DOI: 10.7251/QOL2103113L **UDC:** 616.89-008.47:159.952-053.2

Professional Paper

Risk Factors in Musculoskeletal Disorder Development in Children Connected With the Extended use of Information and Communication Technologies

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ABSTRACT: ***Introduction:*** The way of life in modern society goes along with new technological discoveries and achievements. This lifestyle leaves its positive and negative consequences on children. Such changes are especially reflected on health already in earliest stages of life. The studies show that most children have been using computers even since kindergarten and that children's computer use is longer than recommended. It is more effective and cheaper to prevent musculoskeletal disorders than to cure them. ***Goal:*** To examine all risk factors concerning the development of musculoskeletal disorders connected with a long use of information and communication technologies by reviewing scientific literature. ***Material and methods:*** Non-experimental qualitative research into the risk factors of the development of musculoskeletal disorders connected with a long use of information and communication technologies based on relevant databases. ***Results and discussion:*** Based on a discussion of the attitudes and opinions of other authors, risk factors are divided in three basic groups: ergonomic, individual, and psychosocial risk factors. As it is shown in the discussion of this paper, a disbalance of the desk for a desktop computer, the non-ergonomic design of the furniture, the type and time of the ICT usage device, the sedentary way of using the ICT devices at school and at home are just some of the numerous risk factors to children's health. ***Conclusion:*** By examining the risk factors in the development of musculoskeletal disorders in children connected with an extended use of information and communication technologies, the presented evidence in the discussion section based on other authors' attitudes and opinions, leads us to the conclusion that numerous risk factors that affect children's health are due to a larger and more frequent use of computers, console games, tablets and mobile phones.

Keywords: Risk factors, information and communication technologies, musculoskeletal disorders, health, children.

INTRODUCTION

Nowadays students are more often to experience their reality through a virtual world that leaves negative consequences on their mental and physical health. The virtual world of imagination that is shaping itself for a purpose of mass use, decreases the possibility of personal imagination and divides it from the real world and personal initiative, thus creating stereotypes of unified mentalities (Andrijašević, 2009). Most children are constantly looking at mobile phones, tablets, and spend most of their time playing games, miss physical and health education classes, and go to school by car (Badrić et al., 2011). The recent technological progress inspired a new

movement of portable, compact and personalised IT devices, such as laptop, tablets and smartphones sensitive to touch. Mobile phones can be useful in a wide range of physical environments at the time of acquiring position range. In other words, everything can be considered as an IT work environment nowadays (Petrić et al., 2019). The studies about the position of school children while using IT as a work environment were mostly at school (Ciccarelli et al., 2011). The way of life in modern society goes along with technological discoveries and achievements. This way of life leaves its positive and negative consequences on children. Such changes are especially reflected on health in the earliest childhood (Ciccarelli et al., 2015). Children and young people have much more free time than adults, and because of their specific biopsychosocial status in the environment and society, their free time must be organised and specific, and not left to chance (Prskalo et al., 2010). The population of students of all ages is affected by hypokinesia, regardless of where they live, resulting from sedentary way of life (Berčič, 2010). The life habits such as inactivity, reduced walking and reduced mobility of the entire locomotor system have been adopted (Berčič, 2010). The sedentary way of life leads to an unbalanced growth of muscular groups (Badrić & Barić, 2006). Although bad posture does not always mean bad health, maintaining good posture helps body to function better in everyday life. Considering that the problem of improper posture in children, which is one of the most relevant problems of modern society, begins at an early age, it is important to recognise it on time and diagnose it accurately (Badrić & Prskalo, 2011). The surveys show that most children from the time of enrolling in kindergarten use computers and use them longer that that is recommended (Berisha, 2015). Sitting is a burden for the spine, especially improper sitting, that leads to other negative consequences. It is important to carry out timely measurements of the spine so deviations can be detected on time (Robotić, 2015). A disbalance between the dimensions of school furniture and the anthropometry of the body is one of the main reason that leads to pain and musculoskeletal disorders in various parts of the child's body. There is limited research about postural risks connected with children's IT use at home (Rapajić, 2015). When they are at home, children will probably use their mobile phones to spend their free time and social activities. At home they take several different positions when using IT, and use IT technologies longer to finish their tasks than when they are at school (Namwongsa et al., 2018). Laboratory studies show extreme angles of the cervical part of the neck spine and a deeper head flexion. The surveys in adolescents show a bigger risk of neck pain, lower part of the spine as well in eyes after a long use of the laptop (Dockrell et al., 2012). Time spent on the computer involves a muscular activity of a low level in the area of the neck, shoulder girdle and back, which as a consequence can have a local muscle tension, a compression and inflammation of the peripheral nerves and a reduced blood circulation (Breen et al., 2007). One of the main conditions of the proper posture of the body during the class is an ergonomic shape of school furniture, especially chairs and desks. Nevertheless, when designing ergonomic furniture, the ergonomic features as a condition for good health and motivation improvement and successful learning are insufficiently taken into account. With ergonomically designed computers suitable for children and with suitable preventive exercises, the improper posture can be prevented and even corrected on time (Howie et al., 2017). Preventing musculoskeletal disorder development is much more effective and cheaper than its medical treatment. Parents and experts have a leading role in this (Alibegović et al., 2020).

The goal of this research was to examine risk factors of the musculoskeletal disorder development connected with a long use of information and communication technologies by reviewing scientific literature.

MATERIAL AND RESEARCH METHODS

The research is a non-experimental (qualitative) research, i.e. a scientific review of literature. In creating this paper, various databases were used, including Pub Med, Google Scholar, Medline, using the keywords "risk factors", "information and communication technologies", "musculoskeletal disorders", "health", "children". The research is limited to articles published in the Serbian, Croatian and English languages.

RESULTS

In a research of young children (0-4 years old) from rural areas with a low income in the USA, 97% of children used mobile phones and two-thirds of four-year-old children owned their own tablet (Kabali et al., 2015). In a research of children in Singapore, over 60% of children from 18 to 24 months use mobile technology every day (Goh et al., 2016).

Two-third of American high school children aged 16 to 18 years reported that they use their tablets more than 4 hours a day (Sommerich et al., 2007). The Hong Kong students, 12 to 16 years old, reported that they used computers 2,5 hours per day on average (Ho & Lee, 2001). However, it has been observed that even young children use computers. More than a quarter of children, 4 to 6 years old, in the USA use computers 64 minutes a day on average (Sommerich et al., 2007), and more than a half of five-year-olds in Australia use computers every week (Staker et al., 2006).

The abduction of the upper arm during the IT technology use was 13,6 degrees higher compared to the situations when the IT technology is not used ($p < 0,001$). The average elevation of the shoulder was 10,2 degrees higher compared to the situations when the IT technology is not used ($p = 0,001$). The average head flexion during IT technology use was 18,6 degrees higher compared to new IT technology ($p < 0,001$) and 16,4 degrees higher compared to the situations when the IT technology is not used ($p < 0,001$). The average torso flexion during the old IT technology use was 5,7 higher compared with the new IT technology ($p = 0,011$), while the medium value of lateral torso bending while using the old IT technology was 1,6 degrees higher when compared with the situations when the IT technology is not used (Ciccarelli et al., 2011).

In a research in Thailand most smartphones users reported some form of musculoskeletal disorder in the upper part of body: torso flexion (82,74%), shoulder contraction (56,61%), elbow flexion (65,16%), finger and wrist bending (22,40%), hand supination to support the device (21,62%), upper part of the back flexion (67,50%) and lower part of the back flexion (43,23%), that are acquired while using smartphones (Namwongsa et al., 2018).

The results of Nordic Questionnaire (SNQ) showed that musculoskeletal disorders are the biggest in the neck (90,00%), than in the shoulder 73,30%, the upper part of the back 63,30%, the wrist 36,70% and the lower part of the back 30,00 %. The musculoskeletal disorders were less spread in the hip bone and quadriceps 13,30 %, the knee 13,30%, the ankle 10,00% and the elbow 6,70% (Namwongsa et al., 2018).

The Jones and Orr study shows that 28%, 40%, and 41% of students reported a discomfort in hands, a neck/back pain, and a pain in the body, respectively, after using the computer. The carpal tunnel syndrome was reported by 4% of respondents. The evidence reveals that from 30% to 60% of school children report some form of musculoskeletal discomfort, and they think it got worse by computer use (Harris & Straker, 2000).

The Harris and Straker report that 60% of students has discomfort while using the laptop, and 61% has discomfort while carrying the laptop (Straker et al., 2002).

Three of the children reported that the pain got worse, moving from 2 to 3 on the VAS scale (Visual Analogue Scale). Other 12% (n ¼ 8) did not have any pain at the beginning, but had pain (2 on the VAS) at the end of computer use (Breen et al., 2007).

Compared with watching TV, while playing on a tablet device children have a bigger torso flexion (median 12,8, 95% CI: 6,2, 19,3, $p < 0,001$), head bending (33,3, 95% CI: 23,4, 43,4, $p < 0,001$), lateral head bending (6,9, 95% CI: 10,5, 2,3, p ¼ 0,002), upper arm bending (6,6, 95% CI: 2,2, 11,0. P ¼ 0,003), and a bigger medium upper arm abduction (5,9, 95% CI: 1,1, 10,7, p 0,016). Compared with the game Toy, while playing it children have bigger medium torso flexion (9,6, 95% CI: 3,1, 16,2, p ¼ 0,004), medium lateral chest flexion left (3,0, 95% CI: 0,2, 5,7, p ¼ 0,030), medium head flexion (11,6, 95% CI: 1,6, 21,6, p ¼ 0,023), and medium upper arm flexion (11,1, 95% CI: 6,8, 15,3, $p < 0,001$). The muscular activity was bigger while playing with a tablet device than while watching TV (the median distinction of 10,6% of the submaximal contrac-

tions 95% CI: 1,6, 19,5, p ¼ 0,021), but lower while playing with tablet devices compared with toys (14,9% of the submaximal contractions 95 % CI: 23,8, 6,0, p ~ 0,001) (Howie et al., 2017).

The research in Dublin shows that eight children reported discomfort on the BDC (Body Discomfort Chart) at the beginning of the class before the intervention (VAS 1). Three children reported back pain, one child reported neck pain and four of them reported lower extremities pain. The average intensity of pain was 0,9 ± 1,5. Fourteen children reported pain during classes (VAS 2). The most common area of reported pain was in the back (n=4). The average intensity of pain that students reported after the class was 1,8 ± 1,5. The Wilcoxon test showed a significant difference between the intensity of reported pain in children before and after the class (p = 0,04) (Dockrell et al., 2010).

According to a University of Surrey research (Great Britain), students spend about 38% of their time using computers on average, and 28,91% of students have a flexed torso position and even 33,50% of students have considerable neck flexion (Kabali et al., 2015). A BBC programme confirmed the alarming data, showing that because of inadequate sitting position, about 25% of British students complained about back and neck pain, headache and loss of concentration. The research showed that non-ergonomic body position in an extended sitting position creates muscle pain and manifests itself in various musculoskeletal disorders (Kim et al., 2015).

The students spend about 92% of their working time in a static sitting position, 3% in active walking and 2% in a standing position. The international standards of the World Health Organisation and its instructions for sitting on a chair for a long period of time with proper body position causes significant stress for the lumbar spine (Murphy et al., 2003).

In the period of growth and development, between the ages of 6 and 18, the children are exposed to different health problems including the proper body position problem (Troussier, 1999). It is shown that the pain in the lumbar part of the spine in school children occurs from 20% to 51 % of the total population of school children. The back pain is also connected with extended sitting, the weakness of certain muscle groups and bad posture (Cardon et al., 2004).

The period of the most intense growth and development of boys is between 11 and 12 years old, and the acquired data shows that in this period there is a gradual violation of the postural status. A statistically significant difference in the postural status was confirmed in respondents of both sexes, aged 14 to 15 (p=0,011; Z=-2,487). Furthermore, it can be confirmed that boys have a worse posture condition at this age as well (Bogdanović & Milenković, 2008).

In the period from 2013/2014 it was confirmed that 25,6% of children, 11 to 15 years old, reach the recommended values of the World Health Organisation from 60 of moderate to intense physical activity during the day, but the fact is that boys are significantly more active than girls (32,1% compared to 19,1%) (Lafond et al., 2007).

Most children fulfilled the daily need for movement (99,3%) and sleeping (82,1%), but the recommendation related to time spent in front of the computer fulfilled only 15,2% of the children (Protić-Gava, 2015).

The research on a sample of 347 two-year-old children shows that the children who were wearing accelerometer for two days, a minimum of 400 minutes a day, gain the results that show that children spend most of their time in the sedentary position (85,6% of them) (WHO, 2016).

The study shows that for most of the children the custom-made furniture is not available neither in Europe nor in the world. In the last 50 years, the height of the children of the same age has increased. The average height of children of 7 to 10 years old was increased from 5-7 cm on average, while the height of the children of 11 to 14 years old was increased from 7 to 10 cm (Carson et al., 2017).

The epidemiological study conducted in The Republic of Korea showed that 18,8% of smartphone users have musculoskeletal disorders at least in one part of the body, especially in the neck, upper part of the torso and the upper extremities (Wijtzes et al., 2013), while in another Korean study that also includes smart-

phones, it was discovered that the most painful part of the body due to smartphone use, was in the cervical spine (55,8%) (Domljan & Grbac, 2008).

DISCUSSION

By identifying the results of the RULA test, we came to the conclusion that the ergonomic risk in smartphone users is high, and that is a result of two key factors: body posture and muscle use. The position of the neck, back and lower extremities had a combined effect on the musculoskeletal system of the neck. The results of the RULA test showed that there is a high risk of pain in the musculoskeletal system if the ergonomic measures are not applied (Namwongsa et al., 2018).

The type of the computer task influenced the posture of the children.16% of the children reported pain, especially when using the mouse. These results show that children at the age of 9 can develop musculoskeletal symptoms in the period of computer use for a short time (Breen et al., 2007).

The current findings suggest the possibility that a sedentary way of life and low physical activity lead to higher musculoskeletal disorders. Based on the evidences, it is important to understand that new technologies and their use carry a big risk for children's health (Howie et al., 2017).

By means of a quantitative analysis of the sedentary posture in school children, it is confirmed a higher head flexion while carrying a laptop in contrast with a desktop computer. It is also confirmed that head flexion is significantly smaller in younger children compared to older children. The type of IT technology that a child uses to communicate, as well as their age and sex affect the child's posture. The children that were reading from books have a smaller angle of head and flexion while watching compared to reading from a laptop. Reading from a laptop was connected with bigger head bending, neck bending and a bigger angle of watching compared to reading from a desk computer (Briggs et al., 2004).

In non-conditioned logistic regression analyses adjusted to the age, gender, and race, frequent users of desktop computers (daily or almost daily) had NUE symptoms (neck or upper extremity), i.e. a higher degree of neck and upper extremities pain in contrast with users who used the computer less frequently. Those who used computers for a long time without a break had higher NEU (neck or upper extremity) symptoms. Obesity and wearing glasses or contact lenses also were connected with the symptoms (Gillespie, 2006).

As the use of the internet becomes intensive at school and at home, the consequences of the disbalance of furniture and children's posture became more serious. To teach children about healthy computer habits will protect them from future painful disorders. Future worker is in schools nowdays. Because of that, certain attention must be payed to their work surface that will help in preventing problems connected with information and communication technologies in the future (Patel et al., 2015).

Musculoskeletal disorders connected with the use of a child computer are not only a concern for young people, but also affects the potential for higher musculoskeletal disorders in adults (Harris et al., 2005).

The respondents that usually watched TV till noon and late at night during the weekend have a bigger chance to be intense IT device users. 24% of girls and 10% of boys in the "intense" categories of IT devices were at a higher health risk that can be connected with a metabolic syndrome and cardiovascular diseases (Straker & Pollock, 2005).

There is more and more evidence that psychosocial factors connected with home and work environment play the leading role in musculoskeletal disorder development. Psychosocial factors that are connected with musculoskeletal disorders of the upper extremities include: an increase in labour demands, monotonous work, dissatisfaction, low social support, and conditions such as depression, stress and anxiety (Kelly et al., 2009).

A lot of changes in children's behaviour that parents see simply show normal distancing that adolescents mostly show when they are teenagers. Computer addiction can be viewed as a phase of intensive

computer use and its potential that all IT devices produce. A lot of children will pass this phase and will integrate IT device use in everyday life (Straker & Pollock, 2005).

The Body Discomfort Chart (BDC) and the Visual Analogous Scale (VAS) showed that the majority of respondents (65%) were at the level of 2.30% at the level of 3, and 5% at the level of 4. There was a statistically significant increase in reported discomfort from the beginning to the end of the computer class. A longer teaching process (80 minutes) did not result in a higher number of reports of discomfort than in a shorter teaching process (40 minutes). The problems are reflected in the lack of ergonomic considerations in the design and layout of computer workstations, both in schools and at home (Kelly et al., 2009).

The relationships between the computer work environment, the keyboard, and musculoskeletal disorders are significant, but they suggest that students without ergonomically designed furniture are more likely to have musculoskeletal disorders. Risk factors associated with computer use and discomfort are also significant. (Jacobs & Baker, 2002).

Particular computing activities, such as using a joystick or mouse, significantly predict musculoskeletal problems by means of multiple logistic regression. Many parents report difficulty removing their children from the computer (46%) and that their children spend less time outdoors (35%) (Burke & Peper, 2002).

Adjusting the height of the computer screen and the height of the table resulted in an increase in head tilting, neck flexion, viewing angle, activity of the cervical spine and a trend in the activity of the right upper trapezius. Greater head flexion represents the normative values of the child's inclination of the cervical spine (Straker et al., 2002).

The lowest level of muscular activity in children was found when they used a desktop computer. The cervical erector spinae and the upper trapezius muscle were found to be larger on the left side when using the book compared to higher levels of right side muscle activity. The three types of IT devices had different effects on the activities of the cervical erector spinae and upper trapezius muscle, suggesting different risks associated with different types of IT. The levels of activity were often above 5% of the maximum EMG (electromyography). Children are potentially at risk of health consequences associated with the use of IT devices (Greig et al., 2005).

CONCLUSION

By researching risk factors od musculoskeletal disorder development in children connected with long-time information and communication technology use, the outlined evidence from the discussion of the attitudes and opinions of other authors lead to the conclusion that a lot of risk factors affect children's health because of an ever-increasing and more frequent use of computers, consoles, tablets and mobile phones.

It can be concluded from this paper that using modern technology considerably more presents a detriment to children in the field of health than it presents a benefit to them.

By a means of a multidisciplinary approach, using ergonomic preventive measures when using computers, different educational content, as well as with various physical activities as a part of various school activities, and by following scientific achievements, it will be possible to enable children to have a comfortable, cheerful, painless, and most importantly a healthier way of life while using information and communication technology as an indispensable factor of modern life.

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Recived: January 17, 2021
Accepted: March 10, 2021