ORIGINAL ARTICLE

The effects of corrective gymnastics on the postural status of the spine in the frontal plane in preschool children

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Abstract

Postural irregularities, i.e., deviations from normal posture, are a growing problem today. Physical inactivity in preschool children can lead to some physiological changes, which, if not remedied timely, tend to more seriously impair health in later stages of life. Muscle activity caused by biomechanical adaptation to certain body positions in a sedentary regime in children can form muscle asymmetries. The study aimed to determine the effects of corrective gymnastics on the postural status of the spine in the frontal plane in preschool children. The total sample of children (n=133; AGE: 6.2±0.6) was divided into three sub-samples: experimental group E1 - 45 (25.57%), experimental group with additional exercises E2 - 45 (25.57%) and control group C-43 (48.86%). This is a longitudinal-type study that involved the application of a ten-week corrective gymnastics intervention on children aged 5 to 7 from Subotica, who participated in the formation of the sample. Based on the analysis of the results of the multivariate analysis of variance it can be concluded that there are no statistically significant differences (P=0.17) between the subjects from the experimental groups and the control group in the variables used for assessment of the spinal column in the frontal plane, and it is necessary to extend the treatment time in preschool children when corrective gymnastics is applied to changes in postural status when it is observed in the frontal plane.

Keywords postural status • muscle asymmetries • corrective gymnastics.

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Introduction

The report of the World Health Organization (WHO, 2016) indicates the importance of physical inactivity and its negative correlation with the level of quality of life, and sociological aspects of children's development, i.e., with the maintenance of health homeostasis in general. Physical inactivity in preschool children can lead to some physiological changes, which, if not remedied timely, tend to more seriously impair health in later stages of life. Muscle activity caused by biomechanical adaptation to certain body positions in a sedentary regime in children can form postural stability. It is these changes in the structure of the locomotor system that have a rather negative effect not only on the formation of the spinal column but also on the creation of conditions for the progression of many other dysfunctions in the body (Davidov et al., 2015) even in adulthood (Simonenko, Medvedev, & Yu, 2008; Kutafina & Medvedev, 2015). Disturbed posture can be seen as a precondition for the formation of impaired postures in the true sense. If they are not treated adequately, they tend to disturb the harmonious musculoskeletal balance and can lead to the changes in the spinal column and to scoliotic posture. There are many causes and factors that can lead to scoliotic posture. It is defined as an excessively pronounced curvature in the frontal plane, i.e., a curvature of over 10˚, and it is estimated that about 2% of children have scoliotic posture (Cheng et al., 2015). Scoliosis in children is considered a very dangerous disease that leads to disorders in the work of many internal organs (Moment & Semenov, 2016). Hypoxia is one of the conditions in the background of scoliotic posture. It occurs due to unfavorable morpho-functional changes in tissues (Gromnatskii & Medvedev, 2003; Medvedev & Savchenko, 2010). Thus, the consequence of the progressive development of scoliosis is cardiopulmonary insufficiency, thoracic insufficiency syndrome, and severe pain (Cunin., 2015).

Postural irregularities, i.e., deviations from normal posture, are a growing problem today (Jorgić & Đorđević, 2016; Đorđević et al., 2016; Novaković et al., 2016). The prevalence of impaired postural balance in children is 10-29% (Girish, Raja & Kamath, 2016; Tsui et al., 2016). Muscle asymmetries, i.e., impaired posture, are constantly increasing due to current and modern lifestyles, as well as due to the improvement of diagnostic procedures (Kutis, Kolarova & Hudakova, 2017).

There are various exercise methods used to regulate muscle asymmetries, and prevent the development of scoliotic posture. Some of the approaches are the Schroth method, Corrective Corrective gymnastics, Pilates ball exercises as well as the Yoga approach. However, the study (Gür, Ayhan & Yakut, 2017) indicates greater efficiency of the core stability concept of exercise compared to others. In addition to physical activity, which has a significant impact on the prevention of bad postures (Mrozkowiak et al., 2016; Feng et al., 2018), they emphasize the importance of parents in both the prevention and correction of impaired postures.

Quantification of body posture is performed mainly by small detection of body posture center movement (using force plates) or based on radiographic lateral asymmetries (Thomkinson & Shaw, 2013; Schmid et al., 2015). In general, the body posture is quantified by various methods, including digital photometry (Stolinski, et al., 2017). Although the system of photocells and photometry is used today, the Contemplas method stood out among them. Monitoring posture in children, as well as muscle asymmetries using the Contemplas method, was done on older children, and children of younger school age (Kojić, 2014; Kovač et al, 2015; Šćepanović, 2017, Kapo, et al, 2018) which generated a lot of important data on the condition of the spinal segments. No research has been done on preschool children with this method.

Based on the above, the aim of the study was to determine the effects of corrective gymnastics on the postural status of the spine in the frontal plane in preschool children.

Method

This is a longitudinal-type study that involved the application of a ten-week developmental gymnastics intervention on children aged 5 to 7. The preschool institution "Naša Radost" (Our Joy), as well as the preschool institution "Mandarina" (Tangerine) from Subotica, participated in the formation of the sample. The total sample of children (n=133,) was divided into three sub-samples: experimental group E1 - 45 (25.57%), an experimental group with additional exercises E2 - 45 (25.57%), and control group C-43 (48.86%). The average age of the total sample was 6.19±0.58 years, and the subjects were classified into groups by approximately the same age (p=0.83). The average age of the subjects in the control group was 6.18 ±0.60, the average age in the experimental group with the intervention was 6.21±0.57, and the average age of subjects in the experimental group with the intervention and additional exercises at home was 6.19±0.57 years. Two experimental interventions were implemented in groups E1 and E2. At the end of the treatment, there were only 43 subjects in the control group, because there was an epidemic of smallpox in a preschool institution.

Procedures/testing

3D Compact analysis by Contemplas (Professional motion analysis software) was applied for assessing muscle asymmetries. This method is fast and efficient. The results are obtained in the form of simple animations that give a precise picture of muscle deviations, i.e., the asymmetry of the body. Recording is done with three cameras, after which reports are received. Marking of reference points enables reading of the position of shoulders, pelvis, body posture in the sagittal and frontal plane, as well as the position of legs. The 3D module consists of three cameras on the basis of which a precise image of the postural status is obtained from all three perspectives, and the accuracy of the system was confirmed by the Cologne University of Sports

(Šćepanović, Marinković, Korovljev, Madić, 2015). According to the relationships between points in the calibrated space, values are determined that help define whether a person deviates from normal posture and whether there are muscular imbalances or frontal distances (Table 1).

Table 1. Variables and abbreviations for 3D posture analysis

Frontal Cervical spine
Variable expressed in centimeters indicates the distance of the cervical spine in the frontal plane in relation to the vertical line projection of the sacrum. If the result is positive, it indicates the right displacement of the cervical spine, and the negative result indicates the left side displacement.
Frontal Thoracic spine
Variable expressed in centimeters indicates the distance of the thoracic spine in the frontal plane in relations to vertical line projection of the sacrum. If the result is positive, it indicates the right displacement of the thoracic spine, while the negative result indicates the left side displacement
Frontal Lumbar spine
Variable expressed in centimeters indicates the distance of the lumbar spine in the frontal plane in relation to vertical line projection of the sacrum. If the result is positive, it indicates the right displacement of the lumbar spine, but if the result is negative, it indicates the left side displacement

Intervention

The experimental intervention (a program of targeted activities) was carried out for 10 weeks. The intervention included two activities every week, plus individual intervention conducted by the parents. The activities carried out by the author of the work in the preschool institution "Naša Radost" lasted 45 minutes and were more focused on general motor skills (Table 2), while the individual part was focused on exercise at home conducted by previously trained parents, which lasted 20 minutes (E2). Experimental intervention E2 (Table 3) was more directed towards the correction of muscle asymmetries, i.e., muscle movements at the level of the spinal column in the frontal plane.

Table 2. E1 module: The structured exercise program

Duration	Organization	Volume	Frequency	Intensity
10 weeks	Frontal work, group work, the group with stations, polygon, and circuit work	45 minutes per session	2 times a week	According to external signs (sweat, blush, spontaneous break)

Table 3. E2 module: The structured exercise program

Duration	Organization	Volume	Frequency	Intensity
10 weeks	Individual work	20 minutes per session	2 times a week	According to external signs (sweat, blush, spontaneous break)

Set of corrective exercises E2 - Set of exercises for disturbed body posture, keeping the spinal column in the frontal plane. The same set of exercises is also applied to the right side.

1. SP (starting position) - lying prone, right arm in the overhead position, left arm against body. Reach with the right hand as far forward as possible.
2. SP-lying prone, right arm in the overhead position, left arm against body, palms down. Raise the hands from the ground, and reach with your right hand as far forward as possible.

3. SP-lying prone, right arm in overhead position, left arm extended sideward and bent. Extend the back, hold for a few seconds and return to SP.
4. SP-lying prone, right arm in overhead position, left arm extended sideward and bent. Extend the back, bend the torso sidewards, return, SP.
5. SP-lying prone, right arm in overhead position, left arm extended sideward and bent. Touch the left shoulder with right hand, endure and return to SP.
6. SP-seated position, legs spread, cross the legs while bent, right arm in overhead position, left arm extended sideward and bent. Pull the left elbow back, extend the right hand as high as possible.
7. SP-seated position, legs spread, bent and crossed, arms in bent overhead position, fingers crossed on the back of the head. Bend the torso sidewards, return, SP.
8. SP-seated position, legs spread, bent and crossed bent, arms in bent overhead position, fingers crossed on the back of the head. Twist to the left, endure, twist back, SP.

The statistical software SPSS Statistics for Windows, version 20 was used for statistical data processing. All collected data were processed by descriptive and comparative statistics procedures. The statistical method of data processing determined the basic descriptive statistics of motor variables: arithmetic mean (AS), standard deviation (S) of initial and final measurement, separately for all three groups of subjects. The normality of the distribution was tested using the Shapiro-Wilk test (SWp) at the inference level of $p \leq 0.05$. Multivariate analysis of variance (MANOVA) was used to determine differences in the entire posture space at the initial and final measurements. One-Way ANOVA was used to determine individual differences. The effects of the treatment were determined by multivariate analysis of covariance (MANCOVA) and univariate analysis of covariance (ANCOVA). After determining the significant differences between the groups of respondents, using Bonferroni comparison, we attempted to determine the groups between which there are real differences. Due to the uneven number of subjects, the Pillai's Trace statistic was used.

Results

Descriptive statistics of variables of the spinal column in the frontal plane at the initial measurement in all three analyzed groups (Table 3) indicate negative average values of results with significant individual differences. Such data indicate generally higher deviations of the spinal column to the left observed from the back of the body. The parameters of the spinal column in the frontal plane, in all three groups of subjects, have a normal distribution of results (SWp> 0.05).

By analyzing the results of multivariate analysis of variance (Table 4), it can be concluded that there are statistically significant differences (P=0.00) between the subjects from the experimental groups and the control group in the variables used for assessment of the spinal column in the frontal plane at PT test value of 4.35. Before applying the treatment, a statistically significant difference was found between the groups in the variable Lumbar Distance (p = 0.00).

Table 4. Descriptive statistics and differences between groups at initial measurement of variables of the spinal column in the frontal plane of different groups

Variable	Control		Experimental 1		Experimental 2			
	Mean±SD	SWp	Mean±SD	SWp	Mean±SD	SWp	f	p
Cervical distance (cm)	-0.20±1.27	0.28	-0.15±0.86	0.21	-0.63±1.11	0.49	1.94	0.15
Thoracic distance (cm)	-0.43±0.84	0.46	-0.26±0.82	0.20	-0.63±0.95	0.16	1.37	0.26
Lumbar distance (cm)	-0.01±0.30	0.11	-0.36±0.24	0.16	-0.10±0.32	0.10	10.25	0.00
PT=4.35 P=0.00								

Note: SD – standard deviation; SWp – level of statistical significance of Shapiro-Wilk coefficient, f – univariate f-test; p – level of statistical significance of the f-test; PT – multivariate Pillai's Trace test; p – the statistical significance of multivariate PT test.

Differences between groups were determined by Bonferroni comparison (Table 5) at the inference level of p≤0.0.167, so it can be stated that at the initial measurement there were statistically significant differences in the variable Lumbar Distance between:

1) control and experimental group 1 where the control group subjects showed better results (p=0.000) and
2) experimental group 1 and experimental group 2 with treatment and additional exercise at home (p=0.003) whereas the subjects from the experimental group 2 with treatment that also practiced at home, showed better results.

Table 5. Differences between groups

Variable	(I) Group	(J) Group	Mean Difference (I-J)	p
Lumbar distance (cm)	C	E1	-0.266	**0.003**
		E2	0.093	0.518

Note: p - level of statistical significance

Descriptive statistics of variables in relation to the spinal column in the frontal plane at the final measurement (Table 6) in all three analyzed groups indicate the average negative values in all three variables considered: cervical distance, thoracic distance, and lumbar distance. In all analyzed variables, the normal distribution of results obtained by the Shapiro Wilk coefficient (SWp> 0.05) is observed.

Table 6. Descriptive statistics and differences between groups at the final measurement of variables of the spinal column in the frontal plane at the final measurement of different groups

Variable	Control		Experimental 1		Experimental 2			
	Mean±SD	SWp	Mean±SD	SWp	Mean±SD	SWp	f	p
Cervical distance (cm)	-0.15±0.81	0.21	-0.55±1.04	0.40	-0.66±1.13	0.84	2.25	0.11
Thoracic distance (cm)	-0.12±0.50	0.17	-0.60±0.76	0.43	-0.41±1.02	0.69	1.93	0.15
Lumbar distance (cm)	-0.25±0.52	0.36	-0.25±0.52	0.31	-0.13±0.50	0.21	0.60	0.55

PT=1.53 P=0.17

Effects of experimental intervention on parameters of the spinal column in the frontal plane

By analyzing the results of the multivariate analysis of covariance (Table 7), it can be concluded that there are no statistically significant differences (P=0.15) between the subjects from the experimental groups and control group in the variables used for estimating the parameters of the spinal column in the frontal plane at the value of the Pillai's Trace statistic PT=1.62. By equalizing the subjects before the application of intervention and individual observation, it can be concluded that there are no statistically significant differences after the application of treatment. The subjects retained average negative values in all three variables, as was the case on the initial measurement.

Table 7. Multivariate covariance analysis for analyzed variables (MANCOVA)

Factor	Variable	f	p	Group	Mean*	PT	P
Group	Cervical distance	2.42	0.10	C	-0.15	1.62	0.15
				E1	-0.74		
				E2	-0.69		
	Thoracic distance	2.40	0.10	C	-0.07		
				E1	-0.77		
				E2	-0.44		
	Lumbar distance	0.46	0.63	C	-0.30		
				E1	-0.19		
				E2	-0.17		

Note: E1 - experimental group, E2 - experimental group with additional exercise, C - control group; f - univariate f test; p - level of statistical significance f of the test; PT - Pillai's Trace test; p - statistical significance of multivariate PT test; Mean* - adjusted arithmetic mean

Discussion

The aim of the study was to determine the effects of corrective gymnastics on the postural status of the spinal column in the frontal plane in preschool children from Subotica. After applying the experimental intervention of developmental gymnastics with elements of corrective gymnastics, it can be concluded that there are no statistically significant differences (P=0.15) between the subjects from the experimental groups and control group in the variables used for estimating the parameters of the spinal column in the frontal plane at the value of the Pillai's Trace statistic PT=1.62. Subjects retained average negative values in all three variables, as was the case on the initial measurement.

Muscle asymmetries in preschool children in the frontal plane treated through programmed physical activity have not yet been examined in detail (Bikbulatova, 2017). Some studies indicate a correlation between physical activity and impaired posture (Radaković et al., 2017), however, a large number of studies indicate insufficient or incomplete research when it comes to the impact of kinesitherapy on the spine. Such data indicate only the complexity of scoliotic posture, whether it is asymmetries or an already formed postural disorder. The lack of treatment effects can also be attributed to the insufficient length of the experimental process. The study (Mrozkowiak et al., 2016) indicates positive effects of corrective exercise in the frontal and sagittal plane in children, where the duration of treatment was three years, while the treatment in this study lasted ten weeks. The results of the study (Biševac et al., 2021) support this, where the authors pointed out that corrective exercises can affect impaired postures, but the treatment in the mentioned study lasted much longer. Also, the same study emphasizes that a period of three months is not sufficient to influence muscle asymmetries in the frontal plane, which was confirmed by the first control measurement (Biševac et al., 2021).

Another aspect that can explain the obtained results is reflected through the applied 3D protocol that measured muscle deviations. The muscular asymmetries of the spinal column muscles on the complete sample were measured in a standing position. Since these are preschool children, it should be noted that the attention of children of that age is somewhat lower, and therefore it is more difficult for them to maintain the position they have to take when imaging with the Contemplas camera. Any movement of the locomotor apparatus can cause "false" asymmetries and lead to wrong conclusions. The importance of body posture in assessing asymmetry is very important and plays an important role when it comes to the accuracy of the results obtained, and some authors (Ludwig, et al., 2016; Ruivo, et al., 2014)suggest standing position assessment, while a group of authors (Caneiro, et al., 2010; Falla et al., 2007; Edmondston et al., 2007) propose assessments in a sitting position, while the study (Kuo et al., 2009) indicates that there are differences in results depending on body position.

Education is one of the important factors when it comes to resolving muscle deviations, impaired posture, and even deformities. The authors (Nettle & Sprogis, 2011) emphasize the importance of education when it comes to the prevention and correction of disturbed postures. However, muscular deviations in the frontal plane are more complex in structure than any type of impaired posture in the sagittal plane, which may justify the absence of effects. The fact that this is a three-dimensional impaired posture presupposes that, in addition to the education of parents and children, it is necessary to have an expert who will lead the rectification process.

Conclusion

The ten-week treatment on the postural status of the spine in the frontal plane in preschool children is not long enough to notice significant differences in the parameters for its assessment. The limitations of the study were the short period of treatment, the complexity of impaired posture, and the insufficient time foreseen for the education of parents who exercised and supervised their children. In future research, it is necessary to increase the duration of treatment and monitor these children for a longer period.

Conflict of interest

The authors declare that they have no conflict of interest.

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