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Diversification of the physical and sport education syllabi and its effects on the musculoskeletal system in young female students

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Abstract

Introduction. The prevalence of musculoskeletal disorders in the school-age population might lead to the occurrence of vertebrogenic diseases in adulthood, which stresses the importance of timely primary prevention in the form of health-oriented compensatory exercise programs. Aim of Study. This pilot study presents targeted diversification of physical and sport education syllabi focused on the improvement of the musculoskeletal system's functions in young female students, including body posture, dynamic capacity of the spine, and the muscle system. Material and Methods. The study group comprised of 24 high school female students, divided into experimental (EG; 16.32 ± ± 0.32 years) and control (CG; 16.56 ± 0.56 years) groups. The data were acquired using standardized methods focused on the functional capacity of the musculoskeletal system. Results. In contrast to the control (V_{1-2}) stage, the experimental (V_{3-4}) stage involved diversification of physical and sport education syllabi for the EG subjects, which led to significant changes in their overall body posture ($p < 0.01$). The most significant changes occurred in the abdominal segment and pelvic inclination ($p < 0.01$). The dynamic capacity of the spine ($p < 0.01$), in all five tests, also changed in the EG participants. Bad movement habits affected the quality of the muscle system in the members of both groups. We noted the most significant changes ($p < 0.01$) in m. trapezius pars superior and m. levator scapulae, the muscles responsible for neck pain. The hip flexors contributed significantly ($p < 0.05$) to lower back pain. We found significant differences between the EG and the CG. The EG participants demonstrated improvements in all monitored segments. Conclusions. The results obtained by the EG significantly prove how important it is to diversify physical and sport education syllabi to improve health and the functional capacity of the musculoskeletal system in the school-aged population.

KEYWORDS: musculoskeletal system, physical and sports education, student.

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Introduction

Even ancient books and documents highlight the unity of body and soul in terms of human irreplaceableness and uniqueness. Nowadays, it takes a lot of effort to comprehend the philosophy and essence of health due to opportunities and snares lurking in the 21st century consumer society [5].

Physical activity is closely related to health, quality of life, and lifestyle. It is a multidimensional and complex behavior to measure; its various domains are often misunderstood. It has a fundamental role in the prevention and treatment of chronic diseases. What is more, physical activity is a key commodity for maintaining the proper physical and mental functioning of the human body [4]. Its deficiency significantly affects people's physical fitness, work performance, and health condition [24]. Statistics of health insurance companies in the USA, Canada as well the European Union member states, including Slovakia [9], attest to this fact and point to serious economic and social consequences.

Over the past two decades, the current lifestyle of the school-age population in Slovakia has become hypokinetic [3], which has led to an increase in the prevalence of lifestyle chronic diseases [6], including the musculoskeletal disorders [17]. Insufficient primary prevention of musculoskeletal disorders in childhood leads to vertebrogenic diseases in adulthood, the prevalence of which ranges from 60% to 80%. The most common and primary symptom of musculoskeletal changes and diseases is pain. As many as three-quarters of patients complain about back pain [21], the prevalence of which is 22% in Europe, including children. 46% to 53% of children feel the pain at least once in their lives while 15% of them suffer from persistent pain. The situation in Slovakia, where the occurrence of pain tripled between the years 1996 and 2008, is getting worse as well. The incidence of idiopathic pain syndromes among children in Slovakia ranges from 4.2% to 15.5%. According to Lewit [16], the primary symptom of cervical spine disorders in children is a headache, which is not given enough attention. Moreover, it has been proven that muscle imbalance in childhood can result in later pain. The most common symptoms of functional disorders of the spine in healthy children are sacroiliac shift and functional disorders in the region of the upper cervical spine connected with different types of headaches. Musculoskeletal pain is more commonly secondary and has an additive effect. It can be at the forefront of the whole pain syndrome. Continuous overloading results in coordination disorders and inadequate muscle innervation, which leads to deterioration of degenerative processes. In addition to excitation of nociceptors, segmental disorders also cause reflex muscle tension and further excitation of nociceptors. Consequently, muscles shorten and become weaker, bones are demineralized and tendon entheses become shorter [16].

The aforementioned facts prove how necessary it is to teach school-aged children to be responsible for their health and to search for new preventive measures in their lifestyle. Besides the family [13], physical and sports education at schools can also play an important role [8, 25]. Health, quality of life, lifestyle, and physical activity of the school-age population are becoming widely discussed topics also concerning contemporary physical and sports education at elementary and secondary schools both in Slovakia and abroad [1, 20]. These issues are examined also because the number of school-aged children in Slovakia, who are excused from compulsory physical and sports education owing to different diseases and disorders, is increasing (8% to 15%). Similarly, the number of pupils who do not exercise rises. The percentage of boys who do not exercise ranges from 27.7% to 39.6%, and the percentage of girls who do not exercise ranges between 38.2% and 48.1% [3, 4]. According to the findings reported by the Ministry of Education, Science, Research and Sports of the Slovak Republic, approximately 30% of the school-age population regularly excuse themselves from physical and sport education classes even though there was the major reform of the education system in Slovakia, including physical and sports education in 2008. The aim and the focus of physical and sports education shifted markedly from performance-based classes to the development of pupils' and students' competences and values and attitudes towards their health. The goals of physical and sports education are associated with health care and the development of a healthy lifestyle. Individual teaching methods in physical and sports education focus on the acquisition of habits, attitudes, and knowledge related to physical activity, health, and a healthy lifestyle in the school-age population [3]. In terms of primary prevention of diseases of the musculoskeletal system [15], which is one of the determinants of health, physical and sports education requires interventions [7] in the form of health-oriented exercise programs. These programs help to improve body posture (postural stability), functions of the spine and the muscle system in school-aged children [14, 19, 28], support their adequate development and improve the quality of their health at present and in the future.

Aim of Study

The study aimed to purposefully diversify the physical and sports education syllabi regarding the improvement of the functional capacity of the musculoskeletal system in young female students. This diversification was focused on body posture, the dynamic capacity of the spine, and the muscle system.

Material and Methods

Sample and procedure

The entire study group consisted of 24 female students in the second grade of a high school. The experimental group (EG) comprised 12 students with an average age 16.32 ± 0.48 years (body height 168.36 ± 7.21 cm, body weight 57.62 ± 6.51 kg) and the control group (CG) also consisted of 12 students whose average age was 16.56 ± 0.56 years (body height 167.87 ± ± 6.83 cm, body weight 56.36 ± 4.61 kg). The members of both groups were not interested in physical and sports education and did a physical activity in their free time only occasionally and with low intensity. Furthermore, all the girls complained about pain in the cervical and lumbar regions of the spine, which is regarded as functional disorders of the spine.

Measurements

The pedagogical experiment was conducted in three stages during the school year 2018/2019. The first stage of the study (09/2018) was focused on initial examination (V_1) of the EG and CG participants' musculoskeletal system (body posture, the dynamic capacity of the spine, the muscular system) performed by a physiotherapist. The results of the preventive medical examination confirmed that none of the girls suffered from any serious organic or neurological diseases. Pain intensity was measured using the visual analog scale (VAS). The experiment then continued with physical and sport education classes taught according to the School Education Programme. The second assessment (V_2) of the EG and CG members' musculoskeletal system took place in December. The first stage also included analysis of the classes focused on the syllabi and the use of individual exercises within each physical and sports education lesson. The second stage (01/2019) of the experiment included evaluation of the EG and CG members' musculoskeletal system again (V_3). During this stage, the subjects in the EG had different physical and sport education lessons. They carried out 45-minute health-oriented exercise programs (based on the Acral Coactivation Therapy – ACT) led by their PE teacher twice a week (Tuesday and Thursday) over three months. These programs were also based on the functional capacity of the EG subjects' musculoskeletal system (V_{1-2}).

The ACT exercise programs, introduced by Palaščáková Špringrová [23], are based on children's motor development and its patterns. The basic principle lies in pressing against palm and heel roots or toes, which results in the straightening of the spine. It is essential that the exercises are focused mainly on the closed kinetic muscle chains. The exercise programs based on the ACT method involve movement patterns that are most frequently used in everyday activities of the so-called ADL (Active Daily Life). The subjects wore the FHAS (functional hand arch support) gloves, which supported arches of their hands. This maintained muscle coactivation throughout the entire period of exercise in basic and more dynamic transitions.

The CG members continued having physical education lessons in line with the syllabi determined by the School Education Program. The third stage of the study (04/2019) involved final assessments (V_4) of the monitored factors of the musculoskeletal system in the EG and CG members, which were further analyzed.

We acquired data on the functional capacity of the musculoskeletal system (body posture, the dynamic capacity of the spine and the muscle system) in both groups during the initial (V_1, V_3) as well as the final assessments (V_2, V_4).

Static body posture was evaluated using the method invented by Thomas and Klein and modified by Mayer [11]. This method assesses five segments of body posture: a) head and neck posture, b) shape of the chest, c) the abdominal segment and pelvic inclination, d) curvature of the spine, e) shoulder height and position of the shoulder blades. Each segment was assessed by points 1, 2, 3, 4 (from the best to the worst), where a total of these points classifies the overall body posture of the subjects:

I. Ideal body posture .... 5 points
II. Good (almost ideal) body posture .... 6-10 points
III. Poor body posture .... 11-15 points
IV. Bad body posture................................. 16-20 points

Assessment of the muscle system, which was focused on hyperactive postural muscles that tend to shorten (m. trapezius pars superior, m. levator scapulae, m. pectoralis major, m. quadratus lumborum, m. erector spinae, m. adductores coxae, m. iliopsoas, m. rectus femoris, m. tensor fasciae late, m. knee flexors, m. triceps surae) and hypoactive antagonists with the predominance of phase activity that tend to weaken (deep neck flexors, lower fixators of the scapula, m. abdominis, abductors of the hip joint, extensions of the hip joint), was based on functional diagnostics of the musculoskeletal system Vojtaššák [29].

Aspect-palpation assessment of the dynamic capacity of the spine consisted of six tests [29]: Schober's test (the lumbar spine, normative value: 4-6 cm), Stibor's test (the lumbar and thoracic spine, normative value: 7.5--10 cm), Otto's test (the thoracic spine, normative value: 6 cm), Thomayer's test (overall flexibility of the spine, normative value: 0-2 cm), right and left lateral flexion (flexibility of the lumbar spine to the sides, normative value: 20-22 cm). The intensity of pain was measured using the visual scale (VAS), which is a Likert 11-point scale: 0 = without pain, 10 = the worst possible pain [29].

Statistical analyses

We processed the acquired quantitative and qualitative data using mathematical and statistical procedures: arithmetic mean, standard deviation, and Wilcoxon t-test ($p < 0.01\%$, $p < 0.05\%$). Practical and objective significance was assessed through effect size (r). We used the Mann–Whitney U test ($M_{WU\text{-}test}$ $p < 0.01$, $p < 0.05$) to verify the degree of conformity between two independent groups. The relationship between the selected factors of the musculoskeletal system was assessed using Spearman's correlation coefficient (r_s). We also used the logic analysis and synthesis methods as well as inductive and deductive procedures and comparisons. The data were processed with the R-Project statistical program.

Results

Concerning the aim of the study, we present the results that should be viewed from a wider social and economic perspective as informational and explanatory regarding the current health status of the school-age population.

The initial assessment (V_1) revealed that in both EG and CG the poor body posture was the most prevalent. Eight subjects from the EG had poor posture and 4 subjects had good body posture (the 2nd category). Similarly, 9 subjects from the CG had poor body posture (the 3rd category) and 3 subjects had good body posture. None of the subjects from the EG or the CG had ideal body posture (1st category). The first three months ($V_{1\text{-}2}$) of physical and sports education lessons led by the PE teacher according to the School Educational Program did not lead to any significant changes ($p > 0.05$) in body posture, in either group. However, the health-oriented intervention exercise program that the subjects from the EG performed during three months ($V_{3\text{-}4}$) resulted in positive changes in their body posture. All the subjects in the EG ($n = 12$) underwent positive changes with an average of 2.86 points. The final assessment (V_4) revealed that 10 girls belonged to the second category (good posture) and two girls fell into the first category (ideal body posture). These changes were significant ($p < 0.01$) with the large effect size value ($r = 0.62$). However, we did not find any significant changes in overall body posture in any subjects from the CG during the ($V_{3\text{-}4}$) period. Evaluation of significant differences between the EG and the CG proved the positive effect of the applied exercise program with significant improvement in the EG ($M_{WU\text{-}test} = 9.267$, $p < 0.01$).

As far as other segments of body posture are concerned, the worst values during the first stage ($V_{1\text{-}2}$) in both EG and CG regarded head and neck posture, the shape of the chest and pelvic inclination. Physical and sports education lessons taught according to the School Education Programme during the second stage ($V_{1\text{-}2}$) did not lead to any significant changes ($p > 0.05$) in individual segments of body posture in either group. During the third stage ($V_{3\text{-}4}$), however, we noted positive changes in all five segments of body posture in the EG subjects. The segments I ($r = 0.57$) and III. ($r = 0.57$) were at the one percent significance level, and the segments II, IV and V at the five percent significance level (Table 1). There were no significant changes in any body posture segments in the CG ($p > 0.05$) during the $V_{3\text{-}4}$ stage. Analysis of significant differences between the EG and the CG proved the positive effect of the applied exercise program with significant improvement in the experimental group ($M_{WU\text{-}test} = 9.291$, $p < 0.01$).

Table 1. Changes in individual body posture segments during the experimental period ($V_{3\text{-}4}$) in experimental group ($n = 12$)

Body posture segment	p-value	Effect size (r)
I. Head and neck posture	0.0053	0.57
II. Shape of the chest	0.0420	0.41
III. The abdominal segment and pelvic inclination	0.00512	0.57
IV. Curvature of the spine	0.0423	0.41
V. Shoulder height and position of the shoulder blades	0.0168	0.48

In the first (V_1) and second ($V_{1\text{-}2}$) study stage, we assessed the dynamic capacity of the spine in both EG and CG and we found that most of the subjects demonstrated deviations and did not have normative values in all the tests, which meant that all the subjects demonstrated the lower dynamic capacity of the spine. The final assessment in the second stage (V_2) revealed only minimum changes, which were not significant ($p > 0.05$). The experimental period resulted in positive significant changes ($V_{3\text{-}4}$) ($r = 0.62$, $p < 0.01$) in the EG members, in all five segments of the spine dynamic capacity. The subjects in the CG did not demonstrate any significant changes in the monitored factors of the spine dynamic capacity ($p > 0.05$) in the $V_{1\text{-}2}$ and $V_{3\text{-}4}$ stages. Evaluation of significant differences between the EG and the CG proved the positive effect of the applied exercise program with significant improvement in the EG ($M_{WU\text{-}test} = 9.331$, $p < 0.01$).

The initial assessments in the (V_1) and ($V_{1\text{-}2}$) stages revealed that all the members of the EG and the CG had shortened and weakened muscle groups without significant changes ($p > 0.05$) or differences ($p > 0.05$) between the groups. In the $V_{3\text{-}4}$ stage, the subjects from the EG demonstrated positive changes in the muscle groups that tend to shorten: m. trapezius pars superior

($r = 0.63$, $p < 0.01$), m. levator scapulae ($r = 0.61$, $p < 0.01$), m. pectoralis major ($r = 0.41$, $p < 0.05$), m. erector spinae ($r = 0.60$, $p < 0.01$), m. iliopsoas ($r = 0.42$, $p < 0.05$), the knee flexors ($r = 0.44$, $p < 0.05$) and m. triceps surae ($r = 0.45$, $p < 0.05$).

Similarly, we noted the changes in the muscle groups that have a tendency to weaken: deep neck flexors ($r = 0.41$, $p < 0.05$), lower fixators of scapula ($r = 0.43$, $p < 0.05$), abductors of the hip joint ($r = 0.45$, $p < 0.05$), m. abdominis ($r = 0.54$, $p < 0.01$) and extensions of the hip joint ($r = 0.51$, $p < 0.01$). In the (V_{3-4}) stage, we did not find and significant changes in the muscle system in the members of the CG. The significant changes between the EG and the CG proved the positive effect of the applied exercise programme on the muscle system with significant improvement in the experimental group: $M_{WW\text{-}test} = 8.693$, $p < 0.01$ and $M_{WU\text{-}test} = 5.013$, $p < 0.05$. Having assessed both EG and CG, we found out that forward head posture contributes significantly to the development of functional disorders of m. trapezius pars descendens ($r_s = 0.661$, $p < 0.05$) and m. levator scapulae ($r_s = 0.661$, $p < 0.05$). Furthermore, a shortening of m. trapezius pars descendens and m. levator scapulae has a significant effect ($r_s = 0.661$) on the cervical spine, resulting in pain. Moreover, the protruding abdomen in both EG and CG significantly affected ($r_s = 0.709$, $p < 0.05$) functional capacity of m. erector spinae. The hip flexors contributed significantly ($r_s = 0.638$, $p < 0.05$) to occurrence of pain in the lumbar spine. In the V_{3-4} period, the subjects in the EG did not experience any pain in the cervical and lumbar spine, unlike the members of the CG.

The positive finding of our study is that the EG participants demonstrated significant changes ($p < 0.05$) (Table 2) in the (V_{3-4}) stage, which resulted in improvement and stabilization of low back pain in contrast to the CG subjects ($p > 0.05$) throughout the whole (V_{1-4}) period. As a result, we found significant differences between the EG and the CG ($r = 0.92$, $p < 0.05$).

Discussion

In our opinion, diversification of the physical and sports education syllabi had a positive impact as the participants of the EG demonstrated overall improvement in all monitored segments of the musculoskeletal system and their back pain stabilized. It is important to mention that the physical and sports education syllabus applied in the V_{3-4} stage was based on the assessment of the musculoskeletal system in the participants of the EG while the subjects in the CG had physical and sports education classes taught according to the School Education Program. As far as the healthy development of the school-age population is concerned, even the smallest changes in their lives can have a tremendous impact on their health. In practice, it means that more respect and attention should be paid to the health-oriented fitness of the school-age population, which involves also the musculoskeletal system. The truth is that this system is not given enough consideration in the Slovak physical and sport education syllabi, which need intervention in terms of postural exercise programs focused on pain prevention and lessons teaching good movement habits in everyday life [10].

Several authors [2, 12, 18, 22, 27, 30] have proved in their studies that appropriately selected and targeted exercise programs and health-oriented compensation exercises can have a positive effect on individual segments of the musculoskeletal system as well as on pain [26]. It is important to start and focus on prevention already in childhood before the primary symptoms of the back pain appear.

Even though the school reform in Slovakia continues at different levels and has different forms, it will be necessary to modify the compulsory physical and sports education syllabi at elementary and secondary schools to incorporate the latest scientific findings. The goal is to make teachers' work more effective and broaden school-aged children's knowledge in terms of their health. The aforementioned findings suggest that school

Table 2. Changes in pain assessment during the experimental stage (V_{3-4}) in experimental group (n = 12)

n = 12	1	2	3	4	5	6	7	8	9	10	11	12
$V_{1\ input}$	1	1.5	1	2	1	2	1.5	1	1	1	1.5	2
$V_{2\ output}$	0	0	0	0	0	0	0	0	0	0	0	0.5
$V_{1\text{-}2\ difference}$	1	1.5	1	2	1	2	1.5	1	1	1	1.5	1.5
Wilcoxon test						p = 0.002						
Effect size						r = 0.64						

can considerably influence the health of the school-age population from both qualitative and quantitative points of view.

Conclusions

This empirical study helps to extend the knowledge of how to use health-oriented exercise programs, which are focused on the musculoskeletal system segments such as the functional capacity of the spine, the muscle system, and body posture, in physical and sports education lessons. According to our findings, we recommend diversification of the physical and sports education syllabi, which should include lessons focused on the prevention and elimination of musculoskeletal disorders and consider the individual needs of school-aged children. Our study also proves that the diagnosis of changes in this age has a positive effect in terms of prognosis.

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Conflicts of Interest

The authors declare no conflict of interest.

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