Neuroendocrinology Letters Volume 40 Suppl. 1 2019
ISSN: 0172-780X; ISSN-L: 0172-780X; Electronic/Online ISSN: 2354-4716
Web of Knowledge / Web of Science: Neuroendocrinol Lett
Pub Med / Medline: Neuro Endocrinol Lett

ORIGINAL ARTICLE

Analysis of body segments and postural state in school children

Marina Kolarová[1], Peter Kutiš[1], Róbert Rusnák[1,2], Zuzana Hrčková[2], Zuzana Hudáková[1], Ľudmila Lysá[1], Milan Luliak[3], Róbert Babeľa[3]

1 Catholic University in Ružomberok, Faculty of Health, Department of Physiotherapy, Slovakia
2 Central Military Hospital in Ružomberok, Neurosurgeon clinic, Slovakia
3 St. Elisabeth University, Bratislava, Institute of Healthcare Disciplines, Bratislava, Slovakia

Correspondence to: Peter Kutiš
TEL.: +421 908 226 393; E-MAIL: peter.kutis@gmail.com

Submitted: 2019-04-06 *Accepted: 2019-06-12* *Published online: 2019-09-20*

Key words: **posture; body segments; postural assessment; postural disorders**

Neuroendocrinol Lett 2019; **40**(Suppl.1):17–23 **PMID:** 31785222 NEL400919A5 • **www.nel.edu**

Abstract

OBJECTIVE: Aim of our study was to identify the number of existing posture disorders in children in primary schools and to identify the most prevalent position of body segments that cause postural disorders.
METHODS: The occurrence of postural disorders was analysed in the school year 2016/2017. The sample consisted of 311 pupils age 6–8 from the 16 districts of the Slovak republic. We used Klein, Thomas and Mayer method to evaluate the posture. Flat feet were evaluated according to Napoleon Wolanski scale. The results were verified by using a base rate quantity test. We determined the level of statistical significance at $p = 0.05$.
RESULTS: We observed statistically significant postural disorders in children. Poor posture occurs in more than 50% of the population under the study. The most critical body segments which were subjected to pathology were shoulder blades and shoulders. Pathology in these segments exceeds 80%. Flat feet occurrence was in 65% children. Adverse results were also seen in pathologic position of: pelvis anteversion (46 %), head protruding (42%) and spinal curvature deformities in the sagittal plane (30%). In the frontal plane deformities of spinae reached 13%.
CONCLUSION: Health status of the children's locomotor system, especially postural system is poor. High prevalence of postural disorders in children requires preventive programs such as introducing corrective exercises into physical education and engaging children in sports. Knowledge of the most frequent body segments defects in children can be helpful for professionals in creating adequate corrective programs for children.

INTRODUCTION

Postural disorders are a serious problem for a modern society. We are increasingly seeing them in children. The start of compulsory education is the time when children quit natural movement, as they have in kindergarten and postural deformities are increasing. Its alarming occurrence has been pointed out by many professionals from industrially developed countries. The lack of movement and long-term sitting contribute to the increased occurrence of poor posture in children (Protić-Gava 2015; Nikšić *et al.* 2015; Marjanović *et al.* 2012; Kolarová *et al.* 2018). Professional literature describes poor posture as the pandemic of modern age. *„Poor posture is one of the diagnosis which fall into the category of posture disorders. I tis a very topical issue as changes in posture, whether functionals or later even structural are often connected with pain, the pandemic of modern age.“*

(Janda 2001). If we assessed deeper and even smaller deviations, we would not find almost any child or a young person with the motor system that could be described as ideal (Janda, 2001).

Based on current scientific knowledge and our clinical experience, we specified aim of our study to detect postural disorders in school-aged children in the first stage of primary school. Partial research aims were:

- Evaluate the incidence and prevalence of postural disorders in school-age children.
- Evaluate the position of 9 segments that directly influence the overall body posture.
- Evaluate the most critical segments of posture that are susceptible to become pathological.

RESEARCH METHODS

Research participants

Assessment of the body segments and posture was carried out in the school year 2016/2017. The sample was created from 311 pupils of the first grade, aged 6-8. These were randomly selected pupils throughout Slovakia (Western, Central and Eastern parts), from 16 districts. The pupils were without any neurological, orthopaedic, vestibular and other congenital or acquired disorders. It was potentially health population.

Data collection and research methodology

Data collection was carried out within the project „Healthy Backbone" under the auspices of the National Sports Centre and the Ministry of Education, Science, Research and Sports of the Slovak Republic. During the examination, the respondents were barefoot and in underwear. Examination distance was of 1 meter. We used inspection for body segments and posture analyses. Pupils were examined with the consent of their legal representatives.

To evaluate the posture, we chose the methodology according to Klein and Thomas and Mayer (Haladová & Nechvátalová 2010). The methodology evaluates 5 sections of the body: I. head and body position, II. chest shape, III. shape of the abdomen and bowl inclination, IV. total curvature of the spine in the sagittal and frontal plane, V. height of the shoulders and position of the shoulders. The positioning of the segments is expressed by a numerical value of 1 to 4. The physiological position of the body segment is expressed by 1, a good posture by 2, a faint posture is indicated by 3 and a value of 4 represents a poor posture. The points for each segment are counted and the overall score is obtained. Based on the overall score, the subjects are categorized in 4 postural categories. The lower the overall score, the better the child´s posture, and vice versa.

Categories are created as follows:

- excellent body posture up to 5 points (postural category I.),
- good, almost excellent posture 6–10 points (postural category II.),
- relaxed body posture 11–15 points (postural category III.),
- incorrect body posture 16–20 points (postural category IV.).

The shape of the arch of the foot was evaluated using the Napoleon Wolansky methodology (Beganović *et al.* 2012). This methodology evaluates the position of body segments by awarding numbers 0, 1 and 2. 0 represents physiological position of the segment, 1 a slight deviation and 2 a serious pathology. The arch of the foot, based on the Wolansky methodology, is evaluated as follows:

- 0 – well-formed arch, 1/3 of the foot touches the floor,
- 1 – slightly fallen arch, 2/3 the foot touches the floor,
- 2 – significantly fallen arch, almost all the foot touches the floor.

Data processing methods

The results of the examinations were processed in MS EXCEL. The correctness of the assumption was verified by using a base rate quantity test. We determined the level of statistical significance at $p = 0.05$. We formulated mathematical hypotheses in the form of zero and alternative hypothesis. We tested the hypothesis of the match of the base set π and the constant π_0.

Zero hypothesis: H0: $\pi = \pi_0$.

Alternative hypothesis for a two-side test: $\pi \neq \pi_0$.

In the case of one-sided test, we formulated an alternative hypothesis as follows: $\pi < \pi_0$, or $\pi > \pi_0$.

File range n=311 was high enough and we could approximate the distribution by a normal division $N = \left(\pi, \sqrt{\frac{\pi.(1-\pi)}{n}}\right)$ and used a test statistic $z = \frac{\pi-\pi_0}{\sqrt{\frac{\pi.(1-\pi)}{n}}}$ for the division N (0,1). We compared the test statistic with the critical value z_α. If the value is $|z| < z_\alpha$ we recommend to accept the zero hypothesis. Otherwise, we recommend to accept the alternative hypothesis.

RESULTS

The total number of pupils studied was three hundred and eleven (n = 311). Occurrence of postural disorders in children and the distribution of the pupils in the postural categories are presented in Table 1. Column I. presents the number of children whose posture has been rated as perfect. Overall score to classify to this postural category, according to Klein, Thomas and Mayer was 5 points. Column II. presents the number of children whose posture has been rated as good, almost perfect posture. Overall score to classify to this postural category, according to Klein, Thomas and Mayer was 6–10 points. Column III. presents the number of children whose posture has been rated as faint posture. Overall score to classify to this postural category, according to Klein, Thomas and Mayer was 11–15 points. And column IV. presents the number of children whose

Tab. 1. Pupils based on posture assessment

I.	II.	III.	IV.	n	I.+II.	III.+IV.
53 (17.04%)	118 (37.94%)	99 (31.83%)	41 (13.19%)	311 (100%)	171 (5.98%)	140 (45.02%)

posture has been rated as poor posture. Overall score to classify to this postural category, according to Klein, Thomas and Mayer was 16–20 points. Correct posture was the sum of the children in the I. and II. postural category and it is presented in column I.+II. The incorrect posture corresponded to the sum of the children of the III. and IV. postural category and it is presented in column III. + IV.

Out of 311 examined pupils, 53 (17.04%) pupils had perfect posture and were classified to postural category I. Good, almost perfect posture was assessed in 118 (37.94%) pupils and they were classified to postural category II. Faint posture was evaluated in 99 (31.83%) pupils and they were classified to postural category III. Poor posture was present in 41 (13.19%) pupils and these pupils were classified to postural category IV. Correct posture was evaluated in 171 (54.98%) children (column I. + II.) and incorrect posture was evaluated in 140 (45.02) children (column III. + IV.).

The number of proper posture: n_s= 171, π=171/311=0.549839, q= 1-π = 0.450161, constant π_0=0.5.

Test characteristic:

$$z_{stat} = \frac{0{,}549839 - 0{,}5}{\sqrt{\frac{0{,}549839 * 0{,}450161}{311}}} = 1{,}766647,\ z_{0{,}05} = 1{,}644854.$$

The calculated value of "z" is higher than the critical value, therefore we recommend to accept alternative, one-side hypothesis. The statistically significant postural disorders were found in the sample which allows us to assume that this trend is general. Generally speaking poor posture occurs in more than 50% of the population surveyed.

Children's posture is result of proper body segments position. Incorrect body segments position causes postural disorders and pathologic posture. That's why we assessed all the body segments which directly affect posture.

Our additional assumption was that the most critical body segments that are the most affected by the deformities are the shoulder blades and shoulders and that its occurrence in children reached 80%. We also assumed, that very critical body segment that directly affect children's posture is fallen arch of the foot (flat feet) and that this deformity occurs in 70% of children. That's why we analysed each body segment separately. The occurrence of pathological position of body segments are shown in Table 2.

The most critical segments, as we supposed, were shoulder blades, shoulders and arch of the foot. All three segments have higher occurrence than 50%. Shoulder blades deformity (scapula alatae) occurring in almost 82% of respondents. They were followed by the pathologic shoulder position – shoulder protruding (occurrence in 80%) and flat feet (occurrence in almost 66%). Pelvic disorders (pelvis anteversion) reached almost 46%. Pathologic position of head (forward head) occurrence in 42% of understudy children. Spinal deformities in sagittal plane (cervical hyperlorosis, thoracal hyperkyphosis and lumbar hyperlordosis) occurrence in more than 30%, chest deformities reached 17% and scoliosis were found in 13% of assessed children. Let us verify the assumption in surveyed.

In Table 3, we present the occurrence of shoulder blades and shoulders deformities and feet defect in children we assessed.

Out of 311 school children we studied, shoulder blades deformities had 254 children (81.7%), pathologic position of shoulders was found in 250 children (80.4%) and flat feet was assessed in 205 school children (65.9)

Tab. 2. Pathologic position of body segments

Body segments deformities	%	order
scapula alatae	81.67203	1
shoulders protruding	80.38585	2
flat feet	65.9164	3
pelvis anteversion	45.98071	4
head protruding	42.44373	5
cervical hyperlordosis	37.94212	6
hyperkyphosis	32.15434	7
lumbar hyperlordosis	30.22508	8
chest deformities	17.36334	9
scoliosis	13.18328	10

Tab. 3. Number of children with pathological position of shoulders, shoulders and flat feet (n=311)

Body segments	*No of children with pathologic segment position*	*%*
shoulder protruding	250	80.4
Scapula alatae	254	81.7
flat feet	205	65.9

To verify our assumption, we used base rate quantity test. File range n=311 was high enough and we could approximate the distribution by a normal division

$N = \left(\pi, \sqrt{\frac{\pi.(1-\pi)}{n}}\right)$ and use a test statistic $z = \frac{\pi-\pi_0}{\sqrt{\frac{\pi.(1-\pi)}{n}}}$

for the division N (0,1). We compare the test statistic with the critical value z_α. If the value is $|z| < z_\alpha$ we recommend to accept the zero hypothesis. Otherwise, we recommend to accept the alternative hypothesis.

Results for base rate quantity test for shoulders:

n_s= 250, π=250/311=0.8167, q= 1-π= 0.18328, constant π_0=0.8, π.(1-π)=0.1497

Z_{stat}=0.76213, critical value $z_{0.05}$=1.644854.

Based on our calculations shoulder deformities occurrence in 80% of children in first grade. The assumption of the occurrence of the poor shoulder position was confirmed.

Results for base rate quantity test for shoulder blades:

n_s= 254, π=254/311=0.8038, q= 1-π = 0.196, constant π_0=0.8, π.(1-π)=0.1577

Z_{stat}= 0.171367, $z_{0.05}$=1.644854.

The test results confirmed that the shoulder blades deformities occurrence in 80% of children in first grade. The assumption of the occurrence of shoulder blade position disorder was confirmed.

Results for base rate quantity test for flat feet:

n_s= 205, π=205/311=0.6592, q= 1-π = 0.3408, constant π_0=0.8, π.(1-π)=0.2247

Z_{stat}= -1.51934, $z_{0.05}$=1.644854

The test results also confirmed that the flat feet occurrence in 70% of children in first grade. The assumption of the occurrence flat feet was also confirmed.

DISCUSSION

We found a high frequency of poor posture in children. These phenomena occur in first graders in all 16 districts throughout Slovakia. Poor posture is a serious issue concerning children of elementary schools. Mitová (2015) state it is a fairly common diagnosis in children age, as well as adolescence and the occurrence are starting to become alarming. As early as in 1993 Thurzová pointed out the fact that only 10% in younger school age children has and outstanding posture (Thurzová 1993). It means that only 10% of children under her study in 1993 was classified as category I according to Klein *et al.* Subsequently Vajíčková in 2005 rated the posture in first stage of primary school in two primary schools in Slovakia. The results showed that in one of the primary schools none of the children (0%) was classified as category I – perfect body posture, while in the second school 5.6% of children fell into category I. Both samples arithmetic average gave only 3.6% of children with perfect posture (Vajíčková, 2005). The latest research of postural disorders in children in Slovakia was carried out within the project "Preventing Bad Body Holding in School Children". The results from the project point to the occurrence of postural disorders in pupils in 22.5% of cases (Zanovitová *et al.* 2011). Our findings shoe that out of 311 school children bad posture had 41 children (13.19%). Flimsy posture had 99 children (31.83%). 118 children had a good posture (37.94%) and only 53 pupils (17.04%) had excellent, physiologic body posture.

Situation is critical all over the world. Brianzi *et al.* (2011) observed the incidence of postural disorders in 210 children aged 7 to 10 years at a primary school in San Paule, Brazil. They reported that postural deviations and asymmetry of the posture were found in each child they investigated. In the Czech Republic, Kratěnová *et al.* (2008) monitored posture in 3520 children in 10 cities and they recorded incorrect posture of the body in 38% of monitored pupils. Similar incidence of the body and the musculoskeletal disorders (40.86%) was observed in smaller study from Montenegro with children enrolled in elementary school (Joksimović *et al.* 2012). In Bulgaria, Mitova reports high occurrence of non-physiological behavioural disorder. Out of 2129 children she observed, 58.85% of the monitored population had postural disorders (Mitova 2015). Lafond *et al.* (2007) evaluated children's posture in Canada. They evaluated the deviations of the posture in the sagittal plane. Their results indicate that the children aged 4 - 12 years have pathologic posture in sagittal plane and it is characterized by the forward head position, forward shoulders position, pelvis and knees forward position. In Israel, 62.4% of the children surveyed had body posture issues (Adar 2004). In Switzerland, the incidence of musculoskeletal disorders in children in the first and third grades of primary schools for 2008 was 55% of the children surveyed, while in 2010 this number increased to 66.5% (Jehle & Kühnis 2011). In Poland, 2372 children aged 3 to 18 years followed and 67.9% evaluated at least one postural defect (Macialczyk-Pap-

rocka 2017). Brzek *et al.* (2016) report the incidence of postural disorders in Poland ranging from 30 to 69%. In Serbia, 1309 children were examined and up to 1060 children, representing 80.9%, had postural disorders diagnosed (Nikšić *et al.* 2015). In Croatia, Paušić found that 51.58% of children that was observed had certain asymmetry in the body (Berisha 2015).

Kutílek *et al.* (2015) report that disorders of the musculoskeletal system (where we include posture disorders) have a negative effect on the position of the body segments. This fact has been confirmed in our study. In the observed school population, we noted the pathological status of each observed body segment. The most critical body segments that affected posture in children we observed were pathological position of blades, shoulders and fallen arch of the foot. Out of 9 observed segments blades, shoulders and fallen arch of the foot ended up in first three places. These findings confirmed our assumption that these are the most critical posture segments. The most critical segments in children we assessed was shoulder blades. 82% of respondents has pathological position of blades. Poor shoulders position were second the most critical body segments. Its pathology is occurring in 80% of respondents. Fallen arch of the feet was third body segment, in which deformities reached almost 65% of children. Kratěnová *et al.* (2008) also claim that protruding blades are the most critical segments. Another pathological position they mention were shoulder asymmetry, anteversion of the pelvis and pathological spine curvature in sagittal plane. In their sample, just like in ours, spine deformities in sagittal plane exceeded 30% (Kratěnová *et al.* 2008). We have to highlight also unfavourable values obtained in other segments. Pathological position of pelvic, in our research group, was found in almost 46% of respondents, pathological position of the head in 42%. Pathological spine curvature in sagittal plane exceeded 30% in each section and we found also spine deformities in frontal plane. In this plane 13% of respondents had scoliotic posture. Pathological position of thorax was observed in 17% of respondents. Penha (2005) also reports pathologic position of body segments in first stage of primary school. Girls in the first stage of primary school show the following disorders – pathological position of shoulders, shoulder blade, anteversion of the pelvis, head position disorder, lumbar hyperlordosis, hyper kyphosis, scoliosis, and pathological position of the trunk (Penha *et al.* 2005).

Longitudinal arch is also an important segment which influencing the overall body posture. Foot arch has an important impact on body posture and keeping balance. Signals from mechanoreceptors and proprioceptors of the sole are processed in central neuros system (CNS) and the body reacts by the change in its position. Flat feet make this afferentation inaccurate so the motion is distorted (Hošková *et al.* 2012) and so is the body posture. Therefore, it is important to observe also fallen arch and flat feet and in case of pathology introduce suitable measures to minimalize their impact. The arch is very often fallen in pupils in the first stage of primary school and children often have flat feet. In our sample fallen arch exceeded 65%. These pupils were diagnosed with pedes plani. Similar situation is described by Joksimović *et al.* (2012). They diagnosed pedes plani in 64.53% children when they were starting their school attendance.

Negative situation concerning school age children body posture resulting from unsuitable lifestyle of both children and their families. Nowadays negative lifestyle of children is characterised by the lack of motion and long-time sitting. This phenomenon is described by authors as modern population´s hypokinesis. Hypokinesis, according to Romanov *et al.* (2015), is the time spend sitting or lying in front of a TV, computer, tablet or mobile phone but also driving children to kindergartens and primary schools, using lifts, etc. Kratěnová, *et al.* (2008) state that besides free time spent unsuitably, children lack organized physical activity in schools and time spent sitting is more and more common. In Slovakia physical education is limited to 2 lessons a week, which is an unproportionable short time compared to activates done while sitting. At the same time less and less children spend their free time moving and they do more and more activities at home sitting. Kratěnová also state that only a third of children they observed spent a maximum of one hour watching TV, playing PC games, etc. As much as 12% of school age children watch TV (video, PC) 1.5–2 hours a day and other 20% spent 2,5-3 hours sitting. The amount of time gets higher with age. Adar (2004) claim that posture disorders in the observed children was in general interconnected with the lack of motion and disproportionally long time spend in such posture inappropriate position as sitting is. Except hypokinesis, posture disorders and the pathological position of body segments are caused by improper sitting, standing or moving, weight and mischief of the school bag, passivity of children in their free time, overweight children and improper nutrition (Grannemann *et al.* 2018; Chaves *et al.* 2017; Macialczyk-Paprocka 2017; Brianzi *et al.* 2016).

The prevalence of postural insufficiencies in children is high (Albertsen *et al.* 2018) and need to be addressed.

In our study we tried to approach the issue postural disorders in school-age children. For postural diagnostic we used the methodology of Klein, Thomas and Mayer and for the pedes plani diagnostic we used Napoleon Wolanski scale. Both methods are available, a simple, inexpansive and reliable diagnostic methods. Therefore, any physiotherapist, podiatrist, orthopaedist or physician doctor may use them in its practice to monitor the incidence of postural disorders and propose timely preventive and therapeutic treatment. However, we have encountered certain limitations of these methodology. The Klein, Thomas and Mayer methodology and Napoleon Wolanski scale are visual diagnostic methods. At present time, there are sev-

eral modern computerized diagnostic methods that are applied in clinical practice. Unfortunately, access to computer assessment of posture in our workplaces is currently not available and therefore we have been limited to visual diagnostics. The size of the deformities cannot be seen from our examination and it cannot be judged whether these deformities are functional or structural. We recommend completing an examination by pathography and computational analysis in specialized clinics. The limitation of our research was also the subjectivity of the examination techniques compared to the computerized techniques. Although the methodology of Klein, Thomas and Mayer, that we used in posture analysis, accurately describes the numerical values of the position of body segments and spinal segments, the physiotherapist's professional experience (years of practice, number of examined children, etc.) plays a role in analysing and in the postural evaluation. To rule out this subjective factor, the posture of school children was always analysed by the same physiotherapist.

Although we did basic, simple, but reliable body segments and posture analyses, we did not do a complex kinesiological analysis in children (family history of skeletal deformity, exploring the skin for any unusual skin stigmata, exploring the skin or muscles for trigger or tender points or hyperalgic zones, we didn't do backbone mobility measurements etc.). These assessments were recommended for children diagnosed with postural categories C and D as additional diagnosis techniques in the department of physiotherapy.

Our research group was small. Its consisted from 311 school children from 16 districts in Slovakia. We consider it as another limitation of ours study. Evaluating of posture should be extended to a larger population of schoolchildren.

On the basis of facts which we have gained in our research, we would suggest apply postural assessment of schoolchildren's in clinical practice. We also recommend monitoring the impact of the long-term sitting, the effect of wearing a school bag and monitoring the movement activities of children on their posture. We recommend implementing corrective and compensation exercises into the physical education. Corrective and heath exercise prevents development of muscular unbalance, posture and backbone deformities, unproper body segments position and promotes the correct development of the musculoskeletal system in children (Rusnák *et al.* 2017). Last but not least, we recommend include sports activities to children's lifestyle and parent´s education about postural disorders in their children. Parents must be aware of the impact of sedentary activities on the posture. Instead of allowing their children to sit in front of the computer, TV or mobile phone, parents should encourage different types of movement for children, such as walking to and from school, cycling, playing at the playground, taking the stairs instead of a lift, hiking and, of course, encourage regular sport activities to children´s lifestyle.

CONCLUSION

The aim of our study was to identify incidence and prevalence of postural disorders in school children and to identify the most critical body segments in school children that are the most common affected by deformities. Based on our assessment and analysis of children's body segments we found that the health status of the children's locomotor system, especially postural status, is poor and that there is need to create preventive programs for school children. There is need to implement corrective exercises for scapula alatae, protruding shoulders and flat feet during physical education. There is also need to focus corrective exercises to reduce: pelvis anteversion, head protruding and spinal curvatures deformities. Although chest deformities reached 17%, there is also need to implement respiratory exercises and respiratory gymnastic to physical activities. Last but not least, there is need engaging children in sports.

Early identification of postural disorders in children and adequative prevention based on assessment results may be helpful in reducing of this civilization disease.

REFERENCES

1 Adar BZ (2004). Risk factors of prolonged sitting and lack of physical activity in relate to postural deformities, muscles tension and backache among Israeli children (dissertation). Budapest: Semmeleweis University.

2 Albertsen IM, Brockmann B, Hollander K, Schröder J, Zech A, Sehner S, Stücker R, Babin K (2018). Spinal posture changes using dynamic rasterstereography during the modified Matthiass test discriminate between postural weak and strong healthy children (10-14 years): a pilot study. Eur J Pediat. **11**:1327–1334.

3 Beganović E, Bešović M, Bešović H (2012). Držanje tijela kod učenika šestih razreda. [(Body posture of students sixth grade pupils.) (In Serbian with English abstract.)] Sport Mont. **34, 35, 36**/X: 53–61.

4 Berisha M (2017). Posturalne smetnje djece pretpubertetske dobi uzrokovane nepravilnim držanjem i nedostatkom tjelesne aktivnosti. [(Postural disorders of pre-pubertal children caused by improper posture and lack of physical activity – dissertation). (In Croatian with English abstract)]. Zagreb: Kinziološki Fakultet u Zagrebu.

5 Brianezi L, Cajazeiro DC, Maifrino LBM (2011). Prevalence of postural deviations in school of education and professional practice of physical education. JMS. **28**: 35–36.

6 Brzek A, Soltys J, Gallert-Kopyto W, Gwizdek K, Plinta R (2016). Body posture in children with obesity – the relationship to physical activity (PA), Pediatr. Endocrinol Diabetes Metab. **22**: 148–155.

7 Chaves PJ, De Oliveira FEM, Damázio LCM (2017). Incidence of postural changes and temporomandibular disorders in student, Acta Ortop Brasi. **25**: 162–164.

8 Grannemann J, Holzhauer S, Blumentritt S, Larsen J, Braunschweig L, Hell AK (2018). A prospective 1-year study on load reduction of school backpacks shows reversible changes of body posture in schoolchildren. Int J Adolesc Med Health. [online]. [Epub ahead of print]. [cit. 25.12.2018]. doi:10.1515/ijamh-2018-0132

9 Haladová E, Nechvátalová L (2010). Vyšetřovací metody hybného systému. [(Examination methods of the locomotor system) (In Czech)] Brno: Národní centrum ošetřovatelství a nelékařských zdravotní odborů.

10 Hošková B (2012). Vademecum. Zdravotní tělesná výchova (druhy oslabení). [(Health physical education (types of weakening) (In Czech)].Praha: Univerzita Karlova v Praze.
11 Janda V (2001). Vadné držení těla, m. Scheuermann. [(Faulty posture, M. Scheuermann) (In Czech)] IGA MZ ČR 5390-3. Posjećeno: 14.12.2017 na mrežnoj stanici Česká lékařská společnost Jana Evangelisty Purkyně: https://www.google.sk/search?q=JANDA%2C+Vladim%C3%ADr%2C+2001.+Vadn%C3%A9+dr%C5%BEen%C3%AD+t%C4%9Bla%2C+m.+Scheuermann.+IGA+MZ+%C4%8CR+5390-3.&oq=JANDA%2C+Vladim%C3%ADr%2C+2001.+Vadn%C3%A9+dr%C5%BEen%C3%AD+t%C4%9Bla%2C+m.+Scheuermann.+IGA+MZ+%C4%8CR+5390-3.&aqs=chrome..69i57.1228j0j8&sourceid=chrome&ie=UTF-8.
12 Jehle C, Kühnis J (2011). Postural assessment of primary school children in Liechtenstein: a longitudinal study 2008–2010. Schweizerische Zeitschrift für Sportmedizin und Sporttraumatologie. **59**: 133–135.
13 Joksimović V, Joksimović M, Tomić S (2012). Najčešći deformiteti koštano-zglobnog sistema kod djece pri upisu u osnovnu školu. [(The most common deformities of the musculoskeletal system in children at primary school enrollment) (In Bosnian)] U Lazović M. (ur.): 12. Kongres fizijatra Srbije sa medjunarodnim učešćem. (str. 88-89). Vrnjačka Banja: Udruženje fizijatra Srbije.
14 Kratěnová J, Žajglicová K, Malý M, Filipová V (2008). Výskyt vadného držení těla u dětí školního věku v ČR. [(The increase of defective body holding in children's age.) (In Czech with English abstract.)] Demografie. **50**: 144–148.
15 Kutílek P, Socha V, Schlenker J, Čakrt O, (2015). Trajectory length of pitch vs. roll: Technique for assessment of postural stability. Acta Gymnic. **45**: 85–92.
16 Lafond L, Descarreaux M, Normand CM, Harrison ED (2007). Postural development in school children: a cross-sectional study. Chiropractic & Osteopathy. **15**: 1–7.
17 Maciałczyk-Paprocka K, Stawińska-Witoszyńska B, Kotwicki T, Sowińska A, Krzyżaniak A, Walkowiak J et al. (2017). Prevalence of incorrect body posture in children and adolescents with overweight and obesity. Eur J Pediatr. 2017 May;**176**(5): 563–572. doi: 10.1007/s00431-017-2873-4. Epub 2017 Feb 22. PubMed PMID: 28229267.
18 Kolarová M, Rusnák R, Hrčková Z (2018). Assessment of body and spine posture in school children [(Hodnotenie držania tela a chrbtice u školopovinných detí) (In Slovak)]. In: Tupý, J, Lacko A, Nováková M, Andráši I: Ružomberské zdravotnícke dni. (str. 216-225). Ružomberok: Verbum - vydavateľstvo Katolíckej university.
19 Marjanović B , Petronić I, Vujačić V, Popović S (2012). The importance of systematic physical examination in prevention of spine deformity. U Lazović, M. (ur.): 12. Kongres fizijatra Srbije sa medjunarodnim učešćem. (str. 74-77). Vrnjačka Banja: Udruženje fizijatra Srbije.
20 Mitova S (2015). Frequency and prevalence of postural disorders and spinal deformities in children in primary school. Research in Kinesiology. **43**: 21–24.
21 Nikšić E, Mahmutović I, Rašidagić F (2015). Postural disorders of the spinal column in students of class teaching in relation to gender (Posturalni poremećaji kičmenog stuba kod učenika razredne nastave u odnosu na pol) (In Bosnian) In Jovanović M, Nićin D (2015): Sportske nauke i zdravlje. (str.100-110). Banja Luka: Panevropski univerzitet „APEIRON".
22 Penha JP, João SM, Casarotto RA, Amino CJ, Penteado DC (2005). Postural assessement of girls between 7 and 10 years of age. Clinics. **60**: 9–16.
23 Protić – Gava B (2015). Dobro držanje tela u detinjstvu - sigurnost za budućnost kvalitetnijeg života [(Good body posture in childhood - security for the future of a better quality of life (In Croatian)] U Jovanović M, Nićin D (2015): Sportske nauke i zdravlje. (pp. 9-18). Banja Luka: Panevropski univerzitet „APEIRON".
24 Romanov R, Stupar D, Mededovć B, Brkin D (2014). Posturalni status dece predškolskog uzrasta na teritorii Novog Sada. TIMAS Acta **8**: 129–135.
25 Rusnák R, Kolarová M, Hrčková Z (2017). Zdravotné cviky pre deti školského veku – metodická príručka [(Health Exercises for School Children – Methodological Handbook (In Slovak)] Bratislava: Občianske združenie za zdravší život.
26 Thurzova E, Kováčová E, Medeková H (1998). Vývoj funkčných svalových porúch u detí mladšieho školského veku [(Development of functional muscle disorders in children of younger school age) (In Slovak with English abstract.)] Rehabilitácia. **26**: 153–156.
27 Vajičková J (2005). The effect of dynamic sitting in schools [(Efekt dynamického sedu na školách) (In Slovak with English abstract)] Rehabilitácia. **42**: 155–160.
28 Zanovitova M, Zanovit I, Bendíková E (2011). Health and condition of locomotor system in adolescents. [(Zdravie a stav oporno-pohybového systému u adolescentov) (In Slovak with English abstract.)] Kontakt. **13**: 356–366.