desk; drawer height (DRH): vertical distance from the lowest point below the drawer to the lowest point below the front edge; seat height (SH): vertical distance from floor to middle point of the front edge of the sitting surface.

and chairs made in accordance to the standard are still suitable to the current generation of Korean children.

Recently, height adjustable desks and chairs have become widespread in Korean schools to accommodate more children. However, these desks and chairs are discretely adjustable within the seven level ranges. According to KSG-2010, the desk and seat heights have fixed values at each level. However, the values of other dimensions (e.g., below desk height, seat depth, seat width, and backrest height) are not fixed at each level. Therefore, they range between a standard minimum value and maximum value. Thus, under the assumption that the children in every school are not quite different to each other, the degree of mismatch for the desk and seat heights in Korean primary schools is consistent, in contrast with the degree of mismatch for other dimensions.

Numerous studies have been conducted to survey the anthropometric characteristics of students and evaluate the anthropometric suitability of school furniture in several countries including Greece (Panagiotopoulou et al., 2004), Gaza strip (Agha, 2010), Chile (Castellucci et al., 2010), Saudi Arabia (Ramadan, 2011), United Arab Emirates (UAE) (Bendak et al., 2013), and Indonesia (Yanto et al., 2017). Remarkably, all of these studies reported that the height of the investigated school furniture did not match well. Panagiotopoulou et al. (2004) collected anthropometric data from 180 elementary school students (90 males and 90 females) aged from 7 to 12 years in the Thessaloniki region of Greece and analyzed the degree of mismatch to school furniture dimensions. Two types of desks and chairs were used, and the mismatch between the school furniture dimensions and the anthropometric data was analyzed by the graders. The results revealed that the seat and desk heights matched by 55–60% and 68.3–80%, respectively, which implies that up to a 45% mismatch was confirmed for the seat height. Agha (2010) measured the anthropometric dimensions of 600 children aged from 6 to 11 years old. He revealed that the mismatch for the seat and desk heights was approximately 100%. The author proposed a new design for lower and upper graders and analyzed the mismatch in a similar manner. The results revealed that the suggested heights of the seats and desks were suitable for more than half of the students. Castellucci et al. (2010) reported the degree of mismatch based on the anthropometric data collected from 195 students (94 males, 101 females) aged between 12 and 14. The seat height matched at least 14%, and the seat to desk height had a mismatch of approximately 100%. Ramadan (2011) conducted a mismatch study for height adjustable desk and chair with four levels. The anthropometric dimensions were measured from 124 students between the ages of 6 and 13, who are the first to sixth graders in Saudi Arabia. Accordingly, the highest degree of mismatch for the seat height was 92.8%, while the lowest was 7.3%. In the case of desk height, the maximum mismatch was 100%, while the minimum mismatch was 9.7%. Bendak et al. (2013) collected anthropometric data from 200 sixth graders (100 males and 100 females) in Dubai and the Sharjah region of the UAE to assess the classroom furniture dimensions in terms of ergonomics. The seat height matched 32% of the students of one school. In case of the other school, the seat height was not matched by any student. The seat to desk height in the two schools was matched by 20% and 26% of the students. In the case of the seat to desk clearance, 25% of the students touched the desk, which could limit the movement of their feet. Yanto et al. (2017) conducted a mismatch study of small and large types of Indonesian elementary school furniture for a population of 1146 students (male: 584, female: 562) aged between 6 and 12. The seat height mismatched 63.4% of the students at its lowest level and 99% at its highest level. The desk height mismatched 32.3% of the students at its lowest level and 99% at its highest level. To enhance the degree of matching, they proposed a new size system based on existing studies and demonstrated that it could achieve an increase in the degree of matching. However, such studies with regard to Korean primary school furniture are lacking. Several studies have reviewed ergonomically the present size systems of Korean school furniture. However, these studies are outdated and also did not carry out a quantitative analysis of the degree of matching (Chung and Park, 1986; Kim et al., 2006; Min, 2007).

This study conducted a mismatch analysis for the height systems of the desks and chairs used in Korean primary schools, based on the recent anthropometric data of Korean children. Moreover, this study proposed new height systems of desk and chair by adopting an algorithmic approach to increase the degree of matching.

2. Methods

2.1. Present height systems of desks and chairs in Korean primary schools

As mentioned above, the desk height at Korean primary schools can be adjusted up to seven levels (Fig. 1). According to KSG-2010, each level of the desk height (DH) is 400, 460, 520, 580, 640, 700, and