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EFFECT OF APPLIED HEALTH-ORIENTED EXERCISES IN PHYSICAL AND SPORT EDUCATION ON MUSCULOSKELETAL SYSTEM OF FEMALE STUDENTS

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Summary: The aim of the research was to determine the effect of the health-oriented exercises included in the final part of the physical and sport education on the selected factors of the musculoskeletal system of the female students of the selected secondary school, as well as to point out the diversification and the realization of the innovative contents of the teaching lessons with the health aspect, especially from the point of view of the primary prevention of the female students' health of secondary school, improving the level of the posture and the overall muscular system. The monitored group consisted of 33 female students of the selected secondary school in Trenčín (Slovakia). The experimental group (EG) A consisted of 17 female students (age = 16.9 ± 1.3 years, height = 168.6 ± 3.9 cm, weight = 57.3 ± 3.4 kg) and the control group (CG) B consisted of 16 female students (age = 16.3 ± 1.1 years, height = 167.3 ± 4.7 cm, weight = 58.9 ± 4.8 kg). From the point of view of the data acquisition methods, in initial, ongoing and final evaluations were applied standardized methods for assessing the posture and the muscular system for physical and medical practice. Subsequently, the applied health-oriented exercises were used in the final part of the physical and sport education for 3 months, 3 times per week, for the duration of 12 minutes. The results significantly showed the improvement of the monitored musculoskeletal system ($p < 0.01$), as well as the overall muscular system ($p < 0.01$). Based on the findings, we point out the suitability of including the health-oriented exercises in the teaching process of the physical and sport education with the focus on the musculoskeletal system. This study was supported by *VEGA 1/0242/17 Physical activity as prevention of functional disorders related to the musculoskeletal system of secondary school students*.

Key words: female students, health, health-oriented exercises, muscular system, posture.

Introduction

The issues of the health-related physical fitness, in the relation to the health, are at the beginning of the new millennium one of the most up to date problems of the modern society (Kurková, Nemček & Labudová 2015; Nemček 2017; Nemček, Kraček & Kurková 2018).

One of the areas of the health is also the area of the musculoskeletal system of human beings, where the functional disorders of the system have become as the negative syndrome, resp. today's civilization disease (Bendíková 2014; Łubkowska 2017). The current hypokinetic lifestyle of the children and youth in the European Union member countries (Page 2007; Biddle et al. 2009) is manifested in the ascending trend of the civilization diseases (Boreham & Riddoch 2001), in the area of the musculoskeletal system (Łubkowska & Troszczyńsk 2011; Żukowska et. al. 2014), starting within preschool age, continuing by younger school age, not excluding period of pubescence (Farioli et al. 2014; Mitova 2015; Azabagic et al. 2016) or adolescence (Nemček & Lojek 2009; Acasandrei & Macovei 2014), which is culminating in period of adulthood and old age, in forms of the vertebrogenic disorders.

The musculoskeletal system is needed to be perceived holistically (Véle 2006), which is the sensitive mirror, in which the dysfunctions of the individual systems of the whole organism are projected, such as the visceroverteb ral syndromes. Conversely, the disease states of the musculoskeletal system manifest themselves in other systems than the visceroverteb ral syndromes (Vaňasková & Tošnerová 2006). In terms of the orthopedics, there are functional and morphological disorders of the musculoskeletal system, where the muscular imbalance is somehow pre level of the first stage of the more serious functional disorders, within the musculoskeletal system, which are directly involved in the postural disorders in the area of the posture – so-called bad posture, in which is located one of the main causes of the functional failure of the spine, within the vertebrogenic disorders in the adulthood (Buran 2002; Bonetti et al. 2005), of which the correction is already very small or none, while involving in the rise of other structural health disorders with the multifactorial nature.

The basis of position and motor coordination is the functional balance of the muscles, which ensures the positioning of the individual parts of the body and their posture. Each disturbance of this equilibrium causes deviations in the curvature of the spine and the position of the segments of the posture (Véle 2006). The muscle imbalance should be seen as the lack of the functionality between the postural and the phasic muscles, which create certain syndromes, characterized by the group of the shortened and the weakened muscles, the

disturbances of the competent motor stereotypes, the change in the dynamics and the spinal statics, in which the external manifestation is the bad posture (Rýchliková 1997).

Therefore, in this context, it is necessary to look for the preventive measures, which can be taken from the point of view of the school reform from 2008, in teaching the physical and sport education, within the school education program by changing the content of the teaching, which may be mentioned as the preventive basis of the prevalence of the functional disorders of the muscular and the skeletal system of the school population.

Bendíková (2016a) points out that the cooperation between the theory and the practice is very important, as *"Physical and sport education directly and indirectly creates space for the diversification and the implementation of the innovative content of the teaching lessons, which should influence the health indicators with the positive consequences on the physical, the functional and the muscular development of the student, as well as the health-oriented physical fitness "*, which includes the area of the musculoskeletal system.

There are several studies on the effectiveness of the physical programs and the health-oriented exercises on the musculoskeletal system, in which the views of the authors on their intervention associated with positive changes of the muscular and skeletal system differ, in the length of the intervention (Rowe & Jacobs 2012) and agree in the positive effect on the other hand (Bendíková & Stackeová 2015; Łubkowska, Zdeb & Mroczek 2015). Most often, however, we encounter 10 to 12-week physical programs, during which we practice three times a week, where positive changes are recorded, even after 6 weeks of exercise intervention 2 – 3 times a week in 30 minutes (Łubkowska, & Troszczyński 2011; Lee, Park, & Kim 2013; Vetkasov, Hošková & Pokuta 2014; Kim et al. 2015; Bendíková, 2016b).

Aim

The aim of the research was to determine the effect of the health-oriented exercises included in the final part of the physical and sport education, focusing on the posture and the overall muscular system of the female students of the selected secondary school thereby to contribute to the acquisition and the dissemination of the knowledge from the point of view of the primary prevention of the health of the female students.

Methods

Participants and procedure

In accordance with the aim and the extent of the processed material, the experimental group (EG) A consisted of 17 female students of the secondary school of Trenčín (Slovakia), with the mean age of 16.9 ± 1.3 years (body height 168.6 ± 3.9 cm, body weight 57.3 ± 3.4 kg) and control group (CG) B consisted of 16 female students with the mean age 16.3 ± 1.1 years (body height 167.3 ± 4.7 cm, body weight 58.9 ± 4.8 kg). The primary characteristics of the groups are presented in table 1.

Table 1

Characteristics of EG (n = 17) a CG (n = 16)

Groups/factors	n	Decimal age	Body height (cm)	Body weight (kg)	BMI
A Group (EG)	17	16.9±1.3	168.6 ± 3.9	57.3 ± 3.4	21.2 ± 3.4
B Group (CG)	16	16.3 ± 1.1	167.3 ± 4.7	58.9 ± 4.8	21.3 ± 2.9

Legend: BMI – Body mass index, EG – experimental group, CG – control group

The research was carried out in school year 2017/2018 in three consecutive stages. In the diagnosis of the health with the intent to the selected determinants of the musculoskeletal system, the female students participated in the initial physiotherapeutic examination (September/2017), by the standardized method for the medical and the physical practice, according to Jaroš & Lomíčka (Vojtaššák 2000). The level of the muscular system was diagnosed by the standardized method of the evaluation of the overall muscular balance, modified for the purpose of the physical education practice (Labudová & Thurzová 1992) and processed within the overall muscular balance according to Kováčová (2003) (Table 2). Subsequently, were applied the health-oriented exercises in the experimental group, within the three hours a week, with 12-minute duration, in the final part of the lesson, aimed at improving the musculoskeletal system (focusing on the posture and the muscular system) for 12 weeks. The last week of October/2017 was conducted to the ongoing evaluations and in December/2017 to the final evaluations of the monitored factors of the musculoskeletal system by the physiotherapist.

Measurement taking

The evaluation of the posture was carried out as part of the preventive screening, using the standardized method for the medical and the physical practice (Vojtaššák 2000) performed at initial, ongoing and final evaluations. To each component (I. - V.) was given points (1, 2, 3, 4) according to the quality of the posture. The overall posture was expressed by the total points and the quality level (I. - IV.). The evaluation was focused on:

I. Head and neck posture, II. Chest (shape), III. Abdomen and pelvic tilt, IV. Spine curvature, V. Front posture (evaluation of posture of shoulders – shoulder girdle).

Classification of postures:

I. Perfect posture: 5 points, II. Good (almost perfect) posture: 6 – 10 points,

III. Poor posture: 11 – 15 points, IV. Bad posture: 16 – 20 points.

Table 2

The overall muscular balance according to Kováčová (2003)

Qualitative grades muscle imbalance	**Degree**		
	shortened muscle	**weakened muscle**	**distorted movement stereotype**
I. Muscle balance	0	0	0
II. Low degree (muscle imbalance)	1-6	1-3	1-4
III. Medium degree (muscle imbalance)	7-16	4-7	5-12
IV. Generalized degree (muscle imbalance)	17-22	8-10	13-16

Data analyses

The obtained qualitative and quantitative features were processed by the method of clinical case study (Vojtaššák 2000) with the application of the theoretical methods of the logical analysis and the synthesis, using the inductive and the deductive methods, the comparison and the generalization, as well as the arithmetic mean (x), the variation range ($R_{max - min}$), the standard deviation (s) and the median (m). In order to determine the statistical significance of the difference between the observed marker (posture and individual segments) between the input, the ongoing and the final evaluations, the non-parametric Wilcoxon test (W_{test} $p < 0.01$; $p < 0.05$) was used. To verify the compliance of the level of two independent groups, we used the Wilcoxon Mann-Whitney test (M_{WWtest} $p < 0.01$, $p < 0.05$). To determine the statistical significance of the overall muscular balance, we used the Chi-squared test ($p < 0.01$, $p < 0.05$).

Results

Based on the aim, we present part of the results, which are subject to more accurate monitoring and processing. The presented results cannot be generalized, but it is necessary to understand them in the overall context as the orientation and the starting, in the creation of the content of the physical and sports education, in the relation to the health of the students.

In the input measurements, we did not find the perfect posture in any of the experimental (A) and control (B) groups one of the female students, with the grade I. grade of 5 points. This is evidenced by the average score of the posture (Table 3, 4), which at the same time document the status of the posture of the experimental (Table 3) and control (Table 4) groups, before, during and after the realization of the health-oriented exercises, within the final part of the physical and sport education.

Table 3

Overall posture of experimental group (EG) (n = 17)

Factors/EG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Initial	8	8	11	12	14	12	13	15	13	16	16	18	15	14	12	13	17
Ongoing	6	6	6	6	8	6	7	8	7	10	10	12	8	9	7	7	9
Final	5	5	5	6	7	5	6	6	6	9	9	11	7	6	6	6	7
$W_{test =}$ $p < 0.01$																	

In the control group (B), we did not notice any significant changes between the initial, the ongoing (Wtest = 3.46, $p > 0.05$) and the final evaluations (Wtest = 3.46, $p > 0.05$).

By evaluating the statistical significance of the differences between the experimental (A) and the control (B) groups, we recorded the positive effect of the applied health-oriented exercises in favor of the experimental factor ($M_{WWtest} = 7.336$, $p < 0.01$).

Table 4

Overall posture of control group (CG) (n = 16)

Factors/CG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Initial	9	9	10	14	14	13	13	15	14	13	15	12	13	14	15	11
Ongoing	9	9	10	14	13	13	12	15	15	13	15	11	13	14	14	11
Final	9	9	10	13	14	13	13	14	15	14	15	12	13	13	15	10
$W_{test =}$ 3.46, $p > 0.05$																

The effectiveness of the health-oriented exercises on the overall posture evaluation in the experimental group (A) was positive. When comparing the overall posture level of the monitored group we could state that the difference improvement between the initial (13.3 ± 2.94) and the final (6.6 ± 1.44) evaluations were statistically significant ($W_{test} = 3.0696$, $p < 0.01$) with the difference of 6.7 ± 1.44 (Table 5). The statistically significant improvement ($W_{test} = 3.0696$, $p < 0.01$) was also documented by the mean difference of 5.5 ± 1.55 between the initial (13.3 ± 2.94) and the ongoing (7.8 ± 1.93) evaluations of the overall posture.

Table 5

Effect of health-oriented exercises on overall posture of female students (EG) (n = 17)

Values/evaluations (n = 17)	**I_1**	**O_2**	**D_1 (I_1 a O_2)**	**F_3**	**F_2 (I_1 a F_3)**
x	13.3	7.8	5.5	6.6	6.7
min.	8.0	6.0	2.0	5.0	3.0
max.	18.0	12.0	6.0	11.0	7.0
$R_{max - min}$	10.0	6.0	4.0	6.0	4.0
s	2.94	1.93	1.55	1.98	1.44
median	13.0	7.0	6.00	6.0	7.0
Wilcoxon index	$I_1 - O_2$ **p < 0.01				
	$I_1 - F_3$ **p < 0.01				

Legend: I_1 – initial evaluation, O_2 – ongoing evaluation, F_3 – final evaluation, D_1 – difference between I_1 a O_2 , D_2 – difference between I_1 a F_3, ** – statistical significance, x – arithmetic mean, s – standard deviation, $R_{max - min}$ – variation range, EG – experimental group

In the area of the posture evaluation, in terms of the individual areas, we found the following in the monitored group (A). The difference between the initial (3.2 ± 0.72) and the final (1.4 ± 0.48) evaluations, in the area of the head and the neck (1.8 ± 0.39) was statistically significant (W_{test} p = 3.069, p < 0.01). Similarly, in the area of the Abdomen and pelvic tilt, we recorded the statistically significant (W_{test} p = 3.069, p < 0.01) differences with the mean difference of 1.9 ± 0.64 between the initial (3.2 ± 0.69) and the final (1.3 ± 0.43) evaluations. In the area of the spine curvature, the positive changes occurred, statistically significant (W_{test} p = 2.369, p < 0.05), as shown by the initial (1.9 ± 0.76) and the final evaluations (1.3 ± 0.43) with the average difference of 0.7 ± 0.62. In the area of the front posture, we recorded the statistically significant (W_{test} = 3.069, p < 0.01) difference (1.5 ± 0.50) between the initial (3.0 ± 0.71) and the final (1.5 ± 0.65) evaluations. Also, in the chest area, there were significant differences between the individual evaluations (W_{test} = 2.369, p < 0.05). In the group B, we did not notice significant changes in the individual posture areas (W_{test} p > 0.05).

The muscle imbalance of the individual components at the level of the overall muscle imbalance was as follows. In the first qualitative degree we did not record any female student of the EG (A) and the CG (B), which in the view of the present sedentary lifestyle only confirms the assumption of the possibility of the growth of the civilization diseases, including the functional state of the muscular system and the muscle imbalance. We measured 21.3 % of the female students EG (A) in the measurement. Our group (A) also did not have, as well as the group (B) female students who would be included in the IV and IV qualitative degree,

within the initial and final evaluations. By representing the most frequented group in the groups (A and B) in the initial measurements was III. qualitative degree of the muscle imbalance, while in final measurements dominated in the group (A) II. qualitative degree of the muscle imbalance, in which we evaluated the changes positively. In the group EG (A) we observed, by the application of the health-oriented exercises, that there was the significant improvement ($p < 0.01$) between the initial and the final values of the female students (Table 6) in the occurrence of the overall muscle imbalance.

Table 6

Overalll muscular imbalance of students according to qualitative grades (n = 17)

Qualitative grades	**Initial**	**Final**	**Chi square**	**Effect size**
I. Muscle imbalance	0 %	21.3 %	0,01199	0,21
II. Low degree (muscle imbalance)	18.6 %	69.1 %	0,01663**	0,61
III. Medium degree (muscle imbalance)	81.4 %	9.6 %	0,01968**	0,66
IV. Generalized degree (muscle imbalance)	0 %	0 %	0	0.00

Legend: ** - statistically significant difference ($p < 0.01$)

The finding points to the effectiveness of the health-oriented exercises on the individual components of the muscular system in the EG, in which the overall muscle imbalance and the transfer of the female students from III. qualitative degree to II. qualitative degree appeared (Chi = 0.01663, $p < 0.01$), but also to the I. qualitative degree, which we evaluated positively (Chi = 0.01199). The greatest changes and the positive shifts in the overall muscle imbalance occurred in III. qualitative degree (Chi = 0.01968, $p < 0.01$). We did not see significant changes in the area of the overall muscle imbalance between the initial, the ongoing and the final evaluations (Chi = 0.01116, $p > 0.05$) in the control group (B). When comparing the overall muscle imbalance between the EG and CG, we recorded significant changes ($p < 0.01$).

Discussion

During the initial evaluations, we found that the most problematic areas of the experimental and control group were head, shoulders and abdomen areas, which were manifested with the non-physiological curvature of the spine and in the position of the body segments, which are considered, according to Kania-Gudzio & Wiernicka (2002) as segments with the most frequent deviation from the perfect posture in the school population.

The increased curvature of the cervical and lumbar part of the spine in the female students in the initial measurements suggested that they were not caused by the primary functional state of the muscles and the muscle groups but, as reported by Lewit (1998), Véle (2006), in general, the incorrect postural stereotype control of the movement functions with low nerve-muscle coordination, as well as other external and internal factors, including the number of hours spent in unilateral, statically overloading positions, in the ergometric configuration, workplace equipment, as well as the movement and the postural habits of the fixed childhood, inadequate regeneration and recondition, inactivity, genetic predisposition, gender, age and other factors. We also note that none of the evaluated muscles and muscle groups independently affected the reported changes in the spine and individual segments of the posture of the female students in the initial evaluations, equally in both groups, but as Véle (2006), Lewit (1998) state only in the co-operation of the individual muscles and the muscle groups. This finding also corresponds to the finding of Bendíková, Uvinha & Marko (2016), in which the erroneous postural stereotype of the anterior head posture is influenced by the observed development of the functional disorders of the muscle groups m. trapezius - pars descendens and m. levator scapulae, with the contribution of the local imbalance between m. sternocleidomastoideus and deep head and neck flexors. These muscle groups then cause, in addition to the algic conditions, the higher incidence of the trigger points in the neck area (Buran 2002). At the same time, from the kinesiological point of view, good functional state of the abdominal muscles, together with its postural antagonist (erector spinae) contribute to the maintenance of the stability of the lower part of the spine and the pelvis (Véle 2006).

Therefore, we believe that the physical and sport education must have the purposeful role in the shaping, the enhancing and the consolidating of the posture as the proper functioning of the muscular system by the means of the exercises, within each lesson, where the ideal space creates the structure of the teaching unit itself, in its final part of the lessons, which many times absent in the realization of the teaching. Their absence causes injuries of different nature, while their use ensures prevention.

The obtained results are considered to be very important also for the clinical practice. In the relatively short time, the positive changes were achieved in the monitored EG (A) group. If similar health-oriented exercises could be implemented in the physical and sport education, it can be assumed that they have the preventive effect against the development of the functional disorders of the musculoskeletal system.

Conclusion

Based on the aim of the current study, we found that:

- In experimental group A, we recorded significant changes ($p < 0.01$) in the posture, as well as in the individual areas ($p < 0.01$) by applying the health-oriented exercises in the final part of the physical and sport education lessons, unlike in the control group B ($p > 0.05$). A significant difference ($p < 0.01$) was recorded between A and B.
- We also noticed significant changes ($p < 0.01$) in the area of the overall muscular system in group A, unlike in the group B, in which we also recorded significant changes ($p < 0.01$).

These findings should be seen in the broader context towards the prevention of the students´ health and the content diversification of the physical and sport education in the schools.

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