Computer ergonomic of elementary school students

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Abstract. *Software component of the computer system is in focus of the user, explorer and legislation. It implies that the hardware component exists and works without flaws. Trend of the new technological solutions in shape of laptops, PDAs, smart phones, tablets, game consoles and other miniature but highly sophisticated products has progressive hardware base in background, but the users are mostly fascinated by the software interface and capabilities. The question of the compliance of the computers, hardware of the above listed devices and other gadgets with the ergonomic issues of their use is somewhat neglected. And this question is especially sensitive during intensive child development. The paper deals with the ergonomic issues, problems and recommendations for working on computer for elementary school students in grades 7 and 8. Research results of ergonomic conditions and habits of students are presented and elaborated. The study was conducted in several elementary schools in County of Karlovac, Croatia*.

Keywords: computer ergonomic, primary education

1 Introduction

Using the computer is a part of everyday life for most employees, students and parents. Parents use computers for work, children use them in school during the computer science classes, and more over, both use them at home for various activities.

More often than not, the working surfaces, computers and the working environment are not designed in such a way so as to preserve the health of the user. School computer labs and home offices where students work on the computers are no exception to this rule. The reasons for this are mainly financial difficulties of the educational facilities or parents themselves, as well as the ignorance of parents and people equipping those spaces. Thus, it is the responsibility of the teachers using the computer classroom to be well acquainted with the basic ergonomic principles of working on the computer as well as the specific issues related to the students' age.

It is also very important to apply these principles in practice (of equipping/reconstructing the classrooms), and disseminate them, as much as possible, among students and colleagues who will one day be responsible for equipping their own workspace and the workspace for their children. This research had two goals. The first was to examine to which degree the computer equipment and the habits of the students (working at home) are in compliance with ergonomic principles. The second goal was to determine whether there are any health issues (at the students age) which could be a sign of inadequate usage of the computer or computer equipment and workspace. The set goals are examined using a questionnaire form which was used in order to test the feasibility of conducting a wider research on a representative sample.

2 Health risks for students

Ergonomics is a scientific discipline which deals with health risks that result from (in)correct design of tools. Ergonomics is concerned with understanding of interactions among humans and their workplace, with the goal of harmonizing and optimizing the working conditions with the human physical and mental capacities, in order to preserve health and maintain a satisfactory level of productivity [1]. According to IEA ergonomics is defined as the "...discipline concerned with the fundamental understanding of interactions among humans and other elements of a system..." [2].

If the ergonomic principles are not adhered to, a person is exposed to a number of risk factors, as confirmed in numerous research papers [3-5], lab tests, and illness histories [6] and which can

ultimately result in muscle and skeletal system diseases.

The most common health issues associated with frequent and long-term usage of the computer are: nerve compression and inflammation in the area of the hand as well as disorders of the muscle and skeletal structure (lower back pain) and problems with vision [3-5], [7-12]. Besides these problems, the level of comfort while using the computer can also affect the user's mood and the level of productivity.

A negative correspondence between the quality of the computer equipment and the number of working units has been observed in schools. This means that educational institutions with limited financial resources are forced to sacrifice the quality of the equipment in order to provide the required number of computers [13]. The authors of this text share the same experience.

The traditional QWERTY(Z) keyboards (the name comes from the first six keys appearing in the top letter row of the keyboard), are more commonly used then other more expensive, so called "alternative", ergonomic keyboards. According to Amel and Kumar [8], the principal reasons for this may be the initial cost of the product, as well as resistance towards changes. The authors also emphasize that lately we are witnessing some instant ergonomic solutions (such as ergonomic keyboards with wrist rest pad) but such products only conceal the need for a more sophisticated design that would solve a wider range of problems associated with using the keyboard.

Most computer classrooms have the same lighting system as other classrooms in the school. Sheddy et al. [14] have concluded, from their study aimed to determine the recommended level of illumination surrounding the computer monitor, that the said level of ambient light should be equal or slightly lower than that of the central working area. Where this criterion isn't met, there is a possibility of unpleasant glare, resulting in eye strain.

When it comes to children using the computer, the most vulnerable and most sensitive organ are the eyes. Whilst concentrating hard on a certain activity on the screen, children stare at the screen constantly, causing their eyes to dry. It has been scientifically proven that staring at the monitor from a close distance, which children are known to do often, can lead to myopia because the visual system in the child's eye is calibrated according to that distance, as if that was the normal distance [15].

Computers are mostly built for adults, not for children. This makes children unable to use computers properly and safely without some essential changes in the arrangement and size of the elements of the workstation [15]. Computers are often brought to schools with minimal or no adjustment of the furniture (they are installed on the desks already in classrooms). According to recent research, the design of children's workspace (as much as 50 years old) is not suitable for modern elementary school generations [9]. Domljan, Grbac and Hanina [16] reported the results of research carried out in Zagreb elementary schools, confirming that chairs are not (ergonomically) suitable for children, and that no part of the measured population are using chairs of appropriate dimensions.

The legal framework regulating the ergonomic issues in Croatia is represented by:

- Directive 90/270/EEC regarding the minimal requirements for sa`fety and health while using the computer, representing the fifth individual guideline from the 16th Article Guidelines 89/391/EEC. The guideline defines the minimal health and safety requirements when using the computer. It defines the obligation of the employer to carry out a risk assessment of the computer working area, and to take appropriate measures to remedy identified deficiencies and to educate employees about safety measures at work.
- Workplace Safety Law (NN 59/96; 94/96 and 114/03) which introduces measures to encourage the improvement of safety and health of the workers, to prevent occupational injuries, occupational diseases and other work-related diseases, and to increase the safety of the working environment. The minister of labor, in coordination with the representatives of employers and unions, through the decree level act, sets the basic and special rules of safety at work.
- Regulation on safety and health at work while using a computer (NN 69/05) of July 6th 2005 establishes the requirements for safety and health at work while using a computer [17].

3 Ergonomic issues

3.1 Workplace ergonomics

One of the most common mistakes people make when purchasing a computer is neglecting those computer components which they are in constant contact with (monitor, keyboard and mouse). These components are considered to be a "necessary evil", and are chosen according to their cost. Ergonomically better solution requires their proper selection and installation in the operating area.

Working chair: The user should have a stable chair with the ability to adjust the height of the seat and back as well as the angle of the backrest. The front edge of the seat should be round and slightly curved downwards, so as not to slow the circulation in the upper thighs, which is responsible for relaxing pelvic joints (which can become strained during prolonged periods of sitting).

Working desk: The working surface should provide optimal working conditions. The selection of

color and adequate quality of the working surface is very important since this is what prevents reflection of direct and indirect ambient light. The space available on the working surface should be large enough to hold all the accessories needed to perform the activity. In the absence of sufficient space, one can use various tools such as monitor stands allowing rotation, document holders, keyboard and mouse holders, keyboard trays etc. [18]. It is important to note that the height differential between the seat and that of the working surface (which should, for most "westerners" be between 270 and 300 mm) is more important than the height of the working surface itself. [18].

3.2 Ergonomics of computer IO components

Using the monitors: When using the monitors, the eyes, which are by far the most sensitive sensory organ, are exposed to intense strain. The most common symptoms of Computer Vision Syndrome – CVS [7] are [18]:

a) painful eye irritation ("burning"), often with tearing, redness and conjunctivitis,
b) double vision,
c) headaches,
d) reduced ability of accommodation and convergence,
e) decreased visual acuity, contrast sensitivity and perception speed.

The user must have the ability to easily manage display brightness and contrast between the characters and the background, in order to achieve an image that is easily readable under different levels of illumination of the workspace. Excessive changes in the brightness of the screen as well as the environment cause constant vision adjustments, which causes fatigue. The upper edge of the screen should be at the eye level of the user, so that the screen is viewed at an angle of 15° downwards, placed directly in front of the person at a distance of approximately 75 cm from the user's eyes [19]. The most important thing is to move the eyes away from the screen as often as possible (for instance, by looking into the distance through a window, or fixing the gaze on a distant object in the room) so the eyes could relax. Present-day high quality LCD monitors have a high viewing angle, low response time, and they cause less strain to the eyes in comparison to CRT monitors. When choosing a monitor, the height and tilt adjustment are the most important considerations.

Keyboard: The size of the keys, their hardness and sensitivity to pressure vary from one model to the next. While typing, the elbows should be in the same height as the middle row of keys on the keyboard. The flatness of the wrist is the reason why "many ergonomists today recommend keyboards with the basic position not higher than 30 mm above the working desk" [18]. This mode of work significantly decreases the possibility of Carpal Tunnel Syndrome – CTS [20].

Mouse: The user should be able to hold the mouse comfortably in hand without straining the palm or changing the position of his/hers fingers while using the mouse. The best position for the mouse is on the side of the front edge of the keyboard with enough room for free movement. It is not advisable to position the mouse away from the keyboard or on a different height then the keyboard (such as when the keyboard is in a separate keyboard tray) because this leads to unnecessary hand and back exertion. The keyboard and the mouse should be made from materials which prevent the occurrence of glare or the reflection of ambient light, thus reducing the eye strain.

Printer: In today's computer classroom or office, the pin printers are mostly out of use since they are slow, make a lot of noise and have a low readability of the print. Instead, laser and ink-jet printers are used. Ergonomically speaking, the problem with the laser printers is excessive heat emission [21] and ionization of the air, but to most users this is irrelevant as long as the printer is not used too often.

3.3 Ergonomics of laptops

The primary purpose of laptops is the possibility of occasionally working outside of ones office/home, usually no longer than the duration of the battery. Increased offer and demand led to a decrease of laptop prices, essentially lowering them to match the prices of PCs, while their performances can accommodate all users who share a lower standard in regards to the graphics, seeing as it is the weakest component of the laptop in comparison to a PC. This affected many users that normally wouldn't buy a laptop, who now opt for it because of its mobility, size and quiet mode of operation. This is especially true for families with multiple users, who, after buying their first PC with stronger possibilities, often opt for any kind of a laptop as their second computer.

New forms of even smaller laptops are developed daily and even smartphones started to take on many characteristics of classic laptops/PCs. Modern trend of minimization is also apparent in the increased supply of miniature laptops – netbooks, nettop computers (and PDA devices) that literally fit in one's pocket or a small handbag. The ergonomics of these devices is very poor since their keyboard (if it exists), and monitor have been reduced to a size which makes them very uncomfortable to work on.

Laptop ergonomics is far from ideal – the keyboard and screen are attached to a small box producing a lot of heat, with no height adjustment options. The space between the keyboard and the screen is too small, and the dimensions of the screen are usually too small. The resolution is often set too high using the so called "native resolution" which

makes the details tiny, thus straining the eyes. Lowering the resolution results in bigger icons and letters but the image becomes blurry. It is often very difficult to find a comfortable position when using a laptop, which in return, creates the need to make frequent breaks for stretching. While using a laptop positioned on a table, with inadequate combination of the table and chair height (without the possibility to adjust the height) the body and the head unconsciously lean forward due to the low position of the screen. This, in the long run, leads to neck pain and back pain. This problem can easily be solved by using a separate mouse and keyboard as well as an extra screen, thus gaining a table computer with a smaller casing. Most laptops can be used with docking stations which make the usage of the before mentioned combination easier, since they provide a simplified way of switching on and off of the peripheral units.

The worst position for a laptop is holding it in one's lap – the lack of support for the palms puts unnecessary strain to the hands, and the ventilation system (being at the bottom) overheats. When it is absolutely necessary to use the laptop in this position, a solid pad should be inserted between the user's body and the computer so that the hands have a resting pad, and also to help the ventilation system work properly.

3.4 Workspace ergonomics

Because the working environment affects our ability to work, it is very important to make the environment as suitable for work as possible. We can distinguish several environment related issues [21].

Lighting: It is important to have lighting appropriate for the type of work being performed. The eye adapts slowly to rapid changes of light and needs time to adapt to a certain level of light, which can lead to eyestrain. In most cases the artificial light is stronger and better than natural light since it can be regulated and focused on certain areas. Natural light in a classroom can present a problem. If a large classroom is filled with natural light coming from outside, an extensive inner lighting is needed to achieve balance in the whole classroom. Ambient light can create a problem with screens if it overpowers their light thus making them lose contrast.

Due to great differences in the intensity of natural light, it is usually best to place the monitor perpendicular to the window. his puts the windows outside of the visual field of the user and reduces the possibility of external light reflection. It is best to have multiple sources of light: general diffuse light, and stronger local ones for lighting the documents on the working surface.

Temperature: Environment temperature has a strong impact on the productivity and the mood of the workers. Excessive temperature can lead to increased sweating and lethargy, and during the winter months it can lead to dry air and reduced air humidity, which should be at 40-60% [21]. This can, in return, cause dry throat and dry eyes. Decreased temperature can also cause problems such as lowered ability to concentrate, since lower body temperature causes all bodily functions to slow down. This is especially evident with sitting jobs which do not require a lot of physical activity from workers. Advised temperature during the winter period is from 18 to 24˚C and 20 to 26˚C in the summer [21].

Humidity: Humidity in closed spaces is often below the minimal limit of 5-26g/m^3 [21]. Dry air causes the skin to dry which affects children more then adults. People suffering from asthma or allergies also may experience problems because of dry air. Using air humidifiers can help with this problem.

Ventilation and venting: Millions of people work in buildings with installed heating system, ventilation, and air conditioners. Improper ventilation leads to increased concentration of carbon dioxide, which can lead to headaches, drowsiness, dry throat and irritation of the eyes and nose. This is especially important in offices with copy machines, which must have enough ventilation shafts to increase the air flow.

Noise: Noise is an unnerving phenomenon that rarely reaches the level that would actually damage health (hearing), but can have a negative effect on work productivity and (dis)satisfaction of the workers, taking their attention away from their duties. The sources of noise can be: pin printers, system unit fans, hard disk drive mechanisms and keyboards [21], as well as the air conditioning units and other devices.

We mustn't ignore the negative effect of the electricity of the computer equipment, that is, the air ionization and dust in the classrooms which can act as allergens. Even though wireless local networks (WLAN) have not been proven to have a harmful radiation themselves, their radiation in combination with all other emissions we are surrounded by, could potentially be very harmful for us (this is, of course, very difficult to prove). So, in order to avoid this, it is better to use wired connection wherever possible and turn off or localize the wireless connection thus minimizing its usage.

3.5 Ergonomics of human interaction with the working environment

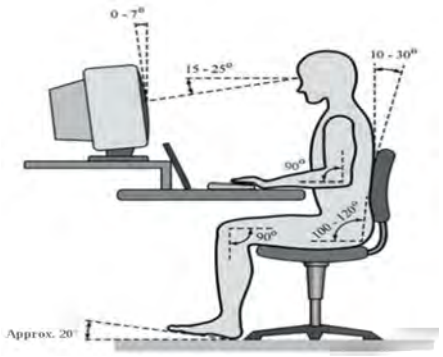
Posture: Picture 1 shows the recommended body posture while using a computer.

Legs: Feet should be firmly on the floor or on a foot pad instead of dangling from the chair, with a knee angle slightly above 90° (upper leg should be parallel with the floor). It is always recommended to leave plenty of room under the table and remove all unnecessary objects to avoid hindering leg movement.

Back: he seat and the back of the chair should support the entire body, without it leaning forward or backwards. If the chair has an adjustment system for

the lower back, it should be adjusted so as to follow the natural curve of the spine.

Shoulders and elbows: Shoulders should be relaxed (neither lowered nor raised), and elbows should be in a comfortable position in the same level as the middle row of the keyboard.



Picture 1. Recommended correlation of the human body and the working environment while using a computer [22]

Forearms and hands: While typing and using the mouse, wrists and hands mustn't lean on the working surface. Additionally, hands should regularly rest on the working surface during the breaks from typing. It is important to ensure that wrists do not bend up or down or to either side. Forearms should be parallel to the working surface at all times.

Head: The head should have a balanced position facing forward and mildly downward depending on the position and the height of the monitor. Positioning the monitor low should be avoided because it causes the person to lean forward, thus bending the head and the back.

4 The research

4.1 Sample and methodology

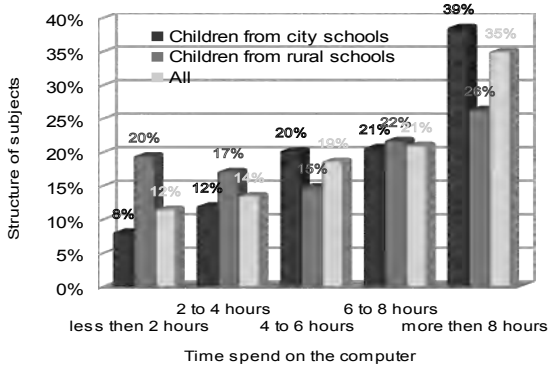
The research was conducted at the beginning of February in the year 2011 in three rural and three city schools in Karlovac County on 294 primary school students in grades seventh and eight, which represents 12% of their overall population (2379). The sample is comprised of 148 girls and 146 boys, of which 174 were seventh grade students and 120 were eight grade students.

The tool used to conduct the research was a questionnaire form with 30 questions related to ergonomic aspects of the students' usage of computers. The questions in the questionnaire were multiple choice questions and yes/no answer questions. The students filled the questionnaire forms voluntarily with previous written permission given by their parents and school principles.

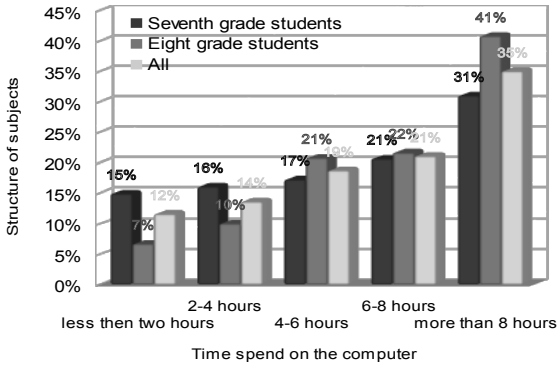
The data was analyzed using descriptive statistical methods with software tool *Statistica 9.0*, and the charts are presented with graphs created by *Calc* (*LibreOffice 3.3.1* office package).

4.2 Research results

All subjects have stated that they use the computer. The graph (picture 2) shows the data regarding the amount of time that the subjects spend on the computer weekly. Using the T-test applied on data shown by picture 2, a significant difference has been established (p=0,05) between the amount of time the children from city schools spend on a computer and the amount of time children from rural schools spend on a computer. Children from city schools weekly spend more time on a computer. Most students, more than one third, spend on average, more than an hour a day on the computer, with a significant difference between children from city schools (39%) and those from rural schools (26%).



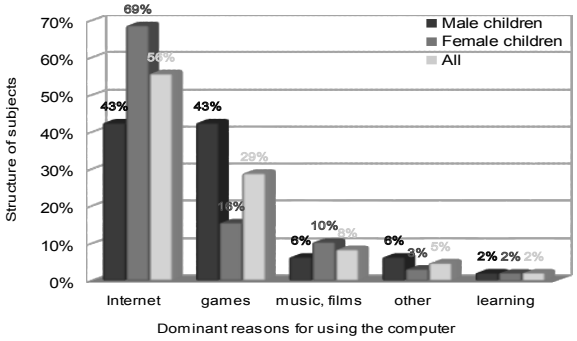
Picture 2. Structure of students from city schools and students from rural schools in regard to the weekly amount of time they spend on the computer



Picture 3. Structure of seventh and eight grade students in regard to the weekly amount of time they spend on the computer

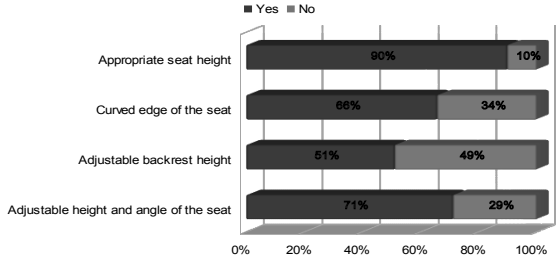
Analysis of variance showed that there is no significant difference between the genders in the weekly amount of time students spend on the computer, but (picture 3) there is a significant difference (the level of significance being 5%) between different grades. Eight grade students spend more time on the computer.

Concerning the dominant reasons for using the computer (picture 4) the results show that most of the subjects use the computer predominantly for games, and they use it the least for studying. Significant difference between genders in distribution of time which students spent in front of a computer is established by $\chi 2$ test ($p=0.05$). On the Picture 4 it can be seen that boys use the computer for games much more than girls.



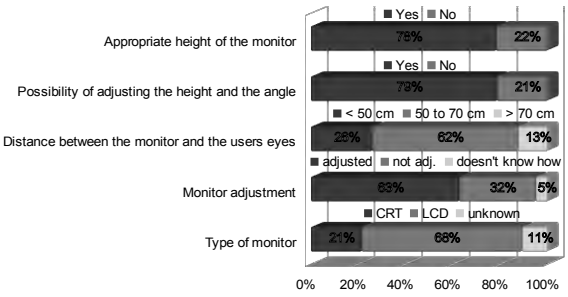
Picture 4. Temporal distribution of modes of using the computer

Most of the subjects have chairs with adjustable height of the seat and back as well as the angle of the backrest, they sit at an appropriate height, and their chairs have a curved edge (picture 5). Of all ergonomic features of the chairs, the biggest problem is the height of the backrest, since half of the subjects do not have the ability to adjust it.



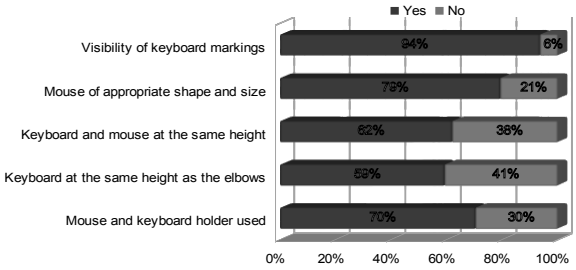
Picture 5. Chair compliance with ergonomic principles

Most of the subjects have their monitors (picture 6) at an appropriate height, with the ability to adjust the height and the angle, which most of the subjects use. LCD monitors prevail. The problem of using the monitors from too close a range is noticeable, and taking into account the prevailing usage of laptops, it is expected that this problem will worsen in time.



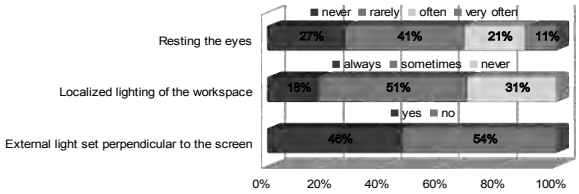
Picture 6. Usage of the monitors

The answers most subjects gave to questions concerning ergonomics of the usage of the keyboard and the mouse (picture 7), show that this aspect of computer ergonomics is not problematic.



Picture 7. Ergonomics of the keyboard and the mouse

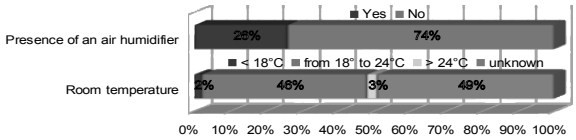
More than half of the subjects do not have the monitor set perpendicular to the windows so that the light would fall at one side of the monitor, illuminating the room, but not creating reflections on the screen. Furthermore, half of the subjects only occasionally use localized lighting for their workspace, while a large amount of subjects never use it at all (picture 8). Also, while using the computer two thirds of the subjects rarely or never avert their eyes from the screen or use some other way of resting their eyes.



Picture 8. The lighting and the habit of resting the eyes

Other parameters that show the amount of compliance of the working space to ergonomic principles, which are easily adjustable, are humidity and room temperature (picture 9). Still, to be able to make assumptions concerning this matter, a more complex research would be required. The reason for this is that it is not enough simply to know if there is an air humidifier in the room, if we do not know the overall condition of the microclimate in that same room, and whether there is the need for an air humidifier in the first place; also, we do not know if

the room temperature is appropriate since half of the tested subjects do not have this information.

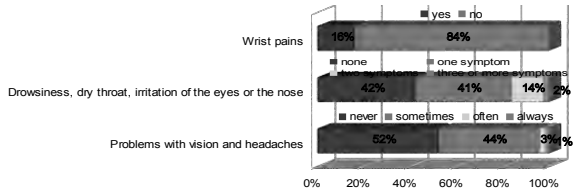


Picture 9. Humidity and room temperature

While using the computer, almost half of the subjects have had one or more difficulties with their sight and/or headaches: burning sensation in the eyes, headache, reduction of vision acuity and double vision. The other half hasn't experienced any difficulties (picture 10). Analysis of variance test showed that there is no significant difference (p=0,05) for this matter between genders or grades. This means that boys and girls, as well as eight grade and seventh grade students experience this difficulties in the same extent.

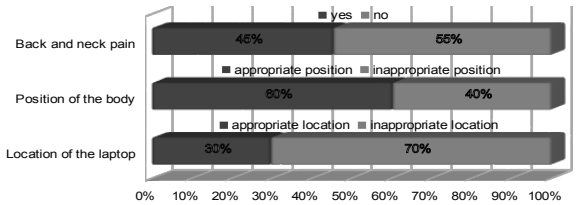
While using the computer, more than a half of the subjects have experienced one or more of the following difficulties: drowsiness, dry throat, irritation of the eyes and irritation of the nose (picture 10). Analysis of variance test showed that there is no significant difference (p=0,05) in the number of symptoms between genders or grades. This means that boys and girls, as well as eight grade and seventh grade students experience the same symptoms.

16% of the subjects have experienced wrist pain. Although this is a relatively small number of subjects, it is not to be neglected (picture 10).



Picture 10. Health issues

Almost half of the subjects tested (44%) use laptops. Those subjects using laptops show a tendency (70 % of the subjects) of inadequate positioning of the laptop while working on them (for example, in their lap), often in unnatural position (40% of the subjects), and this kind of usage provokes neck pain and back pain which 45% of the subjects using laptops have experienced (picture11).



Picture 11. Laptop ergonomics

5 Conclusion

The conducted research provided new insights into the behavior of primary school children when using a computer which will help ground and focus further research.

Out of numerous different ergonomic parameters, in regard to the criteria of accordance of the actual state of the subjects tested with ergonomic parameters, we can discern three groups: adjusted parameters, partially adjusted parameters and non-adjusted parameters. Any future research on a representative sample of subjects should primarily be concerned with the last group: the degree of non-adjustment, its causes and possible ways of influencing it.

Determined adjusted ergonomic parameters are all those related to the seat of the chair; the type, height and adjustment of monitors; as well as all the parameters regarding the keyboard and the mouse.

Partially adjusted ergonomic parameters are: insufficient adjustability of the backrest height; the distance between the monitor and the user's eyes; positioning of the monitor in regard to the external light and (in)sufficient amount of local illumination of the workspace.

Non-adjusted parameters are little or no rest for the eyes and inappropriate positioning of laptops while using them.

Some health issues which children experience already at primary school age, and which are worsened by prolonged usage of the computer are: wrist pain, drowsiness, dry throat, eye irritation, nose irritation, visual problems and headaches as well as neck and back pain. Other research also confirm our conclusions [9], [11], [23-26] although some authors state that it is unclear wether poor posture is related to the sitting posture or to the computer use in itself [12].

There are futher opinions and findings: "psychological, social and emotional factors had a stronger relationship with back pain than physical factors amongst intermediate school children"[27]. Also there is some evidence that the use of computer is not "associated with the presence of pain and musculoskeletal pain syndromes [28].

The cause of this could be the following: "sitting posture as such, and stooped sitting posture in particular increase the stress to spinal structures" and these results further emphasize the importance of proper sitting postures at school [29].

Many authors recommend desktop computers over laptops. Where a laptop computer must be used, its use should be limited to shorter periods of time [30]. With regard to tablet computers (although we were not able to investigate their effect), L. M. Straker et al. say that tablet computer use was very similar to paper use and he encourages moderate duration of exposure which could be achieved with limited periods of tablet use interspersed with other activities requiring different posture/muscle actions [31].

Our study revealed a number of conclusions not related to ergonomics. As expected, children from city schools spend more time on the computer than those from rural schools, and eight grade students spend more time on the computer than seventh graders. There is no significant difference regarding genders. It was also expected that boys spend much more time using the computer for gaming purposes than girls. The study has also shown that of all the possible activities, children use the computer for studying the least. The goals of the research have been accomplished: we identified the ergonomic parameters of computer usage that are being adhered to completely, those that are adhered to to some extent, and those that are not adhered to at all. Furthermore, it has been found that children of primary school age have health issues that can be linked to excessive time spent on the computer as well as inadequate usage of the computer. A more complete contemporary overview of the problematics and some solutions to the problems can be obtained from the following sources: [32-39].

It must be mentioned that a simple exercise is effective in reducing the intensity and prevalence of low back pain in children [40].

Generally "very little research (and even less practical application) has focused on macro-ergonomics´ issues such as classroom environments, and more particularly on ergonomics pedagogy, curriculum content and structure i.e. Ergonomics for schools. The current state of knowledge about ergonomics for schools is limited" [36]. It is our opinion that the need for further studies has been proven. Any future study depends on finding a model for its financing.

References

[1] M. Vodanović, "**Ergonomija i profesionalne bolesti stomatologa**," Hrvatski stomatološki vjesnik (Vjesnik dentalne medicine), Zagreb, Croatia, vol. 13, 2006, pp. 29-34.

[2] S. Legg, **"Ergonomics in schools,"** Ergonomics, vol. 50 (10), 2007, pp 1523-1529.

[3] Z. Žitnik, "**Anketno istraživanje zastupljenosti nekih muskuloskeletarnih poremećaja kod korisnika računala"** - Digitalni arhiv Knjižnice FF-a." available at http://darhiv.ffzg.hr/174/1/ZoranZitnik.pdf, Accessed: July 2011.

[4] R. Talwar, R. Kapoor, K. Puri, K. Bansal, and S. Singh, "**A study of visual and musculoskeletal health disorders among computer professionals in NCR Delhi**," Indian J Community Med, vol. 34 (4), 2009, pp. 326–328.

[5] Purushottam A. Giri, "**Computer related health problems among occupational computer users: A cross-sectional study**," Australasian Medical Journal (available at: http://www.faqs.org/periodicals/201006/2108167471.html, Accessed: July 2011.

[6] "**Zakon o listi profesionalnih bolesti**," Narodne novine br. 162, 1998.

[7] Z. Yan, L. Hu, H. Chen, F. Lu, "**Computer Vision Syndrome: A widely spreading but largely unknown epidemic among computer users**," Computers in Human Behavior, vol. 24 (5), 2008, pp. 2026-2042.

[8] T. Amel, S. Kumar, "**Cumulative trauma disorders and keyboarding work**," International Journal of Industrial Ergonomics, vol. 25 (1), 2000, pp. 69-78.

[9] D. Domljan, Z. Vlaović, I. Grbac, "**Musculockeletal deformities and back pain in school children**," Proceedings of 4th International Ergonomics Conference, June 30 – July 3, Stubičke Toplice, Croatia, 2010.

[10] M. Žugaj, J. Šehanović, "**Zdravlje treba čuvati**," Infotrend, Zagreb, Croatia, 1995, pp. 69-71.

[11] L. Straker, B. Maslen, C. Pollock, "**Principles for the wise use of computers by children**," Ergonomics, vol. 52 (11), 2009, pp. 1386–1401.

[12] R. Breen, S. Pyper, Y. Rusk, S. Dockrell, "**An investigation of children's posture and discomfort during computer use**," Ergonomics; 50 (10), 2007, pp 1582-1592.

[13] D. Zandvliet, L. Straker, "**Physical and psychosocial aspects of the learning environment in information technology rich classrooms**," Ergonomics, vol. 44 (9), 2001, pp. 838-857.

[14] E. J. Sheedy, R. Smith, J. Hayes, "**Visual effects of the luminance surrounding a computer display**," Ergonomics, vol. 48 (9), 2005, pp. 1114-1128.

[15] Lj. Bakić-Tomić, M. Dumančić, "**Odabrana poglavlja iz metodike nastave informatike, sveučilišna skripta UFZG**," Zagreb. 2009.

[16] D. Domljan, I. Grbac, J. Hañina, "**Classroom furniture design-compliance of pupils' and chairs' dimensions**," Collegium Antropologicum, vol. 32 (1), Zagreb, Croatia, 2008, pp. 257-265.

[17] G. Lipnjak, Z. Pap, "**Ericsson Nikola Tesla - Fleksibilno radno mjesto**," Mipro 2008.

[18] K. H. E. Kroemer, E. Grandjean, "**Prilagođavanje rada čovjeku-ergonomski priručnik**", Naklada slap, Jastrebarsko, Croatia, 1999.

[19] R. Burgess-Limerick, M. Mon-Williams, V. L. Coppard, "**Visual Display Height**," Human Factors: The Journal of the Human Factors and Ergonomic Society, vol. 42 (1), 2000. pp. 140-150.

[20] K. R. Scott, M. J. Kothari, "**Non-surgical treatment of carpal tunnel syndrome**," in UpToDate, Rose, BD (Ed), UpToDate., Wellesley, 2005.

[21] M. Đurek, M. Čičin-Šain, P. Dragojlović, J. Sunde, and I. Turčić Prstačić, "**Ergonomija učeničke informatičke učionice**," presented at the MIPRO, Rijeka, 2002, pp. 134-139.

[22] S. Fošnarič, U. Drnovšek, "**Ergonomic aspects of implementing computer technology into schools**," Informatologia, vol. 42 (2), Zagreb, Croatia, 2009, pp. 118-125.

[23] C. Harris, L. Straker, "**Survey of physical ergonomics issues associated with school children's use of laptop computers**," International Journal of Industrial Ergonomics, no. 26, 2000, pp. 337 – 347.

[24] M. Szpalski, R. Gunzburg, F. Balague, M. Nordin and C. Melot, "**A 2-year prospective longitudinal study on lower back pain in primary school children**," European Spine Journal 11(5), 2002, 459-464.

[25] A. Vikat and M. Rimpela, "**Neck or shoulder pain and low backpain in Finnish adolescents**," Scandinavian Journal of Public Health 28 (3), 2000, pp. 164-173.

[26] K. Jacobs, N. A. Baker, "**The association between children 's computer use and musculoskeletal discomfort**," Work, vol. 18 (3), 2002, pp. 221– 226.

[27] F. C. Trevelyana & S. J. Legga, "**Risk factors associated with back pain in New Zealand school children**," Ergonomics, vol. 54 (3), 2011, pp. 257-262.

[28] A. L. Zapata, A. J. Pantoja Moraes, C. Leone, U. Doria-Filho and C. A. Almeida Silva, "**Pain and musculoskeletal pain syndromes related to computer and video game use in adolescents**," European Journal of Pediatrics, vol. 165 (6), 2006, pp. 408-414.

[29] A. Woodcock, "**Ergonomics, education and children: a personal view**," Ergonomics, vol. 50 (10), 2007, pp. 1547-1560.

[30] L. Straker, K. J. Jones and J. Miller, "**A comparison of the postures assumed when using laptop computers and desktop computers**," Applied Ergonomics, vol. 28 (4), 1997, pp. 263-268.

[31] L. M. Straker, J. Coleman, R. Skoss, B. A. Maslen, R. Burgess-Limerick and C.M. Pollock, "**A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children**," Ergonomics, vol. 51 (4), 2008, pp. 540–555.

[32] B. Maslen B, L. Straker, "**A comparison of posture and muscle activity means and variation amongst young children, older children and young adults whilst working with computers**," Work; 32 (3), 2009, pp. 311-320.

[33] C. Pollock, L. Straker, "**Special issue: Selected papers from the second cyberspace conference on ergonomics, CybErg 1999 – Editorial**", International Journal of Industrial Ergonomics, vol. 31 (3), 2003, pp. 141-142.

[34] L. Straker , C. Pollock, "**Delivering the power of computers to children, without harming their health**," Ergonomics, no. 48, 2003, pp. 506–521.

[35] M. Robbins, I.P. Johnson, C. Cunliffe, "**Encouraging good posture in school children using computers**," Clinical Chiropractic (an international journal), vol. 12 (1), 2009, pp. 35-44.

[36] S. Legg, K. Jacobs, "**Ergonomics for schools**," Work, vol. 31 (4), 2008, pp. 489-493.

[37] L. Straker, C. Pollock and R. Burgess-Limerick, "T**owards evidence-based guidelines for wise use of computers by children,**" International Journal of Industrial Ergonomics, vol. 36 (12), 2006, pp. 1045-1053.

[38] E. Heyman and H. Dekel, "**Ergonomics for children: An educational program for elementary school**," Work, vol. 31 (2), 2009, pp. 261–265.

[39] M. Sotoyama, U. Bergqvist, H. Jonai and S. Saito, "**An ergonomic questionnaire survey on the use of computers in schools**," Industrial Health, vol. 40 (2), 2002, pp. 135–141.

[40] G. L. Fanucchi, A. Stewart, R. Jordaan, P. Becke, "**Exercise reduces the intensity and prevalence of low back pain in 12-13 year old children: a randomised trial**," Australian Journal of Physiotherapy, vol. 55 (2), 2009, pp. 97-104.