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Pupils' working postures in primary school classrooms

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Abstract

Background and Purpose: *Primary schoolchildren spend most of their time in classrooms seated in chairs in some manner, but sitting behavior and working postures of pupils are rarely observed as an important criterion in school furniture design. Yet, correctly designed workspace for school children is, among others, one of the most important key factors in regular development of all abilities of youths. This research focused primarily on the pupils' behavior at work, their movements and frequent activities during usage of tables and chairs in primary school classrooms, with the aim to identify main working postures and define them as notable criteria when designing school furniture for the future.*

Materials and Methods: *The research was conducted in one elementary school in Zagreb, Croatia, with 18 pupils from the 2nd to 8th grades. The method employed was video recording.*

Results: *Forty-three characteristic postures and semi-postures, classified in four main groups were recorded. The results showed that there are major differences in the subjects' behavior and in the habits of using the task chair and table with respect to age, gender, daytime, studied subjects, tasks and the teachers' behavior.*

Conclusions: *Design of school furniture must take into account the age and anthropometrics of the child as well as analysis of characteristic postures of the pupils as one of crucial design criteria, to be observed both in 3D and 2D system. New school furniture design has to encourage sitting dynamics and fits psychological, ergonomic, physical, social and cognitive aspects of their users.*

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INTRODUCTION

In Western cultures pupils have traditionally been seated in school chairs and tables as in the official »workplace«. Much development and research on working chairs has been concentrated on office chairs and vehicle seats, but little has been done in the field of school seating. Humans spend nowadays from 8 to 25 years in educational environments. Elementary school-aged children might spend approximately 30% of time on classroom activities (reading, writing, listening and looking at the teacher) *(1)*. Cardon *(2)* found out that in traditional school pupils spend about 92% of their working time in static sitting, 3% in dynamic sitting, 3% in active/walking, and 2% in standing position. When assumed for long periods of time, the standard chair-sitting posture, proposed even by international standards and guidelines *(3, 4)*, puts considerable stress on the lumbar spine *(5)*.

Above all factors present in the school environment (such as age, gender, physical and sports activities, television and computer usage, load carrying, food, psychosocial and other factors), inadequately designed school furniture, as well as anthropometric parameters and spinal (im)mobility, are frequently taken to be the reason of posture problems, back complains and sitting discomforts *(2, 6, 7)*.

Negative effects of poorly designed school furniture that result from required lumbar flexion and kyphotic sitting posture have been realized for a long time. These negative effects include anatomical, physiological and psychological maladaptations *(8)*. They can also be explained by biomechanical studies, showing that sitting with flexed trunk increases the spinal load, compared to standing, and showing that prolonged static sitting increases intradiscal pressure, resulting in decreased nutrition to the disc *(9)*. Considering that during the pre-school and school life time there are dramatic changes in humans physical, psychomotor, intellectual, cognitive, emotional and social development *(10)*, when body heights and proportions change rapidly *(11)*, school children are nowadays at special risk of suffering negative effects due to the prolonged periods spent seated at school and the formation of poor postural habits. Back pain caused by incorrect sitting habits has been identified as the most frequent cause of invalidity in office work *(12)*.

Results of surveys conducted in Croatia some 25 years ago *(10)* showed that approximately 30% of schoolchildren attending primary schools and as many as 45% of secondary schoolchildren exhibited first signs of bad sitting posture. A few years ago the BBC program confirmed the alarming data *(13)*, showing that, due to the unhealthy sitting posture, about 25% of the UK students complain of the back and neck pain, headache and loss of concentration. Yet research confirmed that non-ergonomical body posture in a prolonged sitting generates muscular pains and manifests different musculoskeletal disorders *(6)*. After a prolonged sitting the body becomes restless in the attempt to find a better position *(14)*. Unfortunately, in traditional schools restlessness is held to be unacceptable behavior which disturbs the teaching process in the classroom. It is not interpreted as the biological and biomechanical need of the body *(15)*. Human body is built to move about, not to remain still. There is not any prolonged position (sitting, standing, lying or other positions) of a body which could be comfortable and painless after a period of time. Also, there is not any perfectly designed working chair or table in which, after some time, body fatigue does not occur. Sitting in inappropriate designed school furniture can only intensify the fatigue.

However, inadequate or »non-ergonomically« designed school chairs and desks are only one side of the »sitting« hypothesis. Difference should be made between unsuitable and mismatched furniture on one hand and improper usage of the all kind of furniture on the other.

If we analyze the first part of the problem, most of the furniture found in classrooms is not designed or suited to the anthropometric dimensions of pupils. Many, if not most, pupils have been found to sit in mismatched chairs at desks that are not anthropometrically suitable *(1, 16, 17, 18, 19)*. The reasons are: a) rather old furniture, dimensioned according to old technical standards more than 20 years ago *(20)*; b) aggravated growth curve of the young in the last fifty years *(11, 21, 22, 23)*; c) traditional bureaucratic approach to the purchasing of classroom, only two sizes of the furniture are needed (lower for the younger and higher for older pupils) *(19)*; d) limited budget and suitability for the teaching process (*24*); unchange furniture design over the decade in which static sitting was improved *(20, 25)*; etc.

Even when the furniture fits in dimensions, pupils still sit »incorrectly« and change postures all the time *(26)*. Also, even if the furniture is designed according to the most recent ergonomic principles, the pupils complain of back pain and discomfort *(1)*. Since pupils do not automatically sit properly ergonomic furniture is provided, they need proper instructions in sitting behavior and body adjustments.

Finally, there is generaagreement that furniture design is one aspect of a multidimensional problem, *(1, 2, 7)*, and that the chairs have to allow »active« or »dynamic« sitting *(27, 28)*, which is regarded to be the major factor in the prevention of backache and damaged postures. A sitting child should always have the choice between sitting postures (e.g. relaxed or tense). In the project »Moving school« *(2)* innovative solutions in classrooms have been based on different approach to sitting posture. In such a school pupils have freedom to move, so it has been found that pupils sit statically only about 1% such sitting was mainly replaced by dynamic sitting (53%), standing (31%) and walking around (10%). Also, less backache was detected.

Therefore, chairs and desks used by children for considerable periods of time have to be designed and evaluated very carefully. School furniture has to fulfill a variety of different demands, such as anthropometric and ergonomic, orthopedic, ophthalmologic, pedagogic, educational, technical, economical and other design parameters.

Unfortunately, in addition to all these demands, behavior and working positions of elementary school pupils during their usual sessions are rarely observed as important criteria in design of school chairs and desks. Only a few studies investigated the effect of ergonomically designed school furniture on pupils' behavior and attitudes *(1, 8, 26, 29, 30)*. Also, their biomechanical (physical) needs are rarely taken into account.

Present research began with examination of pupils' behavior during schoolwork and identification of frequent behavioural patterns as well as characteristic body postures and movements during use of the task chair and the corresponding desk in their classrooms, with the aim to identify exact requirements and parameters related to future design of school furniture.

MATERIALS AND METHODS

Subjects

Eighteen pupils (12 male and 6 female) participated in the research. The research was carried out in one elementary school in Zagreb, Croatia, from May to June 2005. The subjects were selected randomly from every class from second to eight, except fourth. All subject were healthy pupils of average age in relation to grades from 7.5 to 14.5 years. None of the participants experienced symptoms of back pain, or exhibited any physical disabilities. None of the test subjects had participated in any previous studies.

The school was equipped with conventional and available school chairs and desks procured with the approval and control of the Croatian Ministry of Science, Education and Sports. The school was selected due to differences in teaching approach (private school with alternative teaching methods which combine teamwork and individual work); classroom equipment (one sized, old and low price furniture) and a working number of pupils in every classroom (working groups with 10 to 20 pupils).

Pupils were additionally measured to establish whether the measured types of furniture influenced the behavior of pupils while seated with respect to their anthropometric dimensions.

Permission

Permission was granted from the head teacher of the elementary school involved and both the parents and children who participated in the study. Participation in the study was voluntary and, after explanation of the investigation to the children, teachers and parents, the parents were sent a consent form with the option that their child can withdraw at any stage.

School furniture

Two types of furniture were found in the school, different in design characteristics of the base, materials and dimensions. Both types of chairs were of the similar height of seat, (type *a,* $h_a = 44$ cm; type *b*, $h_b = 45$ cm) classified as height mark 6 according to HRN ENV 1729-1:2003 *(31)*. Desks and chairs were arranged in the classrooms in form »U«. This enables video recording as the main method in this study.

Video recording

In every classroom pupils were video recorded during a single session (for 45 minutes). The lessons recorded included: Math, Croatian Language/Literature, Physics, Geography and Chemistry. The lessons were chosen to minimize disruption and ensure cooperation by teachers involved. Recording took place in both morning and early afternoon lessons, from 8.00 AM to 2.30 PM.

Sitting habits, characteristic behavior and body posture of subjects during classroom activities were digitally recorded using a corresponding recording system. The recording was conducted using a standard digital video camcorder (MV590 Canon, Canon Electronics Inc., Tokyo, Japan) fixed on a stand, positioned 3.5–5 meters away from subjects, depending on the object that was being recorded. Given the fact that the desks were arranged in a »U« shape the camera was placed in a manner to allow recording of three subjects at a time (male and female), of whom two (P1 and P2) were recorded from the back (frontal plane) and the third pupil (P3) from the side profile (lateral plane).

During the first ten minutes of the session the pupils were allowed to prepare themselves to be comfortably seated. The effective recording time was 30 minutes.

RESULTS

Video recording

The results of the video recording analysis showed significant differences in the behavior of subjects during the use of the chair and desk with respect to their age, gender, time of day, classroom subject, assigned tasks, and the behavior of the teacher. Furthermore, there was also a correlation between the anthropometric measurements of subjects, their behavior and the furniture used.

Forty-three characteristic movements, postures and interim postures were recorded for all subjects regardless of age and gender, furniture type or the time of recording (classification and supplement according to Schröder *(26)*). All movements and postures were separated in four main groups:

- Upper body movements (such as movements of the trunk, head, neck, shoulders or hands)
- Lower body movements (such as movements of upper leg parts, lower leg parts and feet)
- Whole body movements (e.g. walking or kneeling)
- Occasional movements and postures (not characteristic but recorded, e.g. hopping or extreme bending)

The analysis of the video recording showed that gender had no impact on the frequency of specific activities and movements. Female subjects were as dynamic as male subjects. However, the number of movements decreased significantly with age. Younger subjects (from 7.5 to 10.5 years of age) showed a notably stronger need for active participation in classroom activities. The youngest subjects (7.5 to 8 years of age, second graders) were not familiar with »sitting still« during 30 minutes of effective recording, even when they were recorded during the Math lesson. They spent as much as 87% of the time swinging their legs. Also, during the first 5 minutes of recording the subjects started getting up and walking around unrestrictedly. For this particular age group the other most common postures were positions in the third group (the whole body movements) like standing up and walking; kneeling on the seat with both knees; resting elbows and the whole trunk on the desk with buttocks supported by the backrest, or standing in front (or beside) the

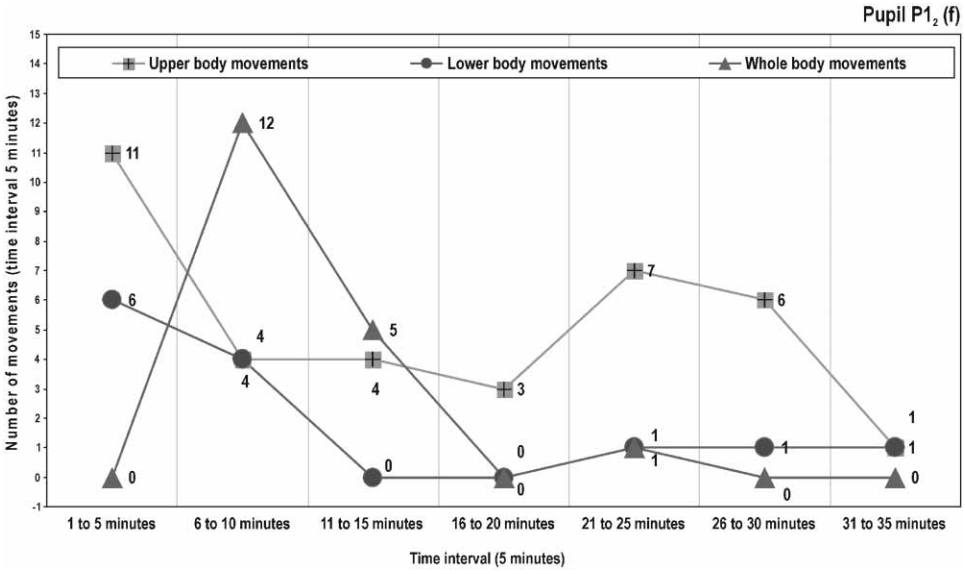

Figure 1. *The number of movements of P1$_2$ (f); Pupil 2, second grade, female; recorded during 35 minutes, within 5-minute intervals.*

chair, leaning on the desk. The most recorded positions from the first group of movements (upper body movements) were head supported by both hand; or with both elbows placed on the desktop (while listening or reading). In lower body movements (second group of movements) the most usual posture was crossed lower legs and feet under the desk. Leg swinging was almost constant and subjects hardly used the backrest.

The secondary graders performed simultaneous movements using their upper body which were connected with the movements of the lower body and coordinated movements of the whole body. Pupils do not sit still and conventional at all, they have different body positions and they move and change their body postures all the time. There was no time relevance to the number of movements but the recording showed that there was a normal physiological relation between all movements. The number of body movements of subject P1$_2$ (f) (Pupil 1, grade 2, female) performed in 5-minute intervals is shown in Figure 1.

The third grade pupils were recorded during the lesson of Croatian Language. They recorded less movement than second graders in the group of the whole body movements, but they had much more lower and upper body movements. They were swinging their legs almost all the time, but they also raised hands often while participating in the lesson.

Older pupils (from 11 to 14.5 years of age) exhibited longer time intervals between static sitting which, rele-

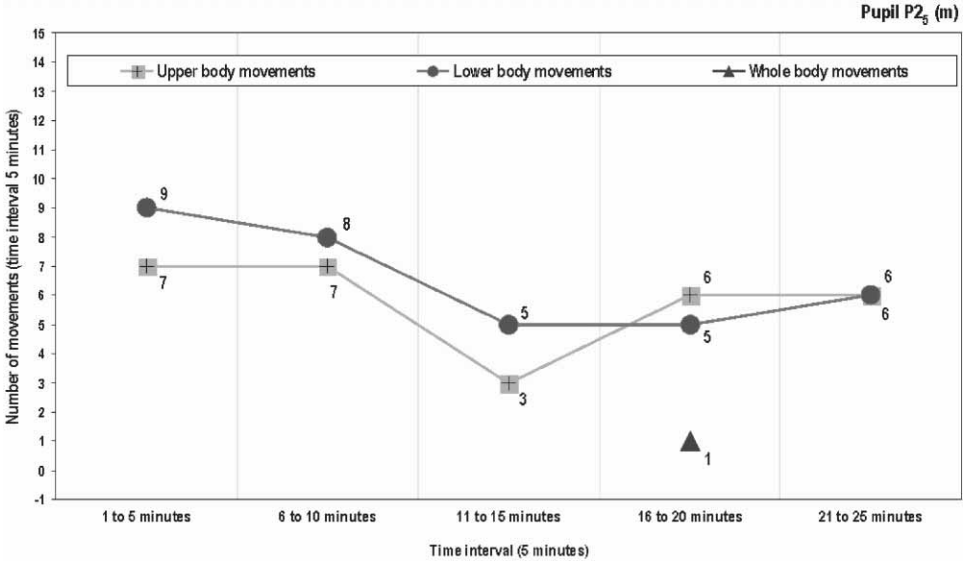

Figure 2. *The number of movements of P2$_5$ (m); Pupil 2, fifth grade, male; recorded during 25 minutes, in 5-minute intervals.*

Figure 3. *Some of the usual positions by seventh grade pupils while reading and writing.*

vant to the subject studied and gender, ranged on average from 17 to 20 minutes of sitting still during which only movement of the lower and upper parts of the body was recorded. Figure 2 shows the number of movements of pupil $P2_5$ (m) (Pupil 2, fifth grade, male) recorded during 30 minutes. The fifth grade pupils recorded only upper and lower body movements, with less of the whole body movements.

In higher grades, uniform movement of the trunk and head were recorded, i.e., s positions when head is supported by one (or two) hand and one (or both) elbow is placed on the top of a desk; or when trunk inclination and bending (backward and forward in the lateral plane) was related to the assigned task (average movement frequency = 2.5 minutes) and there was considerably less »fidgeting« unlike in younger subjects. There was a higher frequency of positions such as crossed upper legs (knees) under the desk; crossed lower legs and feet under the table or forward extension of legs.

In seventh and eight grades there were less swinging and the feet were usually kept close together and resting under the desk. Feet were flatted on the floor and the upper body bent-over from left to right in the frontal plane, or the trunk inclined and bent backward and forward in the lateral plane (Figure 3).

DISCUSSION

Results confirm that pupils generally do not know a »unique« and »correct« body posture during classroom activities. Gender has no impact on the frequency of specific movements, but there are major differences in subjects' postures and in the habits of using task chair and desk with respect to their age and anthropometrics, daytime, studied subjects, teachers' behavior and dimensions of the furniture used daily.

The youngest ones (second grade) know nothing about »sitting still« or »correct sitting posture«. Figure 4 shows the most usual state in the second grade classroom during one lesson. It was recorded in the sixth minute of the lesson. Pupils interrupted monotonous permanent positions to improve comfort. They changed position every 2 to 10 seconds, in both upper and lower body parts and even the whole body.

On the contrary, the older subjects were much more still than the youngest. The fifth graders had less movement with the whole body, but they showed mainly upper and lower body movement positions (Figure 2). The seventh and eight graders were even stiller than pupils in the fifth grade.

Figure 4. *The usual working positions of the secondary graders.*

Such differences in the recorded working positions and pupils' behavir can be explained by several main reasons which can also account for the posture of subjects, and indicate that the design of school furniture is only one of the several factors of the interdisciplinary problem:

Age: During the first 2–3 years of school life, pupils (from 6.5 to 7.5 years of age) are not physiologically prepared to adopt organized work rules. Their bodies still require free movement. They are much more restless and frequently change their body positions (Figure 4). With growing up and gradual learning of the sitting habits pupils are literally trained in the »appropriate« sitting posture. Consequently, in higher grades there is no more need for free movements. Static sitting posture becomes apparent (Figure 3). It could be the main reason why the older pupils have much more LBP/MSD problems than younger graders, as detected in other studies *(2, 7)*. From culturological approach, as we live in the Western society, any unexpected movement and body posture (such as lying with both shoulders, elbows and head on the work surface; posture with forward extension of legs, etc.) is still interpreted as rude and unacceptable behavior and may thwart teachers' to keep the class quiet.

Design of furniture: The reason why pupils are stiller with ags can be explained with mismatch in furniture and pupils' anthropometric dimensions. If furniture allows free movements and restlessness, pupils act accordingly. For example, younger pupils are smaller in their height than the older ones, so shorter pupils seated on high chairs have swinging legs, mostly because they could not touch the floor. In our study we only one height of the furniture (especially chairs) in the whole school. According to standards (*31*), the height of the chair is defined by comparison with the popliteal height (or shin height) measured in sitting position. A chair that was too high (seat height h = 44/45 cm) in relation to the popliteal height (F), of second graders (mean F_2 = 37.41 cm), third graders (mean F_3 = 38.59 cm), and even fifth graders (mean F_5 = 42.32 cm) enabled constant swinging of the lower part of the legs because their feet could not touch the floor. On the contrary, the dimension of the same chairs were suitable and much more matched to the popliteal height of older subjects, where the seventh grade boys (mean F_{7m} = 46.19 cm) and girls (F_{7f} = 44.21 cm), or eight grade boys (mean F_{8m} = 46.26 cm) and girls (mean F_{8f} = 44.32 cm) could put the feet on the floor (Figure 3).

The time of recording: According to the results of video recording, pupils were notably quieter and less active during morning lessons, while in the afternoon they would lie on top of their desks (especially the younger pupils) or were more restless. Also, in the first ten minutes of the video recording pupils were more physically active, so the numbers of movements increased. From the 11^{th} to 15^{th} minute of recording all subjects in all recorded classes were stiller and the body movements reduced. They got their tasks, and participated in the lesson (writing or reading). Therefore they recorded only lower or upper body movements, or even occasionally recorded movements such as extreme bending (while copying from another pupil or whispering). As the end of the lesson approached, they finished the tasks and again started to be physically active. The reasons might be either they were physically tired or they were psychically free of teacher's tasks.

The subject being taught and learned also affected the posture of pupils. For example, proactive behavior during classroom activities and verbal teamwork implied more physical engagement and hand rising with pupils even getting out of their seats. Group work for written tasks requires more pronounced bending of the body over the desk and towards other pupils in the group.

CONCLUSION

Contemporary humans spend one third of their lifetime sitting, of which almost 10.000 hours in classrooms. The purpose of modern designed school furniture is to provide proper and comfortable seating at matching, under various conditions determined by contemporary curricula, during writing, reading, listening and watching the teacher, modeling or drawing, in a team- or individual work, during use of a computer or any other similar activity. In addition to meeting basic requirements (mobility, portability, maintainability, functional adjustability, etc., with satisfactory durability, strength and safety) contemporary furniture has to comply with fundamental ergonomic and anthropometric principles, as they have to provide dynamic and active sitting during different lessons.

According to the results it can be concluded that design of school furniture must take into account the analysis of characteristic postures of pupils as one of the crucial design criteria to be observed not only in two-dimensional but in three-dimensional system which implies a study of the biomechanical movement of a pupil's body. The use of static 2D anthropometric measurements in resolving dynamic 3D problems and exclusion of biomechanical parameters of human movements is not a proper approach to design. Unfortunately, in the absence of new findings, the basic starting points and guidelines for chair and desk design are still international standards and static anthropometry *(3, 4, 32)*. They clearly recommend, even by sketches, that one should sit with a 90° flexion of the hipjoint and a concavity in the small of the back. As it has been seen in the research, no normal young person is able to sit in this posture while working. The standards are relevant guidelines and should be considered only as dimensional recommendations.

Present research confirms that to date static and rigid design of school chairs and desks cannot be the support to an active and restless young person of normal psychophysical growth and development. Also, the research showed that regardless of the modern teaching process, the school management could only choose conventionally designed furniture or the furniture that is financially acceptable to the government due to the bureaucratic system of procurement of equipment. Consequently, pupils use static and outdated chairs and desks.

The research on furniture influence on youths' posture has shown that, irrespective of its design, both the awareness of healthy sitting and the practices employed are of equal importance and value. The point is in maintaining the body dynamics over prolonged sitting. A child must be given a wider choice of body positions. Ergonomically designed furniture that matches body proportions and size is of great help in achieving this goal. Teaching about correct sitting must start already during schooling, so that future sitting issues in the office chair are minimized. Such approach as in this study – considering not only to consider static body positions statistically evaluated but focusing on quantitative and qualitative children working postures and their sitting behavior, offers new criteria in school furniture design. Result of the application of the above-mentioned parameters in design process must be a product that enables dynamic and active interaction with pupils, which will ultimately lead to the final goal – the healthy and comprehensive growth and development of young people.

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