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School Furniture Ergonomics in Prevention of Pupils' Poor Sitting Posture

Ergonomija školskog namještaja u prevenciji lošeg držanja tijela učenika

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ABSTRACT • *Physical and psychological disorders in school-age children, as a consequence of prolonged sitting in class, denote one of the alarming issues of the today's civilization. Scientific and professional literature pays great attention to the causes and phenomena of postural disorders caused by prolonged sitting, such as musculoskeletal disorders and back pain (MSD/BP). This phenomenon in children is increasingly correlated with school furniture design. School furniture, especially the chair and desk, are one of the most important factors to achieve the right body posture of pupils during school education. Despite this, not much attention is paid to the ergonomic requirements in furniture design, which are a prerequisite for good health, motivation improvement and learning of students. The objective of this paper is to show the impact of unmatched school furniture on the development of health problems and poor pupils' posture through a review of scientific literature and previous studies concerning the issue. The results include a comparison of ten papers published in the period from 2004 to 2017 in Finland, Greece, Croatia, Slovenia, Nigeria, Brazil, Iran, Belgium, United Kingdom and India. Various databases have been used, including Pub Med, Google Scholar, Medline, Hrčak, Dabar, Science Direct and Science Citation Index. By reviewing the previous research of the selected authors dealing with sitting posture in school, an insight was gained into the effect of inadequate body postures on pupils' health that could be used as guidance for new school furniture design.*

Key words: *school furniture; pupils; poor posture; ergonomics; design; health*

SAŽETAK • *Tjelesni i psihički poremećaji koji se pojavljuju u djece školske dobi kao posljedica dugotrajnog sjedenja na nastavi jedan su od alarmantnih problema današnje civilizacije. Znanstvena i stručna literatura veliku pozornost pridaju uzrocima i pojavama poremećaja držanja tijekom sjedenja, poput mišićno-koštanih smetnji i bolova u leđima (engl. MSD/BP). Ta se pojava u učenika sve više povezuje i s oblikovanjem školskog namještaja. Ergonomski oblikovan školski namještaj, poglavito stolice i stolovi, jedan su od važnih preduvjeta ispravnog držanja tijela učenika tijekom školske nastave. Usprkos tome, pri oblikovanju namještaja nedovoljno se uzimaju u obzir ergonomski zahtjevi kao uvjet dobrog zdravlja i unapređenja učeničke motivacije i uspješnog učenja. Cilj rada jest pokazati utjecaj neodgovarajućega školskog namještaja na pojavu zdravstvenih tegoba i lošeg držanja učenika, i to na temelju pregleda znanstvene literature i dosadašnjih istraživanja te problematike. Rezultati obuhvaćaju usporedbu deset objavljenih članaka u razdoblju 2004. – 2017., a ta su istraživanja provedena u Finskoj, Grčkoj,*

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Republici Hrvatskoj, Sloveniji, Nigeriji, Brazilu, Iranu, Belgiji, Velikoj Britaniji i Indiji. Korištene su različite baze podataka, uključujući Pub Med, Google znalac, Medline, Hrčak, Dabar, Science Direct i Science Citation Index. Proučavanjem dosadašnjih istraživanja izdvojenih autora koji su se bavili problematikom sjedenja u školi dobiven je uvid o utjecaju neodgovarajućeg položaja tijela na zdravlje učenika, što može poslužiti kao smjernica u oblikovanju novoga školskog namještaja.

Ključne riječi: *školski namještaj; učenici; loše držanje; ergonomija; oblikovanje namještaja; zdravlje*

1 INTRODUCTION
1. UVOD

In the last thirty years, the poor posture of pupils during school lessons has become one of the most important research issues for many scientists. Classroom furniture affects children's postures, comfort, health, and ability to learn. Research indicates that many school children sit in furniture that does not fit them properly. Further, school children, who sit in awkward postures for a long period of time, are prone to experiencing back and neck discomfort and other musculoskeletal symptoms that may worsen with time and even progress into adulthood (Hedge and Lueder, 2007). The causes of development of poor posture that lead to numerous health problems are more and more researched. It has been proved that postural deviations are becoming more frequent with children of school age and that they are triggered by various aspects of modern lifestyle (Gh *et al.*, 2012; Latalski *et al.*, 2013; Quka *et al.,* 2015). School furniture (here mainly school desks and chairs are taken into consideration), which should enable the pupils to work during classes, presents an important issue from the point of design. Optimal school furniture design means an interaction of a number of various factors including pedagogy, medicine, industrial design, architecture, economics, ecology, technical standards, ergonometric, construction and production (Domljan *et al*., 2002). In most of the so-called "traditional" schools, pupils spend 92 % of time in classrooms in static sitting, 3 % in dynamic sitting, only 3 % in active sitting or walking and 2 % in standing (Domljan *et al.*, 2010a). Due to spending a lot of hours sitting in classroom and learning at home, especially in front of computers and other IT devices, motoric abilities of pupils are decreased and due to incorrect sitting posture, their backbone becomes curved (Herga and Fošnarič, 2017). The correct use of ergonomics and functional dimensions is indispensable for maintaining good health, improving academic accomplishments, learning and being motivated (Odunaiya *et al.*, 2014).

Although it is very important to modify school desk and chair dimensions according to pupils' bodies, in most schools the school furniture designed by the manufacturers often does not follow neither standards nor anthropometric dimensions of different age groups (Domljan *et al.*, 2008). As a result, the chairs and desks become uncomfortable for pupils who take improper posture during lessons. For a long time, it has been recommended to primary schools to provide tables and chairs that pupils can easily adjust, move or carry (Bajbutović, 1983). The school furniture, that can be easily moved and carried, can help in improving education and health quality of pupils (Dhara *et al.*, 2009: Purwaningrum *et al.*, 2015).

The purpose of the appropriate and ergonomically designed school furniture is to ensure proper and comfortable sitting at the desk, under the terms set by the contemporary curriculum, during writing, reading, listening or tutoring, drawing, individual or team work, during computer use or any other activity (Domljan and Grbac, 2003). Ergonomic and fully-fitted furniture is available in the world market but, due to extremely high prices, many schools cannot afford such furniture (Domljan *et al.*, 2015). The price of ergonomically adjusted furniture also depends on higher resources needed for systematic and comprehensive research of school children anthropometric measures in individual schools or across the country and the objective is to define educational guidelines and design standards for furniture (Domljan and Grbac, 2003).

Classroom chairs connect pupils to the classroom environment and therefore are a key factor in providing adequate physical support to pupils' behavior during classes (***, 2008). Sitting ergonomics also has the same validity for the younger generation – there is no correct posture in which a pupil would not feel fatigue and there is no perfect chair where the body fatigue would not appear (Walch, 1985). Children come to sit in school chairs directly from the kindergartens, where there was no six to eight hours of continuous sitting at the (school) desk. Therefore, especially young pupils (age 6 to 10) need a possibility to realize a dynamic and active position of the body when sitting (which teachers should never explain as "fidgeting during a teaching hour"). In other words, furniture should be designed to meet the needs of students of the 21st century (***, 2008; Domljan *et al.*, 2010a).

The problem is even bigger due to the impact of numerous external factors: changes in the pedagogical system of education, the economic and public system of a state, the culture of behavior, the traditional attitude of "adults" in terms of changing the habits of school equipment, the needs of any individual curricula and schedule in higher education when one classroom can be transformed and occupied by different age groups (and anthropometric groups) of pupils, unconsciousness of most bureaucratic staff concerning the importance of carrying out the knowledge of sitting position, the anthropometric changes (secular changes in growth and development), which were already noticed some twenty years ago. In the last 50 years, the children height of the same age group has been increasing; the average height of children aged 7 to 10 increased by an average of 5-7 cm, while the height of

children aged 11 to 14 increased by as much as 7 to 10 cm. Furniture measurements in the classrooms should follow this data (Domljan *et al*., 2008).

The solutions in classroom sitting and furniture design should enable free movement and dynamics of the pupil's body while working. Chairs that can be quickly and easily moved and rotated are the essence of the modern design. The requirements for the school furniture construction are becoming more and more stringent, demanding distinctive stability and strength, in particular for desks and chairs, but also lightweight portability, collapsibility, and easy storing (Domljan and Grbac 2002; Vlaović *et al*. 2004; ***, 2008).

The aim of this paper is to determine and prove, by review of the scientific studies, how big is the impact of inadequate school furniture, primarily chairs and tables, on the health of pupils and their sitting postures during educational activities.

1.1 The consequences of mismatched dimensions of school furniture compared to anthropometric dimensions of pupils
1.1. Posljedice neusklađenosti dimenzija školskog namještaja s antropometrijskim značajkama učenika

Children of school age spend most of their school activities in sitting position, while writing, drawing, reading or listening to the teacher (Knight and Noyes, 1999). Problems that occur due to prolonged sitting arise mainly because children have to sit in classrooms around 5-10 hours in almost unvaried position as this is required by the norms (Grbac and Domljan, 2007). Muscle fatigue that occurs due to many hours of sitting results in back pain, postural discomfort, headache, pains in hands and feet (Murphy *et al.*, 2004). The professional literature pays much attention to postural disorders such as children bad posture as well as development of musculoskeletal disorders and back pain (MSD / BP) (Trevelyan and Legg, 2006; Domljan *et al.*, 2010b; Saes *et al.*, 2015; Yanto and Lu, 2016). Physical and psychological disorders that occur as a result of prolonged sitting are one of the pressing problems of today's civilization. Therefore, school furniture is an essential product for the education process but also for the preservation of health. However, still very little attention is paid to the issue of the appropriate ergonomic furniture design (Domljan *et al.*, 2015).

1.1.1 Musculoskeletal disorders and back pain
1.1.1. Mišićno-koštane smetnje i bol u leđima

Muscle and bone system syndromes, especially the occurrence of musculoskeletal disorders and back pain (MSD / BP), are an important issue of the contemporary society, being more accentuated in young people and school children (Jones and Macfarlane, 2005; Trevelyan and Legg, 2006; Domljan *et al.*, 2010b; Azabagić *et al.*, 2016). Musculoskeletal disorders are diseases affecting the tendons, muscles, joints and neck nerves, upper and lower back parts, chest, shoulders, arms, hands, hips, legs, knees, and feet (Murphy *et al.*, 2004). They mostly occur due to non-ergonomic environmental conditions. Neck pain is the most common musculoskeletal disorder in school children, followed by pain in the upper back, and pain in the lower back (Domljan *et al*, 2010b). A high prevalence of pain in the neck indicates the existence of a high level of cervical flexion as well as static and uncomfortable body posture of a child when sitting (Murphy *et al.*, 2002; Azuan *et al.*, 2010).

Although the back pain in children has been identified, this diagnosis was considered uncommon in the clinical practice in the past (Prebeg and Prebeg, 1985). However, studies showed that the pain in the lower back is an increasingly important and growing problem of school age groups and represents a serious health problem for the wider community (Burton *et al*., 2004). Low back pain includes the pain associated with problems in the lumbar region of the spine, discs between the vertebrae, the ligaments around the spine, the spinal column, and nerves, the lower back muscles, the internal organs of the pelvis and abdomen and/or the skin covering lumbar region. The back pain in children and adolescents, as well as in adults is rapidly increasing, mainly due to lifestyle changes and the evolutionary unsuitability to prolonged sitting (Watson *et al.*, 2002; Đapić *et al.*, 2013; Usman *et al.*, 2014), to the heavy school bags (Mačak- Hadžiomerović *et al.*, 2018), to less and less physical activity and other current problems. This is particularly evident when, after school and college school desks, the graduates start to work in offices and continue prolonged sitting at computer displays.

The prolonged sitting in a static posture, with the body tilted forward, was confirmed as the main cause of the low back pain. The discrepancy between the thigh length and the seat depth is also connected with this malaise, whereas the discrepancy between the elbow height in a sitting position and the desk height is associated with pain in the neck and shoulder (Ismaila *et al*., 2013).

1.1.2 Poor posture of school children
1.1.2. Loše držanje tijela u školske djece

In the last few years, the concern of parents, teachers and medical professionals about children posture has been growing, as the situation seems to be worse compared to previous generations (Jones and Macfarlane, 2005; Furian *et al.*, 2013). Based on the numerous studies carried out by different authors in the field of school-age children postural deviations, the obtained results show that the number of children with bad posture increases each year (Bajrić *et al.*, 2012). Non-ergonomic school furniture is often considered as one of the main causes of bad posture in adulthood. Improperly designed school desks and chairs, which are not harmonized with the anthropometric characteristics of children, have a negative impact on pupils' health (Domljan *et al.,* 2008; Kurban *et al.,* 2015).

Poor posture of preschool and school children is an indicator of health problems that can become very serious if not eliminated in time (Prebeg and Prebeg 1985; Burton *et al.*, 2004; Breithecker, 2005; Cardon *et al.*, 2007). However, very often these problems are not

detected in time. In fact, the wrong body posture is one of the initial deformity stages (Bridger and Whistance, 1998). Malfunctions, caused by incorrect posture, will be reflected first on the spine, and then on the other parts of the locomotor apparatus (Dačević and Jovović, 2013; Nikšić *et al.*, 2015a; Nikšić *et al.*, 2015b). There are no changes in the bone structure of the spine because of the poor posture, but insufficient muscle strength can lead to the presence of bad posture (Popovič, 1998). When speaking about the incorrect body posture, it is usually referred to a variety of functionally bad positions of the spine such as the kyphotic (distortion of the upper part of the spine), the lordotic (curvature of the spine inwards in the cervical and the lumbar part of the spine) or scoliotic (lateral curvature of the spine) bad postures (Prebeg and Prebeg, 1985; Paušić *et al.*, 2009; Kujundžić and Paušić, 2011).

1.2. Preventive ergonomic measures against poor posture of school children
1.2. Ergonomske mjere za prevenciju lošeg držanja tijela u školske djece

The prevention against the development of postural disorders is a crucial element for children health as the disorders, in their progression, may advance to deformities, with consequences that are hard to imagine. Their impact is very important for the general psychic and physical development of the child (Gojković and Milinković, 2013; Protić-Gava, 2015).

Preventive measures imply the use of kinesiotherapy activities to prevent the occurrence of a bad posture (Breithecker, 2000). If a poor posture is not recognized in the preschool period, there is a risk of progression and serious changes in the spine. For this reason, practical suggestions should be directed to educational preventive programs for children as well as for parents, educators, teachers, trainers and other professionals working with children, to practice the corrective exercises and workout in order to help the children muscular system to accompany their physical growth (Cardon *et al.*, 2007). In preventive kinesiotherapy activities, the emphasis is placed on improving all segments of the musculoskeletal system. The main focus of treatment is to improve all components of the anthropological status (improvement of muscle tissue, connective tissue, flexibility and posture). Preventive kinesiotherapy procedures are most commonly used with children in stages of development for the prevention of the musculoskeletal system functional disorders (deviations from the correct posture, flat feet, etc.) (Pavlović, 2012; Terzija, 2015).

1.2.1 "Correct" sitting at a school desk - Traditional versus "moving" sitting
1.2.1. „Pravilno" sjedenje u školskoj klupi – tradicionalno sjedenje nasuprot sjedenju „u pokretu"

Using of the furniture that promotes healthy and correct body posture is more important to children than adults because a bad habit of sitting may be established at the young age. Bad seating habits acquired in childhood are very difficult to change later in adolescence or adulthood. Correct sitting posture is an important factor for prevention of musculoskeletal disorder symptoms (Mandal, 1982; Aagard-Hansen and Storr-Paulsen, 1995; Hänninen and Koskelo, 2003; Murphy *et al.,* 2004; ***, 2005; Al-Saleh *et al.*, 2013).

In most schools around the world, the traditional practice is to encourage (compel to be more accurate) children to sit in the body position of the so called ''three right angles'' – back straight, head up and look forward, i.e. when sitting, children have to:

- sit straight, with the thighs at an angle of 90° to the spine – forming the right angle
- have knees bent at an angle of 90°, keeping their legs straight – forming the second right angle
- have legs bent at ankle at an angle of 90°, resting on the floor – forming the third right angle (***, 2005; Grbac and Domljan, 2007).

Regrettably, despite this practice and the efforts of teachers, from the biomechanical and physical-medicine point of view, no child can keep such sitting position of his/her body for more than a couple of seconds (Walch, 1985, Attinger *et al*., 1993; Domljan *et al.*, 2010a). Fatigue occurs, the body begins falling in an uncomfortable and dangerous spine curve for the body, which, after frequent repetition, can cause serious consequences for the child's health, as already mentioned above.

The efforts of doctors, orthopaedists, physiatrists and designers have shown that the only correct way is to enable pupils to make easy movements of their body while sitting in class, which would not interfere with teaching on the one hand, and on the other hand the students would subconsciously have the feeling that they are moving and that the muscles of the body are constantly in an active position (Mandal, 1982). It has been proven that with such type of sitting, known as "dynamic sitting", children have a better memory, they continue to be active in the teaching process and are ready to work without any fatigue or pain (Dordel and Breithecker, 2002; Cardon *et al.*, 2004; ***; 2005; Domljan *et al.*, 2010a).

New manuals and standards (***, 2005; Domljan *et al*., 2015; Yanto *et al.*, 2017), revised standards for school furniture dimensioning (Molenbroek *et al.*, 2003; EN 1729-1:2015) and the contemporary furniture manufacturers focus on the design of school furniture that allows students unrestrained movements of body during sitting.

The European standard EN 1729-1:2015, which defines the functional dimensions of school desks and chairs, is consistent with the anthropometric proportions of school-age children and prescribes seven classes of size (size marks). Moreover, apart from a traditionally designed chair, which can have a fixed seat angle forward or backward at an angle of maximum 5 degrees, they recommend the design of the seat with a double-tilt (the so called double slope seat), which moves forward-backward together with the lower part of the sitter's body and thus prevents the static position of the back, spine and lumbar muscles (Domljan *et al.*, 2015).

However, regardless of the above, in many countries of the world, the general problem of inadequate

pupils' sitting posture during their educational activities is still present. This paper seeks to highlight, through a comparative review of the results of previous scientific studies, the reasons of inadequate pupils' postures and the consequences arising therefrom.

2 MATERIALS AND METHODS
2. MATERIJALI I METODE

Electronic databases, published from the year 2004 to 2017, were searched by keywords: school furniture, poor posture and ergonomics. Out of a total of 68 articles found, there were ten scientific papers that explored the issues: design and ergonomics of school furniture, matching furniture dimensions with pupils' anthropometric dimensions, the behaviour of children sitting in the classroom, the consequences of poor sitting on pupils' health. Based on these articles, consequences were highlighted and solutions were proposed. In preparing the paper, different databases have been used, including Pub Med, Google Scholar, Medline, Hrčak, Dabar, Science Direct, and Science Citation Index.

3 RESULTS
3. REZULTATI

By studying previous research of the authors, who have dealt with the issue of sitting in school classes, an overview of impacts of inadequate body posture on the pupils' health was obtained. Potential consequences shown by the results are outlined in conclusions (Table 1).

The results include comparison of ten articles published in the period 2004 – 2017. The research published in the studies reviewed were carried out in Finland, Greece, Croatia, Slovenia, Nigeria, Brazil, Iran, Belgium, United Kingdom and India.

4 DISCUSSION AND CONCLUSION
4. RASPRAVA I ZAKLJUČAK

The above studies showed that furniture of the appropriate dimensions is not available to a large number of students both in Europe and in the world. In the last 50 years, the height of children of the same age group has been increasing; the average height of children aged 7 to 10 increased by an average of 5-7 cm, while the height of children of 11 to 14 years increased by 7 to 10 cm (Domljan *et al.*, 2008). Year after year, the height of children changes, while, on the other hand, the dimensions of the existing furniture remain the same, which can lead to poor posture and other health problems.

In many countries of Europe and the world, it has been proven that the existing standards to produce school furniture are outdated and should be revised because there is a significant degree of mismatch between the anthropometry of children and standard dimensions of school furniture (Yanto *et al.*, 2017). Guided by the fact that children spend in school most of the time during the day, it is important to use ergonomically designed furniture that suits their anthropometric sizes, and therefore it is necessary to adopt new standards for the production of school furniture. Due to the mismatch between the school furniture and the anthropometry of school children, they sit in an unfavorable posture most of the time during school classes, which leads to health problems (Saarni *et al.*, 2007). Panagiotopoulou *et al*. (2004) dealt with the same issues and their results proved that badly designed school furniture adversely affects the correct posture at sitting, which leads to a poor posture, especially while reading or writing.

Many authors deal with incorrect sitting and other factors that cause muscular and skeletal disorders of elementary school pupils caused by non-ergonomic sitting conditions, overweight of school bags, sedentary lifestyle, reduced physical activity, and lack of exercise. Kurban *et al*. (2015) outlined that non-ergonomic school furniture is one of the main causes of bad posture in adulthood. The use of furniture that does not meet the anthropometric characteristics of its users has a negative impact on health. Domljan *et al*. (2010a) used in their research video recordings as a method of observing the posture of children during classes, and owing to the mentioned research method, detected even 43 distinguishing postures of pupils during classes. Based on their research, the conclusion was that any new design of school furniture has to stimulate the dynamics of sitting and thus prevent the poor posture of pupils in performing their school tasks. In a study conducted by Koskelo *et al*. (2007), it was concluded that the adjustable school desks and chairs provide better seating and thus prevent poor posture, increase muscle strength and relieve pain. The mismatch between the measurements of school furniture and anthropometry of the student's body may be the reason for the presence of poor posture. It can be concluded that an ergonomic intervention is needed to redesign school furniture in order to prevent bad posture and other health disorders (Dhara *et al.*, 2009).

The scientific literature review has shown that in most schools in Europe and the world there is a large discrepancy between the anthropometric dimensions of students and the functional size of school furniture, which results in consequences outlined in this paper. Some of them are: fidgeting in classes, restless sitting in the desire to find a suitable comfortable posture, body aches, musculoskeletal disorders, lower back pain (MSD/LBP), headache and similar complaints. School furniture, especially the chairs and desks that are mostly manufactured and supplied to schools around the world, do not provide seating comfort and focus on work over a long period of time. Moreover, the application of ergonomic principles and anthropometric dimensions of school age children in the design is still not a guarantee that the children will sit comfortably and feel pleasure (Knight and Noyes, 1999, Domljan *et al*., 2010a). There is no simple answer to the question: "What kind of furnishings should be offered to the school classroom environment to make children

Table 1 Overview of research studies and outcomes
Tablica 1. Pregled istraživanja i rezultata

Citation *Referenca*	**Country** *Država*	**Main aims and purpose** *Glavni cilj i svrha*	**Materials and methods** / *Materijali i metode*	**Results** / *Rezultati*	**Conclusion** / *Zaključak*
Panagiotopoulou *et al.*, 2004 *Panagiotopoulou i sur., 2004.*	Greece *Grčka*	To compare pupils' dimensions to the dimension of school furniture in primary school and determine whether this type of furniture is well-designed and wheter it promotes good sitting posture at school by taking into account the dimensions of children. *Usporediti dimenzije učenika s dimenzijama školskog namještaja u osnovnoj školi i utvrditi je li današnji namještaj dobro dizajniran i promiče li ispravno sjedenje, uzimajući u obzir dimenzije učenika.*	A total of 180 pupils (90 boys and 90 girls), aged from 7 to 12 years, from three primary schools participated in the study. The anthropometric measures of pupils and furniture dimensions were compared in order to identify any mismatch between them. *Sudjelovalo je ukupno 180 učenika (90 dječaka i 90 djevojčica) u dobi od 7 do 12 godina iz tri osnovne škole. Antropometrijske mjere učenika i dimenzije namještaja uspoređivane su kako bi se utvrdila neusklađenost njihovih veličina.*	The data indicate a mismatch between the pupils' body dimensions and classroom furniture. The chairs are too high and too deep, and desks are also too high for the pupils. *Podatci pokazuju neusklađenost između tjelesnih mjera učenika i namještaja u učionici. Stolice su previsoke i preduboke, a stolovi su također previsoki za učenike.*	The obtained data indicate that this condition has negative effects on the sitting posture of the children especially when reading and writing. *Dobiveni podatci pokazuju da to stanje ima negativne učinke na položaj tijela učenika pri sjedenju, posebno pri čitanju i pisanju.*
Murphy *et al*., 2004 *Murphy i sur., 2004.*	Great Britain *Velika Britanija*	To identify the extent of back pain in schoolchildren, and establish the intensity, duration and frequency of exposure to physical risk factors present in schools. *Identificirati opseg bolova u leđima u školske djece i utvrditi njegov intenzitet, trajanje te učestalost izloženosti fizičkim čimbenicima rizika koji postoje u školama.*	The sitting postures of 66 children aged 11 – 14 years were recorded in usual lessons using the Portable Ergonomic Observation Method (PEO). *Istraživani su sjedeći položaji 66 učenika u dobi od 11 do 14 godina pri uobičajenim predavanjima, uz primjenu tzv. prijenosne ergonomske metode promatranja (PEO).*	Significant associations were found between flexed postures and low back pain. Static postures and neck and upper back pain were also associated. This study has implications for schools, designers and people in the field of work-related musculoskeletal disorders. *Pronađene su važne poveznice između tijela u savijenom položaju i bolova u donjem dijelu leđa. Pokazalo se također da su statički položaji povezani s bolovima u vratu i gornjem dijelu leđa. Ova studija ima utjecaj na škole, dizajnere i ljude koji se bave poremećajima mišićno-koštanih sustava povezanih s radom.*	Further research is required to examine the association between sitting posture and pain reported at different spinal locations. *Potrebna su dodatna istraživanja kako bi se ispitala povezanost položaja sjedenja s bolovima uočenim u različitim područjima kralježnice.*
Koskelo *et al.*, 2007 *Koskelo i sur., 2007.*	Finland *Finska*	To determine whether adjustable furniture affects the correction of certain irregularities and reduces muscle tension during sitting. *Utvrditi utječe li prilagodljivi namještaj na ispravljanje određenih nepravilnosti i smanjuje li napetost mišića tijekom sjedenja.*	15 (8 female and 7 male) high-school students and 15 anthropometrically and gender matched control students from neighbouring schools were observed in the period of 25 month. Comparison of the effect of adjustable school desks and chairs use (the intervention) and traditional non-adjustable use (the control condition) on sitting and standing postures, muscle strength, muscle tension, pain and learning. *U razdoblju od 25 mjeseci promatrano je 15 srednjoškolaca (8 učenica i 7 učenika) te 15 kontrolnih studenata odgovarajućeg spola i dimenzija iz susjednih škola. Uspoređeni su učinci korištenja prilagodljivih školskih stolova i stolica (intervencija) i tradicionalnoga, neprilagodljivog namještaja (kontrolni uvjeti) na sjedenje i stajanje, snagu i napetost mišića, bol i učenje.*	The results showed that trunk muscle strength increased in the intervention students whose muscle tension fell significantly in the trapezius and lumbar muscles during classes, whereas in control students' lumbar tension increased. *Rezultati su pokazali da se snaga mišića trupa u učenika intervencijske grupe povećala, a napetost u mišićima trapeza i lumbalnog zgloba tijekom nastave znatno se smanjila, dok se u kontrolnoj grupi učenika lumbalna napetost povećala.*	It is concluded that the adjustable school desks and chairs promoted better sitting and standing postures, increased muscle strength, alleviated pain and appeared to be associated with better overall academic marks. *Zaključeno je da su prilagodljivi školski stolovi i stolice pridonijeli ispravnom sjedenju i stajanju, povećali snagu mišića, ublažili bol te se pokazalo da su povezani s boljim ukupnim akademskim ocjenama.*

Cardon *et al.*, 2007 *Cardon i sur., 2007.*	Belgium *Belgija*	To evaluate the effects of combining a back-care program with a physical activity promotion program in elementary schoolchildren. *Procijeniti učinke kombiniranja programa preventivnih vježbi za leđa s programom promicanja tjelesne aktivnosti učenika u osnovnoj školi.*	In a pre-post design over two school years, back care knowledge, back care behavior, fear avoidance beliefs and back pain reports were evaluated in children (mean age (9.7±0.7) years) classified into three categories: those who received a back care and a physical activity promotion program (n=190), those who received only a back care program (n=193) and those in a control group (n=172). *Provedena je procjena unutar tri skupine promatrane djece (srednja starosna dob (9,7 ±0,7) godina) u trajanju dvije školske godine o stanju prije i poslije uvođenja preventivnih vježbi. Prva skupina je provodila vježbe za pravilno održavanje zdravih leđa uz program promoviranja fizičkih aktivnosti (n=190), druga skupina je samo provodila program održavanja zdravih leđa (n=193), dok je treća skupina bila kontrolna (n=172).*	The back-care program and the physical activity promotion program were both comprehensive ones. In both intervention groups, the scores for back care related knowledge and back care behavior were significantly higher than in the control group. *Oba programa, i program održavanja zdravih leđa i program promoviranja fizičke aktivnosti, vrlo su kompleksni. U obje interventne grupe rezultati znanja i pravilnog održavanja zdravlja leđa bili su znatno viši nego u kontrolnoj grupi.*	The present study findings favor the addition of a physical activity promotion program to a back-care program in elementary schools within the scope of early back pain prevention efforts. *Poruka studije glasi: u sklopu preveniranja pojave rane boli u leđima programu za zdravija leđa u osnovnim školama korisno je dodati i program promicanja tjelesne aktivnosti.*
Dhara *et al.*, 2009 *Dhara i sur., 2009.*	India *Indija*	To evaluate the degree of mismatch between the different dimensions of school furniture and anthropometric measures of school children. To evaluate health problems and the cause of postural disorders among school children while attending classes related to furniture. *Procijeniti stupanj neusklađenosti različitih dimenzija školskog namještaja i antropometrijskih mjera školske djece. Procijeniti zdravstvene probleme i uzroke posturalnih poremećaja školske djece tijekom pohađanja nastave koji su povezani s neadekvatnim namještajem.*	621 male schoolchildren (age range 10-15 years) were selected at random from 20 rural secondary schools. The subjective evaluation of health problems of school children was made by questionnaire technique. Postural analysis of the children during classwork was made by video-photographic method as well as direct observation method. *U 20 seoskih srednjih škola nasumično je odabran 621 školarac (dobni raspon 10-15 godina). Subjektivno ocjenjivanje zdravstvenih problema tih učenika obavljeno je tehnikom upitnika. Posturalna analiza djece tijekom nastave provedena je video-fotografskom metodom i metodom izravnog promatranja.*	It has been shown that children, due to a mismatch between school furniture and anthropometry, suffered from various ailments, and that often changed the position of the body during use of such furniture. *Dokazano je da su djeca zbog neusklađenosti školskog namještaja i svojih antropometrijskih značajki patila od različitih tegoba, pa su tijekom korištenja takvog namještaja često mijenjali položaj tijela.*	An ergonomic intervention is required to redesign the classroom furniture for school children of different age groups in order to reduce furniture-related health complaints. *Za redizajn školskog namještaja namijenjenoga različitim dobnim skupinama učenika potrebna je ergonomska intervencija kako bi se umanjili zdravstveni problemi koji su posljedica neodgovarajućeg namještaja.*
Domljan *et al.*, 2010 *Domljan i sur., 2010.*	Croatia *Hrvatska*	To identify main pupils' working postures and define them as notable criteria when designing school furniture for the future. *Prepoznati glavne radne položaje učenika i primijeniti ih kao uočene kriterije pri dizajniranju školskog namještaja u budućnosti.*	18 pupils from the 2nd to 8th grades in one elementary school in Zagreb. The method employed was video recording. Focus was primarily on the pupils' behavior at work, their movements and frequent activities while using tables and chairs in primary school classrooms. *Uzorak je činilo 18 učenika od 2. do 8. razreda jedne osnovne škole u Zagrebu. U istraživanju je primijenjena metoda videosnimanja. Fokus je ponajprije bio na ponašanju učenika pri radu, njihovim pokretima i čestim aktivnostima tijekom korištenja stolova i stolica u učionicama.*	43 characteristic postures and semi-postures, classified in four main groups were recorded as the evidence that children have different biomechanical postures while sitting and working in classrooms. *Promatrana 43 karakteristična položaja i međupoložaja, razvrstana u četiri glavne skupine, zabilježena su kao dokaz da djeca zauzimaju različite biomehaničke položaje tijela dok sjede i rade u učionicama.*	New school furniture design has to encourage sitting dynamics and fit psychological, ergonomic, physical, social and cognitive aspects of their users. *Novi dizajn školskog namještaja mora poticati dinamiku sjedenja i odgovarati psihološkim, ergonomskim, fizičkim, socijalnim i kognitivnim zahtjevima korisnika.*

Gh *et al.*, 2012 *Gh i sur., 2012.*	Iran *Iran*	To assess the presence of musculoskeletal deformities in lower extremities and to detect faulty posture in schoolchildren. *Procijeniti učestalost mišićno-koštanih deformiteta donjih ekstremiteta i otkriti neispravno držanje tijela u školske djece.*	172 schoolchildren aged 5-20 years, (66 boys and 106 girls) living in a rural region of Iran, were screened for deviations in the musculoskeletal system. The postural muscles including the hamstring and gastroc-soleus were examined for finding any shortness. *Pregledana su odstupanja u mišićno-koštanom sustavu 172 djece školske dobi od 5 do 20 godina (66 dječaka i 106 djevojčica) koji žive u ruralnoj regiji Irana. Ispitivani su posturalni mišići, uključujući mišiće stražnje lože i gastrocnemiusa soleusa, kako bi se uočila skraćenja tog mišića.*	The prevalence of cervical lordosis, FHP, thoracic kyphosis, and genu varum increased with age; in the case of genu valgum, the situation was reversed. *Prevalencija cervikalne lordoze, protruzije glave prema naprijed, torakalne kifoze i genu-varuma (O-noge) s godinama se povećavala; glede genu-valguma (X-noge), uočena je obrnuta situacija.*	More attention should be paid to implementing school-based screening programs aimed at early detecting of any musculoskeletal-related abnormalities and taking preventive steps to reduce their negative consequences. *Više pozornosti treba pridati provedbi školskih programa usmjerenih na rano otkrivanje svih vrsta anomalija mišićno-koštanog sustava i poduzimati preventivne mjere za smanjenje njihovih negativnih posljedica.*
Odunaiya *et al.*, 2014 *Odunaiya i sur., 2014.*	Nigeria *Nigerija*	To determine the ergonomic suitability of educational furniture in the lecture theatres. *Utvrditi ergonomsku prikladnost namještaja u predavaonicama obrazovnih ustanova.*	A total of 240 students (120 males and 120 females) at the University of Ibadan. *Ispitivanjem je obuhvaćeno ukupno 240 studenata (120 muškaraca i 120 žena) na Sveučilištu u Ibadanu.*	A significant difference in height between males and females was found, but no significant difference between other anthropometric variables was measured. *Utvrđena je značajna razlika u visini između muškaraca i žena, ali nije izmjerena značajna razlika među ostalim antropometrijskim varijablama.*	It is recommended that further studies, including more universities across a wide spectrum of society, should be performed to determine the effect of furniture on student health. *Preporučuju se daljnja istraživanja koja će uključiti više sveučilišta u širokom društvenom spektru kako bi se utvrdio učinak namještaja na zdravlje studenata.*
Saes *et al.*, 2015 *Saes i sur., 2015.*	Brazil *Brazil*	To estimate the adequacy of school desks and chairs regarding to students' anthropometric characteristics and its possible association with musculoskeletal pain in different parts of the body. *Procijeniti adekvatnost školskih stolova i stolica u smislu antropometrijskih karakteristika učenika i moguću povezanost neodgovarajućih stolova i stolica s mišićno-koštanim bolovima na različitim dijelovima tijela.*	A survey was carried out with 625 students and the furniture of 69 classrooms. The simplified Nordic Questionnaire for AOS* was used for the analysis of musculoskeletal symptoms, and parameters recommended by standard NBR 14006** were used to analyze furniture. *Provedeno je istraživanje sa 625 učenika i s namještajem u 69 učionica. Pojednostavnjeni Nordijski upitnik za AOS * upotrijebljen je za analizu mišićno-koštanih simptoma, a za analizu namještaja primijenjeni su parametri preporučeni standardom NBR 14006 **.*	This study has shown that 87.2 % of chairs and 45.6 % of desks were totally inadequate. *Istraživanje je pokazalo da je 87,2 % stolica i 45,6 % stolova bilo potpuno neprimjereno.*	It is recommended that public authorities be informed of this situation and requested that school furniture be urgently brought into line with prevailing legislation. *Preporučuje se obavještavanje javnih tijela o nalazima istraživanja i traženje da se školski namještaj hitno uskladi s važećim zakonodavstvom.*
Herga *et al.*, 2017 *Herga i sur., 2017.*	Slovenia *Slovenija*	To identify adequacy of school furniture dimensions with the help of anthropometric measurements. *Antropometrijskim mjerenjima utvrditi podudaranje dimenzija školskog namještaja sa standardima.*	192 pupils in the 6th and 7th grade (11 - 12-year-old) of primary schools in North-Eastern Slovenia. Measurements were made on certain pupils' anthropometric dimensions, including posture, popliteal height, buttock-popliteal length, elbow height sitting, thigh thickness, subscapular height and hip width. *Uzorak je obuhvatio 192 učenika u 6. i 7. razredu (11. – 12. godina) osnovnih škola sjeveroistočne Slovenije. Provedena su mjerenja određenih antropometrijskih dimenzija učenika, uključujući držanje, visinu potkoljenice, duljinu natkoljenice, visinu lakta, debljinu bedara, visinu supskapularnog mišića i širinu kukova.*	According to ISO 5971, size 6 corresponds to the pupil's height 173 - 184 cm. The results of anthropometrical measurements showed that pupils in the 6th grade were 152 cm high, and pupils in the 7th grade 160 cm. *Prema ISO 5971, veličina 6 odgovara visini učenika 173 – 184 cm. Rezultati antropometrijskih mjerenja pokazali su da su učenici u 6. razredu prosječno visoki 152 cm, a učenici u 7. razredu 160 cm.*	The research showed high mismatch of school furniture and anthropometrical dimensions, which may have serious consequences on the development of pupils. *Istraživanje je pokazalo visoku neusklađenost školskog namještaja i antropometrijskih mjera učenika, što može imati ozbiljne posljedice za njihov razvoj.*

* AOS – Analysis of Osteomuscular Symptoms; ** NBR – Brazilian Association of Technical Standards / * *AOS – analiza koštano-mišićnih simptoma; ** NBR – Brazilsko udruženje tehničkih standarda*

feel good?" The solution for a part of the problem is the production of ergonomically designed school furniture that complies with the relevant standards, the furniture appropriate to the size and body dimensions of different age students, which provides safety, comfort, improves quality of sitting and thus preserves students' health. There are, however, many other requirements related to the way of teaching, functional arrangement in school interiors, ecological and sustainable environment, social and psychological prerequisites and other designer parameters (Domljan *et al*., 2015).

This study provides an overview of one segment - what happens when anthropometric and ergonomic principles of furniture design are not followed, especially when the furniture does not comply with students' body dimensions. However, open issues still remain related to the requirements of school furniture design to provide children comfort, satisfaction and well-being in the school environment. In any case, the issue of adequate school furniture design is more complex than it seems, and necessarily involves an inter- and multi-disciplinary approach of experts from the areas of pedagogy and contemporary teaching methods, public health and school medicine, occupational therapy and physio-therapy, ergonomics and children anthropometry, architecture of educational facilities, interior design and product/furniture design, ecology and sustainable natural materials, technology and production, and others, as well as pupils, parents and teachers above all.

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