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THE EFFECT OF SWIMMING ON SPINAL POSTURE: A CASE STUDY

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ABSTRACT

The objective of this study was to apply adapted swimming techniques to assess their impact on the sagittal plane posture of the spine in juvenile participants.

Clinical Summary: A 10-year-old boy has been diagnosed with a hyperkyphotic malalignment of 58° in the thoracic region and a hyperlordotic malalignment of 58° in the lumbar region of the sagittal plane of the spine. Diagnostic assessment utilized a non-invasive photometric method employing the Formetric 4D System by Diers, Germany. The individual's physical activity is limited, participating only in routine physical education classes at school. The diagnosis follows the Cobb method for measurement.

Intervention and Outcomes: The participant engaged in a tailored program featuring modified swimming techniques conducted in water for a period of 16 weeks, with sessions held three a week lasting 45 minutes each. Throughout the treatment, the participant was assigned to perform six distinct exercises over a 100-meter distance. Following the completion of the intervention, the measurement indicated a reduction in the kyphotic curve angle to 48° as per the Cobb method. Similarly, in the lumbar region, the lordotic curve angle decreased to 41°.

Conclusion: The conservative treatment, incorporating modified swimming techniques, contributed to a decrease in the angles associated with postural irregularities in the sagittal plane of the spine. These findings underscore the necessity for additional research involving a more extensive participant pool to validate further the favorable impact of the implemented program on postural deviations in both the thoracic and lumbar regions of the sagittal plane in juvenile individuals.

Key words: hyper kyphosis, hyper lordosis, scoliosis, spinal column deformities, swimming, exercise program

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INTRODUCTION

Postural status represents the proper positioning of body segments, which, through their activation from a biomechanical perspective during the execution of a specific motor action, result in the most rational energy expenditure (Demeši-Drljan & Mikov, 2012). Deviations from correct posture are a very common occurrence, especially during early adolescence. By analyzing different body segments and identifying the areas with the highest percentage of postural disorders, research has positioned the spine as the most affected area (Živković, 2009). Postural disorders located on the spine can have different etiologies. Moreover, based on previous research, idiopathic postural disorders and spinal deformities are the most common types, with adolescence being the period of their onset and most rapid progression (Živković, 2009). The most prevalent spinal deformities in adolescents can be categorized into sagittal plane deformities and three-dimensional deformities, specifically scoliosis (Ropac, Stašević, Samardžić, & Mijaković, 2013; Lubkowska, Szark-Eckardt, Zukowska, Bendíkova, & Pavlović, 2015; Lubkowska & Mroczek, 2017). Based on previous studies, the most common sagittal plane spinal deformities include hyperkyphosis, hyperlordosis in the lumbar region, kypholordosis, and flat back syndrome (Đorđević, 2022). However, when analyzing the entire spine in this age group, scoliosis emerges as the most frequent form of spinal deformity during adolescence (Aleixo, Guimarães, Walsh, & Pereira, 2012; Golalizadeh, Toopchizadeh, Fasaie, & Dolatkhah, 2019; Đorđević, 2022). Scoliosis is defined as a three-dimensional postural disorder—deformity—of the spine, characterized by a lateral deviation of more than 10 degrees according to Cobb's method. This deviation tends to affect adjacent bone, tendon, and muscle structures, thereby disrupting the positioning and function of organs in the trunk region (Đorđević, 2022).

Based on previous research, conservative treatment approaches are most commonly implemented in the initial stages of idiopathic postural deformities in adolescents. Individuals diagnosed with scoliosis, as well as those diagnosed with other sagittal plane deformities, undergo kinesitherapy exercises specifically designed for scoliosis correction. This approach assumes that by correcting scoliosis angles, it is possible to influence the correction of associated spinal deformities in the sagittal plane (Berdishevsky, Lebel, Bettany-Saltikov, Rigo, Lebel, Hennes, ... & Durmala, 2016). In the treatment of spinal postural deformities, the methods used can be classified into rehabilitative, orthopedic, and surgical interventions. SOSORT, as the leading organization for the conservative treatment of spinal postural disorders, has officially recognized seven different types of conservative treatment (Berdishevsky, Lebel, Bettany-Saltikov, Rigo, Lebel, Hennes, ... & Durmala, 2016). All conservative treatment methods accepted by SOSORT share the same goal: to act preventively on spinal deformities rather than waiting for surgical intervention after diagnosis. Instead, proactive and preventive measures should be taken (Berdishevsky, Lebel, Bettany-Saltikov, Rigo, Lebel, Hennes, ... & Durmala, 2016). Such perspectives have influenced the need for advancements in postural status diagnostics. Currently, X-ray imaging is considered the gold standard in diagnosis. However, due to the harmful effects of radiation, there is a continuous demand for developing alternative diagnostic methods that reduce or eliminate radiation exposure. In addition to X-ray imaging, other diagnostic methods used today include photometric analysis, somatometric methods, and the Napoleon Volansky method (Aleixo, Guimarães, Walsh, & Pereira, 2012; Čanjak, Jovović, & Stamatović, 2018; Vukićević, Čokorilo, Lukić, Miličković, & Bjelica, 2018). In line with the fundamental principles of the SOSORT school of conservative treatment, which emphasizes movement and physical activity in a natural environment, this case study aimed to apply conservative treatment principles through movement performed in water. By enabling movement through and on water, the objective was to correct the postural status of the spine.

METHOD

A sample of participants

The participant analyzed in this case study is a male, aged nine years and seven months at the start of the study (still Risser 0). He comes from an urban environment and, at the time of the study, was attending the fourth grade of elementary school. Apart from school activities and organized physical education classes, he did not engage in any other structured physical activity.

The initiative for analyzing his postural status came from the participant‘s mother, who, based on her own observations, expressed concerns about her child's posture. She reported that her child appeared "hunched over" and that one shoulder was visibly higher than the other.

Sample measuring instruments

The instrument used to assess the postural status of the spine in the frontal and sagittal planes for the participant was the Formetric 4D System (Diers, Germany). This instrument belongs to the group of non-invasive diagnostic methods (Betsch, Wild, Jungbluth, Hakimi, Windolf, Haex, & Rapp, 2011; Mangone, Raimondi, & Paoloni, 2013; Đorđević, Vidojević, Đokić, Milenković, & Stanković, 2018). The reliability and validity of the instrument have been confirmed through research (Somoskeöy, Tunyogi-Csapó, Bogyó, & Illés, 2012; Lason, Peeters, Vandenberghe, Byttebier, & Comhaire, 2015). The diagnostic method used is photometric, based on the principle of triangulation.

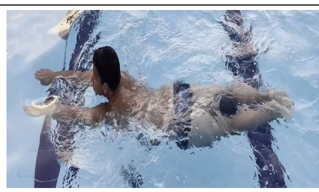
The measurement procedure requires that the participant has markers placed at specific anatomical points before the assessment, namely the fossae lumbales laterales and C7-processus spinosus. The participant is required to wear only underwear (briefs) during the assessment. After preparation, the child stands on a designated platform in an upright position, with feet parallel and back facing the camera. The diagnostic environment was completely darkened to ensure clearer and more precise measurements. The results are recorded and analyzed on a computer system connected to the instrument and camera via specialized software.

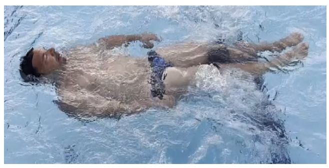
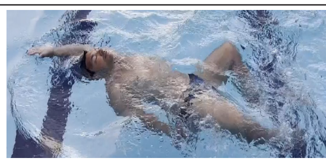
Treatment

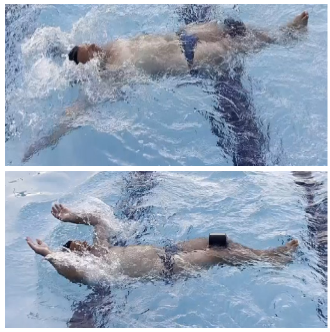
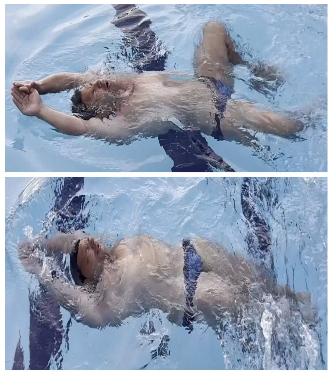
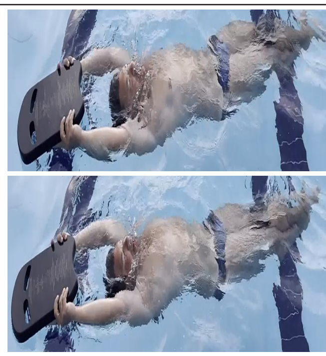
The exercise program implemented for the participant lasted 16 weeks, with a frequency of three sessions per week, and each training session lasted 45 minutes.

In the warm-up phase, the participant first acclimated to the water by entering the pool. This was followed by walking in water at a depth of 90 cm for a total distance of 200 meters, consisting of 10 laps from one edge of the pool to the other and back. The walking movements were performed both forward and backward, with slight knee flexion and weight transfer to the outer arch of the foot. Additionally, during the warm-up, the participant performed short two-legged jumps from a half-squat position, moving forward and backward, with hands placed on the hips. In the main phase of the session, the participant performed specific exercises, which are presented in Table 1.

Table 1. Overview of Water-Based Exercises for Spinal Posture Correction.

EXERCISES IN THE MAIN PART OF THE SESSION			
No.	Exercise Description	Purpose	Image Illustration
1.	One arm in an overhead position and the other at the side, while the legs perform the breaststroke technique.	S	 
2.	The arms perform the breaststroke technique with a shorter arm stroke and maintain maximum extension, while the legs execute adduction, squeezing a butterfly-shaped prop between the knees, and remain in maximum extension.	K, S	 

3.	The arms perform the breaststroke technique with a shorter arm stroke and maintain maximum extension in a crossed position, while the legs execute adduction, squeezing a butterfly-shaped prop between the knees, and remain in maximum extension.	K, S	 
4.	The arms are in an overhead position on the water, while the legs perform the breaststroke technique.	K, S	 
5.	The arms perform a simultaneous stroke movement similar to the backstroke, while the legs are in an adducted position, squeezing a butterfly-shaped prop between the knees and remaining in maximum extension.	K, L, S	 
6.	One arm is in an overhead position, and the other at the side while lying on the back, with the legs performing the breaststroke technique.	L, S	 

7.	The arms perform a simultaneous stroke movement similar to the backstroke, while the legs are in a crossed adducted position, squeezing a butterfly-shaped prop between the knees and remaining in maximum extension.	K, L, S	
8.	The arms are in an overhead position while lying on the back, with the legs performing the breaststroke technique.	L, K, S	
9.	The arms perform a simultaneous stroke movement similar to the backstroke while the legs execute the breaststroke technique.	K, L, S	
10.	The legs perform the dolphin kick technique (crossed position) while the arms are in an overhead position on a kickboard (prop), fully extended, lying on the back.	K, L, S	

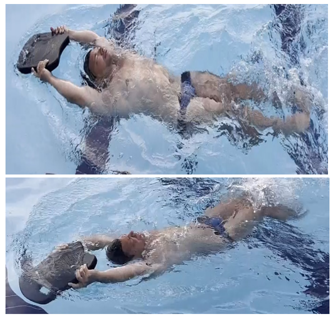
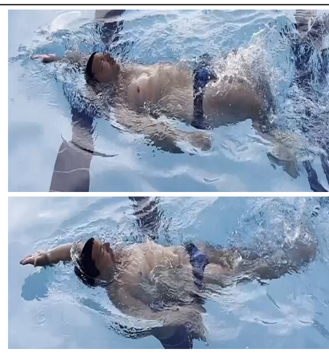
11.	The legs perform the dolphin kick technique while the arms are in an overhead position on a kickboard (prop), fully extended, lying on the back.	K, L, S	
12.	One arm is in an overhead position, and the other at the side, while lying on the back, with the legs performing the dolphin kick technique.	S, K, L	
K – HYPERKYPHOSIS; L – HYPERLORDOSIS; S – SCOLIOSIS			

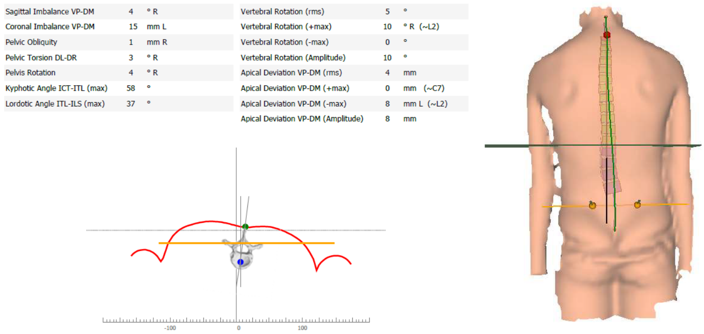
Table 2. Exercise Program in the Main Part of the Session.

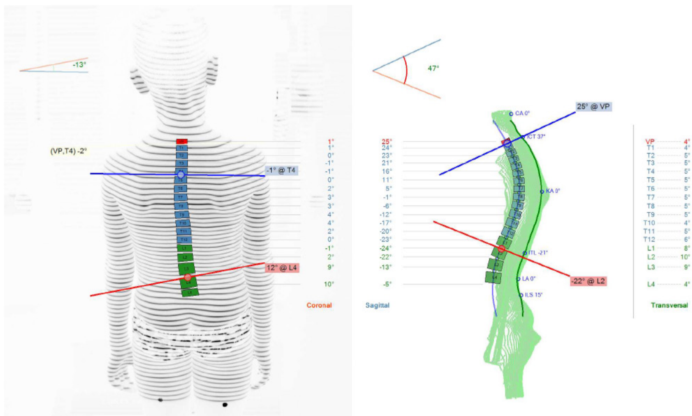
Exercise Program in the Main Part of the Session	
Training Session Number per Week	Exercise Sequence in the Main Phase of the Training Unit (Each exercise is performed 10 × 10m)
I	2, 3, 4, 1, 12.
II	9, 5, 7, 6, 8.
III	4, 10, 11, 12, 6.

The final part of the session consisted of 100 meters of light forward walking in water, conducted in the same area as the warm-up phase. This was followed by exiting the pool, marking the end of the session.

RESEARCH RESULTS

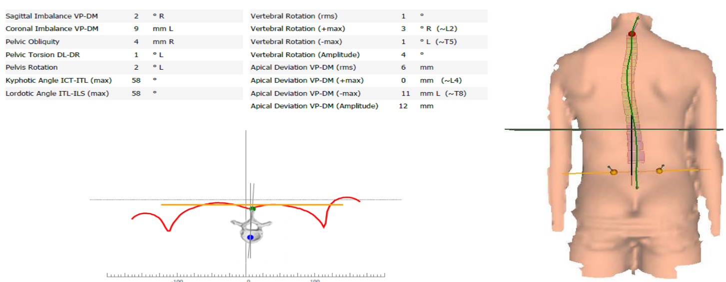
The initial measurement results, obtained using the Formetric 4D System (Diers, Germany), indicated the presence of postural deviations in various regions of the spine in both the sagittal and frontal planes. The results of the initial measurement are presented in Figures 1 and 2.

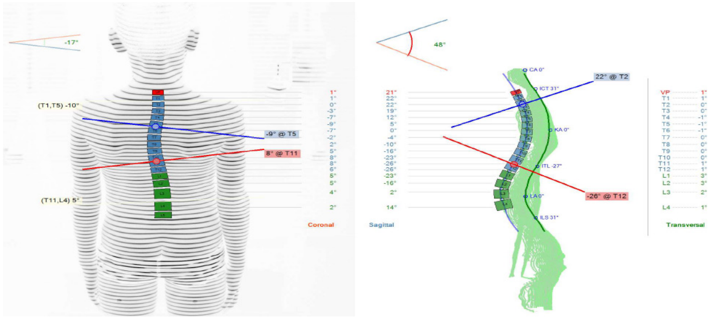




Figures 1 and 2 show the first initial postural status assessment of the spine in the sagittal and frontal planes.

Based on the results shown in Figure 1, which represents the participant's initial measurement in the sagittal plane, the kyphosis angle is 58°, while the lumbar lordosis angle is 37°. Additionally, the sagittal imbalance is 4° to the right, and the coronal imbalance is 15 mm to the left. There is also pelvic rotation, with pelvic torsion DL-DR measured at 3° to the right and pelvic rotation at 4° to the right. Furthermore, a vertebral rotation amplitude of 10° was observed, and scoliosis was detected in both the thoracic and lumbar regions on the left side, measuring 13°.

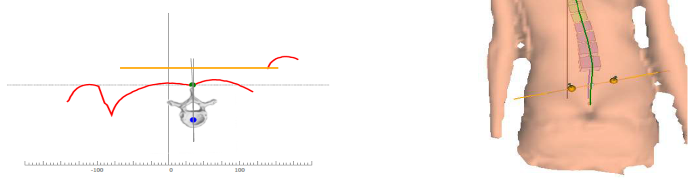


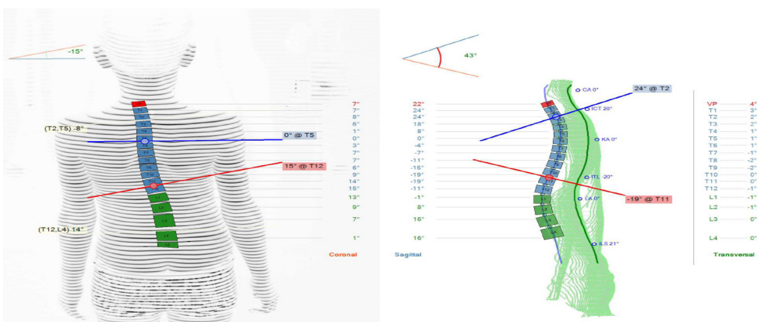


Figures 3 and 4 show the second initial postural status assessment of the spine in the sagittal and frontal planes.

Based on the results shown in Figures 3 and 4, which represent the participant's second initial measurement in the sagittal plane, the kyphosis angle is 58°, while the lumbar lordosis angle has increased to 58°. Additionally, the sagittal imbalance is now 2° to the right, and the coronal imbalance has decreased to 9 mm to the left. Pelvic rotation is still present, with pelvic torsion DL-DR measured at 1° to the right and pelvic rotation at 2° to the right. Furthermore, the vertebral rotation amplitude has decreased to 4°, while scoliosis was detected in the thoracic region on the left side, measuring 17°, and in the lumbar region on the right side, measuring 5°.

Sagittal Imbalance VP-DM	3	°	Vertebral Rotation (rms)	2	°
Coronal Imbalance VP-DM	49	mm L	Vertebral Rotation (+max)	6	° R (~C7)
Pelvic Obliquity	14	mm R	Vertebral Rotation (-max)	2	° L (~T8)
Pelvic Torsion DL-DR	1	° R	Vertebral Rotation (Amplitude)	9	°
Pelvis Rotation	10	° L	Apical Deviation VP-DM (rms)	4	mm
Kyphotic Angle ICT-ITL (max)	48	°	Apical Deviation VP-DM (+max)	7	mm R (~L3)
Lordotic Angle ITL-ILS (max)	41	°	Apical Deviation VP-DM (-max)	5	mm L (~T7)
			Apical Deviation VP-DM (Amplitude)	12	mm





Figures 5 and 6 show the final postural status assessment of the spine in the sagittal and frontal planes.

Based on the results shown in Figures 5 and 6, which represent the participant's final measurement in the sagittal plane, the kyphosis angle has decreased to 48°, while the lumbar lordosis angle is now 41°. Additionally, the sagittal imbalance is 3° to the right, while the coronal imbalance has increased to 49 mm to the left. Pelvic rotation is still present, with pelvic torsion DL-DR measured at 1° to the right, but pelvic rotation has shifted to 10° to the left. Furthermore, the vertebral rotation amplitude is now 9°, while scoliosis was detected in the thoracic region on the left side, measuring 15°, and in the lumbar region on the right side, measuring 14°.

DISCUSSION

The aim of this case study was to apply the fundamental principles of conservative treatment through movements performed in and on water to influence the correction of spinal postural status. The 16-week program, with a weekly frequency of three training sessions of 45 minutes each and a total movement volume of 800 meters in water with a temperature of 26–28°C, indicated a positive impact on spinal posture correction. Significant corrections in postural status were observed, particularly in the convexity of the sagittal plane in the thoracic region, where the Cobb angle was reduced from 58° to 48°, while the concavity angle, calculated using the same method, decreased from 58° to 41°. Additionally, changes were noted in scoliosis deformity, where the thoracic curve was reduced by two degrees, but the lumbar region showed a deterioration, with an increase in convexity on the right side to 14°. Moreover, the final measurement indicated an increase in pelvic rotation, which had significantly progressed, along with a notable increase in the maximum vertebral rotation.

The results obtained from the final measurement indicated the presence of positive changes in the postural status of both convexity and concavity in the thoracic and lumbar regions of the spine, but also revealed a negative progression in vertebral and pelvic rotation. Based on the comparison of the first and second initial measurements, which were taken before any corrective treatment or organized physical activity, significant changes were observed in the postural status of the spine, both in the sagittal and frontal planes, as well as in vertebral and pelvic rotations. Additionally, the participant experienced a growth of five centimeters between August and December, followed by an additional four centimeters between the second initial measurement and the final measurement, during which the corrective water exercise program was implemented. Previous studies investigating the effects of exercise programs on individuals with diagnosed postural deformities have varied in duration (Bettany-Saltikov, Parent, Romano, Villagrasa, & Negrini, 2014; Day, Fletcher, Coghlan, & Ravine, 2019; Tolo & Herring, 2020). Positive changes were observed in these studies; however, the exercise programs were conducted in gym settings. Furthermore, programs lasting longer than one year produced better results (Thompson, Williamson, Williams, Heine, Lamb, & ACTIvATeS Study Group, 2019; Tolo & Herring, 2020). A corrective water exercise program like the one applied in this case study was not found in electronic scientific journal databases. Therefore, it cannot be directly compared with other water-based corrective exercise treatments for individuals with idiopathic postural deformities in the sagittal and frontal planes of the spine. However, this program can be classified among shorter-duration conservative treatment programs. Its structure and session duration align with previous conservative treatment programs (Kuru, Yeldan, Dereli, Özdinçler, Dikici, & Çolak, 2016; Thompson, Williamson, Williams, Heine, Lamb, & ACTIvATeS Study Group, 2019). Moreover, the benefits of the aquatic environment, in which the exercise program was conducted, are notable. Water is 14 times denser than air, providing additional resistance while also enhancing proprioception due to the external forces acting during movement, particularly frontal and lateral resistance.

Accordingly, the advantage of this case study lies in the monitoring of spinal postural status parameters in a prepubescent child using the most advanced non-invasive diagnostic method. In addition to high-precision diagnostics based on the principle of photometry, a water-based exercise program was implemented, incorporating adapted swimming techniques with and without equipment, in accordance with biomechanical principles and the conservative treatment principles of the SOSORT school. The positive results obtained and the application of movement in water may contribute to a better understanding and guidance for future researchers and therapists working on this issue. The unique properties of water, including its density and the biomechanics of required movements, suggest that aquatic exercise can have a positive impact on the correction of postural deformities in the spine.

The limitations of this study may be reflected in the number of monitored postural status parameters. In addition to spinal postural status, other body segments, such as the legs and feet, should be assessed to rule out potential influences from deformities in these areas. Furthermore, to reduce the possibility of errors, it would be beneficial to repeat the measurement multiple times at each time point (initial, transitional, and final measurement) to minimize potential errors caused by subjectivity in assuming the basic posture during testing. These measurements should then be statistically analyzed to determine the significance of differences. In addition to these limitations, it can also be suggested that extending the duration of the corrective water treatment program and adding another measurement time point could result in even greater differences in the treated convexity angles.

CONCLUSION

The results of this case study demonstrated the positive effects of applying a corrective water-based treatment program on the convexity and concavity angles in both the sagittal and frontal planes of the thoracic and lumbar spine in a prepubescent male with idiopathic postural deformities. Additionally, a corrective exercise plan in water was presented. However, based on previous research, the duration of the program can be classified as relatively short, offering future researchers and therapists the opportunity to further develop and expand in this area. In light of these findings, we emphasize the importance of preventive action and early diagnosis to reduce the prevalence of idiopathic postural disorders in children and to prevent more severe stages of spinal postural deformities within this population.

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