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Influence of physical activity on prevention and occurrence of spinal deformities in children during development

Uticaj fizičke aktivnosti na prevenciju i pojavu deformiteta kičmenog stuba kod dece u razvoju

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Abstract

Background/Aim. The published data indicate that the appearance of spinal deformities in children is significantly influenced by physical activity. The aim of our study was to examine the influence of physical activity on prevention and occurrence of spinal deformities in children. **Methods.** The study was conducted as observational, clinical study in the period from 2016 to 2018. Participants were children with spinal deformities, which were examined, for the first time, by physiatrists and pediatric surgeons. The sample included 100 children with spinal deformities, aged 7–17 years. The control group consisted of 100 children without spinal deformity, of similar age. The study instrument was a questionnaire based on a survey filled by children or parents/legal guardians. The questions were related to different parameters of the possible significance for the existence of spinal deformity and especially to the influence of physical activity. The collected data were processed using methods of descriptive and analytical statistics. **Results.** Scoliosis the most common deformity of the spinal column, represented in about 67% of children ($p = 0.0006$). Respondents from both groups did not differ significantly in terms of gender. Children in the group with spinal deformities were older (11.5 ± 3.1 years vs. 10.4 ± 3.1 years, $p = 0.016$), with increased body weight (43.9 ± 16.0 kg vs. 39.3 ± 16.6 kg, $p = 0.046$) and height (151.7 ± 17.2 cm vs. 145.8 ± 18.2 cm, $p = 0.019$), as well as with less physical activity (81.0% vs. 92.02%, $p = 0.001$). Over 80% of children were regularly engaged in physical activity, more often recreationally and on average 2.5–3 hours per week. **Conclusion.** Children in the spinal deformity group were significantly less involved in physical activity than the control group, but there was no significant difference in the frequency and duration of time spent in physical activities during the week. It is important for children to be involved in physical activities of a recreational nature, and according to our research, 3 hours during the week.

Key words:
adolescent; child; exercise; kyphosis; scoliosis; spine; spinal curvatures; surveys and questionnaires.

Apstrakt

Uvod/Cilj. Publikovani podaci ukazuju na to da na pojavu deformiteta kičmenog stuba kod dece značajan uticaj ima fizička aktivnost. Cilj istaživanja je bio da se ispita uticaj fizičke aktivnosti na prevenciju i pojavu deformiteta kičmenog stuba kod dece. **Metode.** Istraživanje je sprovedeno po tipu opservacione, kliničke studije u periodu od 2016. do 2018. godine. Učesnici studije su bila deca sa deformitetima kičme, koja su prvi put pregledana od strane fizijatra i dečjeg hirurga. Uzorak je obuhvatio 100 dece sa deformitetima kičme, uzrasta 7–17 godina. Kontrolnu grupu je činilo 100 dece bez deformiteta kičme, sličnog uzrasta. Instrument studije bio je upitnik na bazi ankete koji su popunjavala deca ili roditelji/staratelji. Pitanja su se odnosila na različite parametre od mogućeg značaja za postojanje deformiteta kičme, a posebno na upražnjavanje fizičkih aktivnosti. Prikupljeni podaci su procesuirani korišćenjem metoda deskriptivne i analitičke statistike. **Rezultati.** Skolioza je bila najčešći deformitet kičmenog stuba, zastupljena kod 67% dece ($p = 0.0006$). Ispitanici iz obe grupe nisu se bitno razlikovali prema polu. Deca u grupi sa deformitetima kičmenog stuba bila su statistički značajno starijeg uzrasta (11,5 ± 3,1 god. vs.10,4 ± 3, 1 god, $p = 0.016$), povećane telesne mase (43,9 ± 16,0 kg vs. 39,3 ± 16,6 kg, $p = 0.046$) i visine (151,7 ± 17,2 cm vs.145,8 ± 18,2 cm, $p = 0.019$) i bila su manje fizički aktivna (81,0% vs. 92,0%, $p = 0,001$). Preko 80% dece se redovno bavilo fizičkim aktivnostima, češće rekreativno

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i u proseku 2,5–3 sata nedeljno. **Zaključak.** Deca iz grupe sa deformitetima kičme su bila značajno manje uključena u fizičke aktivnosti u odnosu na kontrolnu grupu, ali nije bilo značajne razlike u učestalosti i trajanju vremena provedenog u fizičkim aktivnostima tokom nedelje. Za decu je važno da se bave fizičkim aktivnostima, rekreativno, a prema našem istraživanju 3 sata nedeljno.

Ključne reči:
adolescenti; deca; vežbanje; kifoza; skolioza; kičma, krivine; ankete i upitinici.

Introduction

Spine deformities are pathological deviations of the curvature of the spinal column from normal physiological curves. Nonstructural deformities of the spine are due to postural dysfunction, lower limb inability, inflammatory, posttraumatic and other conditions [1]. Structural deformities of the spine include deformities resulting from pathological changes in the structure and morphology of spinal vertebrae that are of etiologically different causes [1–3]. The results of systematic examinations of children in primary and secondary schools show that the deformities of the spinal column are increasing from year to year. The development of spinal deformity in children in the developmental period is associated with the gender, body weight, body height and age of the child, family burden of the spinal column deformities, hereditary diseases and other conditions, as well as with insufficient physical activity [3, 4]. The diversity of psychophysical abilities of children by age groups indicates that aerobic muscle endurance starts from early childhood, and anaerobic endurance and their strength from puberty and later [5]. In children aged 8–10 years, the elasticity and flexibility of the locomotor system is particularly expressed, while in children from 10–17 years, the strength of muscles dominates, along with the development of movements, speed and coordination. Reduced physical activity, rapid growth and poor life habits lead to the weakness of musculature of the trunk in the stage of rapid growth of children and the appearance of dysfunctional deformities of the spinal column [4, 6]. The changed statics have a tendency to progress with the onset of deformities, such as kyphosis and scoliosis, which can have permanent physical, psychological and social consequences on the growth and development of children. Physical activity is the basis for the preservation of health, it has a favorable effect on growth and it is equally important in all life cycles of the child's development. Regular physical activity, through exercises of the appropriate type, intensity and duration, is a prerequisite for preventing the development of spinal deformity in children [6]. Early detection of spinal deformities is of a great importance for the application of preventive measures to prevent the progression of deformities and possible unwanted complications [7]. Bearing in mind the different results in the available literature on the impact of physical activity on deformities of the spinal column, the aim of this study was to examine and determine the effectiveness of regular and individually oriented physical activity on the prevention and appearance of spinal column deformities in children in the developmental period.

Methods

The study was conducted as prospective, observational, clinical study at the University Children's Hospital (UCH) in Belgrade in the period from July 1, 2016 to August 1, 2018. Participants were children aged between 7-17 years, who, due to deformity of the spine, were examined by pediatric orthopedist and physiatrist. The group of respondents were children with deformities of the spinal column (D) (n = 100). The control group (C) was composed of the children without spinal deformity (n = 100), who came for physical examination of the pediatric orthopedist or physiatrist at the UCH, because of another reason and whose normal spinal column was confirmed, at least by one of mentioned physicians. The participants of both groups were otherwise healthy, because the children with congenital anomalies, associated diseases of the spine, syndromes, neuromuscular and metabolic diseases were excluded from the study. Parents or legal guardians of children completed questionnaires in cases where children were unable to fill them. The purpose of the research had been explained to respondents, before they confirmed in writing their voluntary consent to fill in the questionnaire.

The questionnaire, on the basis of the survey, was conducted on a sample of respondents from both examined groups. It contains 10 questions, which are defined quantitatively through 4 groups of questions.

The first group of questions was referred to demographic data on children: gender, age, weight and height.

The second group of questions was related to the type of spine deformity that has been detected in a child, based on a clinical finding: kyphosis, scoliosis and lordosis, as well as family burden on hereditary diseases, in particular hereditary deformities of the spine and associated morbidity.

The third group of questions has been related to the physical activity: the first question defined whether the child was engaged in physical activity, with the answers provided with yes and no; the second question referred to the weekly physical activity rhythm, and the response was offered in 2 scales: 1–3 times and more than 3 times. The third question has been related to the time that a child spends on physical activity during the week, and the response is also offered in 2 scales: 1–3 hours and over 3 hours.

The data collected from the questionnaire were analyzed by comparing the results with respect to the control group.

The questionnaire wass the original work of the author within the doctoral dissertation based on the available literature and many years of clinical experience as a specialist in social medicine.

During the study, all legal regulations, defined by the provisions of the UCH Ethics Committee were respected and harmonized with the European Guidelines in this field.

Statistical analysis

Statistical data analysis was done using the SPSS 20.0 for Windows (SPSS Inc.Chicago, IL, USA). The collected

data were processed using descriptive and analytical statistics and displayed both in tables and graphically. The significance of the difference was obtained by Student's *t*-test (in the form of contingency tables), the Fisher's, Mann-Whitney's and χ^2 test, as well as, by two-way ANOVA test for independent variables on multiple levels. Statistical significance was set as $p < 0.05$.

Results

According to subjects' gender among the subjects of the experimental group (D), 53 (53%) of children with spinal deformities were males, while in the control group, 45 (45%) were males without statistically significant difference between groups ($\chi^2 = 1.281$; $p = 0.258$) (Table 1).

The average age, body weight, and body height, as well as body mass index (BMI) of children with deformities of the spinal column and children in the control group are shown in Table 1.

Among 100 children with spinal deformities, 27% had kyphosis, 6% had lordosis and 67% had scoliosis. The most common spine deformity was scoliosis with very high statistical significance ($p = 0.0006$).

Considering the significant difference in the incidence of various types of spinal deformities (scoliosis, kyphosis and lordosis), demographic data observed within each of them are presented in Table 2.

Deformity of the spine as a family burden was found in 29 (29%) of children in the group with deformities and in 14 (14.0%) of children without deformity of the spine (Figure 1), with statistically significant difference ($\chi^2 = 6.666$; $p = 0.010$). Different inherited diseases of the family members were presented in 11 (11%) children with spinal deformities and in 15 (15%) those without the deformity of the spine, without statistically significant difference ($\chi^2 = 0.707$; $p = 0.400$). Other diseases as family burden, such as hypertension, diabetes mellitus type 2, disorders of thyroid gland etc, were found in 31 (31%) children with deformities and in 28 (28%) children without deformity of the spine, also without statistically significant difference ($\chi^2 = 0.216$; $p = 0.642$).

Physical activity was performed in 81% of children with spinal deformities and in 92.0% of children without spinal deformity, with statistically significant difference between examined groups ($\chi^2 = 5.181$; $p = 0.001$) (Table 3).

The children of both examined groups, with and without spinal deformities were equally engaged in physical activity, 3 times a week, on average 2.5–3 hours per week (range 1–7 h), without any statistically significant difference between them ($U = 4{,}940.5$; $p = 0.879$) (Table 3).

Median time spent in physical activity per week, in children with spinal deformities was 3 hours (range 1–8), while in children without deformity it was 2.5 hours (range

Table 1

Demographic data of participants

Parameter	Values	*p*
Total number (%)		
D	100 (100)	
C	100 (100)	
Gender (M/F), n (%)		
D	53/47 (53/47)	0.258
C	45/55 (45/55)	
Age (year), mean ± SD; median (range)		
D	11.5 ± 3.1; 11.0 (7.0 –17.0)	
C	10.4 ± 3.1; 9.5 (7.0–17.0)	0.016
Body weight (kg), mean ± SD; median (range)		
D	43.9 ± 16.0; 43.0 (18.0–91.0)	
C	39.3 ± 16.6; 34.0 (18.0–90.0)	0.046
Body height (cm), mean ± SD; median (range)		
D	151.7 ± 17.2; 152.0 (116.0–186.0)	
C	145.8 ± 18.2;143.5 (116.0–200.0)	0.019
BMI (kg/m^2), mean ± SD; median (range)		
D	18.5 ± 4.2; 17.9 (11.4–31.9)	
C	17.7 ± 3.6; 17.0 (11.5–32.0)	0.134

D – group of children with deformities of the spinal column; C – control group; M – males; F – females; BMI – body mass index; SD – standard deviation.

Table 2

Demographic data of participants with deformities of the spinal column in regard to the type of spine deformity

Parameter	Values			*p*
Number of participants, n (%)				
scoliosis		67 (67)		
hyphosis		27 (27)		
lordosis		6 (6)		
Gender (M/F), n (%)				
scoliosis	36/31	(54/46)		
kyphosis	13/14	(48/52)		0.705
lordosis	4/2	(67/33)		
Age (years), mean ± SD; median (range)				
scoliosis	11.45 ± 2.996;	11.00	(7–17)	
kyphosis	12.07 ± 3.245;	12.00	(7–17)	0.213
lordosis	9.67 ± 2.658;	9.00	(8–15)	
Body weight (kg), mean ± SD; median (range)				
scoliosis	44.14 ± 16.94;	40.0	(18.0–91.0)	
kyphosis	45.07 ± 13.58;	49.0	(20.0–69.0)	0.485
lordosis	43.93 ± 16.05;	43.00	(18.0–91.0)	
Body height (cm), mean ± SD; median (range)				
scoliosis	152.07 ± 16.28;	152.0	(116–186)	
kyphosis	153.67 ± 18.03;	158.0	(118–185)	0.162
lordosis	151.72 ± 17.21;	152.0	(116–186)	
BMI (kg/m^2), mean ± SD; median (range)				
scoliosis	18.474 ± 4.586;	17.72	(11.4–31.9)	
kyphosis	18.710 ± 3.611;	18.40	(11.9–27.6)	0.946
lordosis	18.135 ± 2.466;	17.36	(15.1–21.4)	

M – males; F – females; BMI – body mass index; SD – standard deviation.

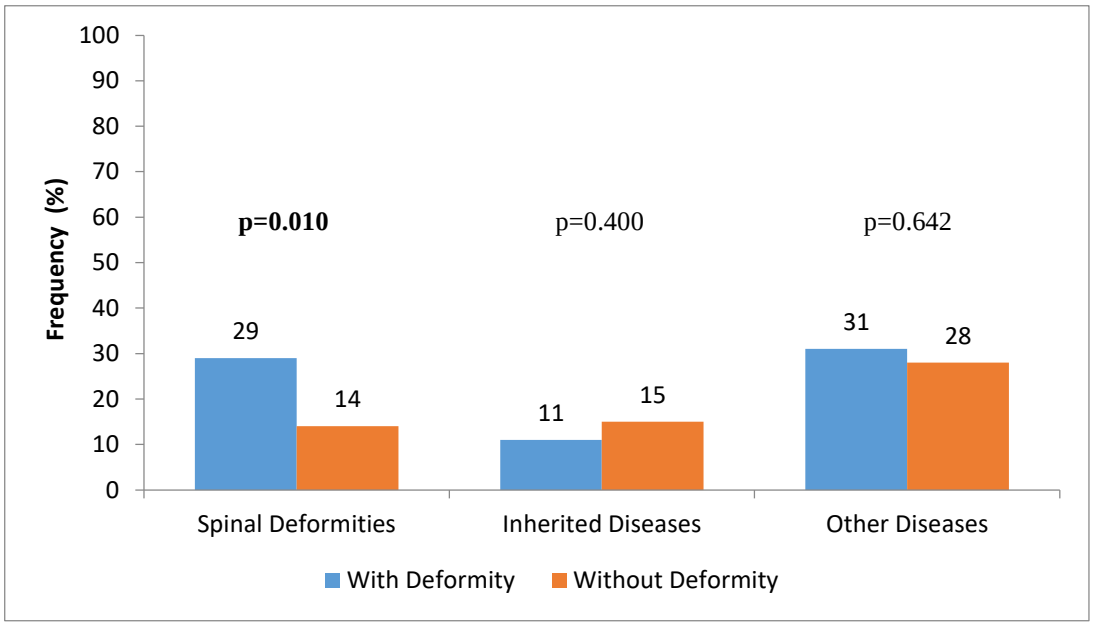

Fig. 1 – Distribution of children according to the association with family burden.

1–9), which was without statistically significant difference (U = 4535.0; p = 0.244) (Table 3).

Physical activity in the D group included recreational activity in 62% of the respondents, while 38.0% of the children had continuous training. In the control group, 61% of the children were engaged in recreational activity and 39% had continuous training, with no statistically significant difference between these two groups (χ^2 = 0.021; p = 0.884).

Also, significantly, more frequent spinal deformities existed in children who had deformity of the spine as a family burden.

In the countries of the European Union, in 10% of children, deformities of the spinal column occur due to insufficient physical activity during adolescence. The exercising physical activity is equally important in all ages, especially in school and at prepubertal age of the child. Reduced physical activity, sudden growth and development of children with bad habits of life, along with family burden, lead to deformity of the spinal column [10].

Table 3

Distribution of participants in regard to physical activity

Parameter	Values			*p*
Number of participants (%)				
D	81 (81)			0.001
C	92 (92)			
Frequency (times/week), mean ± SD; median (range)				
D	3.7 ± 1.7;	3.0	(1.0–7.0)	0.879
C	3.9 ± 1.9;	3.0	(1.0–7.0)	
Duration (h/week), mean ± SD; median (range)				
D	3.2 ± 1.5;	3.0	(1.0–8.0)	0.244
C	3.0 ± 1.7;	2.5	(1.0–9.0)	

D – group of children with deformities of spinal column; C – control group; SD – standard deviation.

Discussion

The most common spine deformities are scoliosis, kyphosis and lordosis [8]. The scoliosis in our study is more frequent, in almost two-thirds of patients, because the most difficult and more complex patients are treated at the UCH as a tertiary healthcare center. The results of the published studies suggest that the incidence of deformity of the spinal column is significantly influenced by the factors of the environment where the children come from, by the age, gender, body mass index, and especially the type and frequency of sport activities [9].

Gunawardena et al. [6], from Japan, in their randomized controlled trial suggest that there is a greater interest for sports in boys vs. girls, which is reflected in the increased incidence of spinal deformity in girls compared to boys in the same developmental period.

Comparing both groups of children with and without the deformity of the spinal column, our research showed that they did not differ much more in relation to the gender, but the older age and increased body weight and height were significantly more frequent in the group with spinal deformities. Although, this is not quite relevant, since these children were certainly older and therefore much heavier and taller than the children in the group without spinal deformities and, in particular, there was no significant difference in BMI among the study groups. Comparing demographic data and BMI of participants in regard to the type of spine deformity, we found that there were no statistically significant difference in the gender distribution, age, body weight and height and BMI among three observed groups of participants with scoliosis, kyphosis and lordosis.

The studies of Plaszewski et al. [9] in 2015 and Tsirikos and Jain [11] in 2011 were aimed to form official protocols on long-term health and treatment of children and adolescents with kyphosis and scoliosis, with the particular importance of prevention and correction of deformities. It was found that physical activities improve and enhance muscle strength, flexibility, bone vitality, BMI, and cognitive function, which emphasize the importance of preventing these deformities in relation to their corrective treatment [9, 11–13].

The World Health Organization has made recommendations on the importance of physical activity by age groups. At the age of 5–17 years, physical activity is recommended through everyday play, sports and recreation and planned exercises within physical education [14]. When choosing sports for children, the age, gender, height, weight of a child, health status and family burden should be taken into account. Moderate to more intense physical activity is recommended in children at least 60 min a day, up to three times a week [15, 16].

The American College of Sports Medicine was the first to formulate guidelines on the amount of physical activity that should be pursued in order to achieve the optimal functional capacity of vital parameters, physical endurance and quality of life [17].

Our research showed that children in the spinal deformity group were significantly less involved in physical activity than those in the control group. Although all of them were regularly engaged in physical activity, on average twice as many of them did it recreationally and not as a continouos

training, which was, on average, 2.5–3 hours per week, or 3 times a week for about 60 min.

Conclusion

Scoliosis is the most common deformity of the spinal column in children.

Children, in the spinal deformity group, are significantly less involved in physical activity than children in the control group, but there is no significant difference in the frequency and duration of the time spent in physical activities during the week. It is important for children to be involved in physical activities of a recreational nature, and according to our research, 3 hours during the week.

REFERENCES

1. *Hawes MC, O'brien JP.* The transformation of spinal curvature into spinal deformity: pathological processes and implications for treatment. Scoliosis 2006; 1(1): 3.
2. *McMaster MJ.* Spinal growth and congenital deformity of the spine. Spine 2006; 31(20): 2284–7.
3. *Bettany-Saltikov J, Weiss HR, Chockalingam N, Kandasamy G, Arnell T.* A Comparison of Patient-Reported Outcome Measures Following Different Treatment Approaches for Adolescents with Severe Idiopathic Scoliosis: A Systematic Review. Asian Spine J 2016; 10(6): 1170–94.
4. *Lizak-Popiołek D, Czarny W, Niewczas M.* The problem of postural defects in children and adolescents and role of school teachers and counselors in their prevention. Sci Rev Physical Culture 2014; 4(4): 11–8.
5. *Baxter-Jones AD, Maffulli N.* Endurance in young athletes: it can be trained. Br J Sports Med 2003; 37(2): 96–7.
6. *Gunawardena N, Kurotani K, Indrawansa S, Nonaka D, Mizoue T, Samarasinghe D.* School-based intervention to enable school children to act as change agents on weight, physical activity and diet of their mothers: a cluster randomized controlled trial. Int J Behav Nutr Phys Act 2016; 13: 45.
7. *Kakar RS, Simpson KJ, Das BM, Brown CN.* Review of Physical Activity Benefits and Potential Considerations for Individuals with Surgical Fusion of Spine for Scoliosis. Int J Exerc Sci 2017; 10(2):166–77.
8. *Sedrez JA, da Rosa MI, Noll M, Medeiros Fda S, Candotti CT.* Risk factors associated with structural postural changes in the spinal column of children and adolescents. Rev Paul Pediatr 2015; 33(1): 72–81. (Portuguese)
9. *Plaszewski M, Kotwicki T, Chwala W, Terech J, Cieśliński IJ.* Study protocol and overview of the literature on long-term health and quality of life outcomes in patients treated in adolescence for scoliosis with therapeutic exercises. J Back Musculoskelet Rehabil 2015; 28(3): 453–62.
10. *Abbott A, Möller H, Gerdhem P.* Contrais: Conservative Treatment for Adolescent Idiopathic Scoliosis: a randomised controlled trial protocol. BMC Musculoskelet Disord 2013; 14: 261.
11. *Tsirikos AI, Jain AK.* Scheuermann's kyphosis; current controversies. J Bone Joint Surg Br 2011; 93(7): 857–64.
12. *Anwer S, Alghadir A, Abu Shaphe M, Anwar D.* Effects of exercise on spinal deformities and quality of life in patients with adolescent idiopathic scoliosis. Biomed Res Int 2015; 2015: 123848.
13. *Fearnbach SN, Masterson TD, Schlechter HA, Ross AJ, Rykaczewski MJ, Loken E,* et al. Impact of imposed exercise on energy intake in children at risk for overweight. Nutr J 2016; 15(1): 92.
14. Determinants of Health. Healthy People 2020. Available from: https://www.healthypeople.gov/2020/about/foundation-health-measures/Determinants-of-Health
15. *Fernández I, Canet O, Giné-Garriga M.* Assessment of physical activity levels, fitness and perceived barriers to physical activity practice in adolescents: cross-sectional study. Eur J Pediatr 2017; 176(1): 57–65.
16. *Schulze A, Schrading S, Betsch M, Quack V, Tingart M.* Adolescent scoliosis: From deformity to treatment. Orthopade 2015; 44(11): 836–44.
17. American College of Sports Medicine. Opinion statement on physical fitness in children and youth. Med Sci Sports Exerc 1988; 20(4): 422–3.

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