



## The ergonomic design of classroom furniture/computer work station for first graders in the elementary school

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### ABSTRACT

Children have been known to spend over 30% of their time at school. Most classroom activities involve sitting for long periods of time, with little or no breaks. Every effort should be made to ensure that young children do not experience back pain and other musculoskeletal disorders due to prolonged sitting on improperly designed classroom furniture. This paper proposes a methodology and guidelines for the design of ergonomic-oriented classroom furniture for first graders in the elementary school. The anthropometric measures of twenty first graders were used to develop regression equations for the furniture dimensions. The analysis of the relevant anthropometric measures such as stature, weight, body mass index (BMI), popliteal height, buttock-popliteal length, and hip breadth shows that stature and body mass index are important factors in the design of the classroom furniture. Adjustability was incorporated into the design in order to recommend the appropriate dimensions for the design of the classroom furniture. Based on the need to accommodate at least 90% of the population of first graders in the United States, this paper proposes furniture design dimensions for seat height (25.83–32.23 cm); seat depth (27.41–33.86 cm); seat width (17.91–23.29 cm); back rest (35.64–44.37 cm); arm rest (16.28–20.68 cm); and desk height (30.12–37.85 cm). This anthropometric analysis could be used to design ergonomic-oriented classroom furniture which would not only incorporate adjustability, but also improve the level of comfort for the intended users.

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### 1. Introduction

The use of furniture has been traced back to the Stone Age, during this period, the handy man carved out chairs and tables from stones and rocks. In the ancient civilization, the chair was one of the first types of furniture which was created in order to convey status, kingship and authority. Recent archeologists have discovered images of early furniture of ancient civilizations, especially in Ancient Egypt. The chair and table changed very little for several thousand years. The chair was typically pictured with a low seat and slightly reclining back as seen in the thrones and folding stools of the Egyptian Pharaohs (Schwartz et al., 1968).

Furniture designs continued to change over time, and by the mid 19th century, the influence of Industrial Revolution and mass production further enabled chairs and tables to be manufactured in large quantities, various sizes and forms (Fiell and Fiell, 1993). Anthropometry and ergonomics have been used to develop new

furniture forms which include task, or office desks and chairs by incorporating adjustability in order to accommodate a wider range of people and population. This is not only aimed at suiting a range of users, but also a range of postures (Lueder and Rice, 2007). Although adjustability has been a primary criterion in many designs, by the early 1960s, the value of adjustable furniture became an issue for debate in cases where there are more than two dimensions to adjust and users have difficulty in determining what fits best, which is often worsened by fatigue. By the early 1990s several manufacturers commenced the mass production of the modern furniture, especially chairs in different sizes and dimensions, based on reliance on the anthropometric data available to the designers (Cranz, 1998). Actual chair and desk dimensions are determined by measurements of the human body or anthropometric measurements. Anthropometric statistics may be gathered for mass produced furniture and designs are made based on these statistics.

Until recently, the design of school furniture for children has received little or no interest. The focus of ergonomic design of furniture has been traditionally based on the design of work furniture based on the anthropometry and biomechanics of the human body. Numerous researches investigated prolonged sitting

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in the work place and proposed design principles for chairs and desks, especially for the computer workstation (Cook and Kothiyal, 1998; Kumar, 1994; Villanueva et al., 1996; Burgess-Limerick et al., 1999). Although several ergonomic-oriented designs have been proposed for classroom furniture, this research intends to effectively recommend design guidelines for elementary school furniture by conducting an initial evaluation of the current furniture design in a particular school. Further analysis is then carried out to obtain the relevant design parameters and dimensions for the ergonomic-oriented classroom furniture based on the need to adequately accommodate at least 90% of the entire population of first graders in the United States.

### 1.1. Research motivation

Several elementary schools in United States and around the world, especially in developing countries are often faced with ergonomics-oriented problem of inability to match students with the available classroom furniture, desks or computer work stations (Panagiotopoulou et al., 2004; Gouvali and Boudolosa, 2006). Economical problems, budget constraints and lack of educational funding in several countries have also led to the problem of inadequate class room furniture in the elementary schools. Overcrowding and increase in student population is also one of the major problems facing numerous elementary schools (Rumberger, 2002; Ready et al., 2004). It should also be noted that anthropometric dimensions of children such as stature, weight, and body mass index (BMI) have increased over the years. This is due to changes in their standard of living, eating habits and lack of adequate exercise (Figueroa-Colon et al., 1997; Jung, 2005; Jackson-Leach and Lobstein, 2006). In the quest of designing effective ergonomic-centered classroom furniture for elementary school children, it will be very important to examine the design of the existing furniture in the school by performing general inspections. In this research, a local elementary school was selected and the existing furniture was examined based on the functional efficiency, ease of use, comfort, as well as health and safety (Pheasant, 1998). Examination of the current furniture in the elementary school revealed several design inadequacies such as the lack of cushion on the hardwood benches, and ergonomic concerns such as elongated benches and desks which do not have back rests. Other observed problems include overpopulation, where at least 6 children seated on a bench which was initially designed to seat only 3 or 4 children. In addition to this, several children complained of body aches and pains, which could be an indication of the ergonomic problems and design flaws identified during the inspection of the classroom furniture.

In order to provide a tangible justification for this study, 126 first graders, 66 boys and 60 girls (average age of 6.5 years) were randomly selected from three additional elementary schools and each student was given a questionnaire to complete. In order to protect the confidentiality of the investigation, the names of the children were not required on the questionnaire. The result obtained from the survey is similar to the survey conducted by Parcells et al. (1999). The survey revealed that the majority of the children (95%) attended classes more than three times a week and were seated in the classroom for more than four hours daily (93%). This shows that children spend a huge part of their school hours in the classroom. Storr-Paulsen and Aagaard-Hansen (1994) observed that 8 and 9 year old children often tend to sit for more than an hour within any given hour and half. According to Dillon (1976), nursery school children are seated for almost 40% of their time in the classroom. Sitting still for a long period of time can cause the blood to move more slowly. Blood pools in the larger veins of the legs, and clots may form leading to a medical condition known as

deep venous thrombosis (DVT). A large number of the students also claimed that their classroom furniture was not comfortable.

Additionally, approximately 58% of the children claimed to have been absent from school at least once in the last 4 weeks, primarily due to aches and pains. The rating of the severity of the aches and pains and how often the aches and pains occurred revealed that over 50% of the children experienced pains and aches in each of the following major areas of their body: neck area, low back, hips, buttocks, thighs, wrists, knees, hands, and the ankles. The degree of pain ranges from slight to unbearable, and often occur either everyday or sporadically. The result of this survey provided sufficient justification for further research based on the need to provide effective recommendations for the design of ergonomic-oriented classroom furniture for the first graders since school children have been found to often spend over 30% of their time at school (Linton et al., 1994).

## 2. Literature review

Several researchers have proposed numerous methodologies for various furniture designs in the past. Until recently, the design of school furniture for children has received little or no interest. The focus of ergonomic design of furniture has been traditionally based on the design of work furniture based on the anthropometry and biomechanics of the human body. In order to effectively design the classroom furniture for first graders, it is important to acquire the necessary background information which would be useful in proposing the experimental design methodology. Numerous researches investigated prolonged sitting in the work place and proposed design principles for chairs and desks, especially for the computer workstation (Cook and Kothiyal, 1998; Kumar, 1994; Burgess-Limerick et al., 1999).

Several research studies have shown that children often remain seated in the classroom for a considerable amount of time (Linton et al., 1994; Kumar, 1994). Prolonged sitting position and static posture in a forward bending manner have been found to be the major cause of low back pain (Salminen, 1984; Balague et al., 1988; Troussier et al., 1994). The problem of back pain is not limited to adults only, as studies have indicated that a huge number of school children have been reported to have back pains and neck pains (Niemi et al., 1997; Olsen et al., 1992). All over the world, increasing population of school children are now noted to be at severe risk of musculoskeletal injuries, postural stresses and strains which could occur due to increasing body size, prolonged sitting position and awkward postures (Evans et al., 1992; Mokdad and Al-Ansari, 2009). Awkward sitting position and posture puts extreme strain on the muscles, the ligaments and on lumbosacral joints (L5/S1) as well as other vertebral discs (Bendix, 1987; Brunswic, 1984). Mandal (1985) and Evans et al. (1992) argued that the occurrence of low back pain among school children could be linked to improper designs of school furniture.

The classroom furniture plays a very important role in the maintenance of good sitting position. Yeats (1997) indicated that the classroom furniture design serves a vital part in the long-term sitting posture of children. Unlike adults, proper sitting posture is found to be more important to children since sitting habits acquired at this stage may be extremely difficult to change later in life. Knight and Noyes (1999) identified the major functions of the school furniture in their research. Classroom furniture is known to provide support to the children when during class activities or when writing on the table. In addition to ensuring that distractions are minimized, comfortable classroom furniture have been noted to enhance effective learning, since the performances and behaviors of children can be easily monitored when seated. When designing classroom furniture, easy mobility of the children should be

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