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ORIGINAL SCIENTIFIC PAPER

PREVENTION AND CORRECTION OF KYPHO-LORDOSIS THROUGH HYDROKINETOTHERAPY

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Abstract

Purpose: The aim of this study was to evaluate the effectiveness of a hydrokinetotherapy program in improving postural indicators in primary school children diagnosed with kypho-lordosis.

Methods: The research was designed as a longitudinal pedagogical experiment carried out over six months. The sample consisted of eight pupils aged 9-10 years, selected from schools in Arad and diagnosed with kypho-lordosis. Participants attended three sessions per week, combining corrective exercises performed on land, in shallow water and in deep water, with respiratory gymnastics and swimming drills. Assessments were conducted initially, intermediately and finally using the plumb line test in the sagittal plane and goniometric measurement. Arithmetic mean, amplitude, coefficient of variability and standard deviation were used for statistical interpretation. The study is exploratory in nature, and the analysis of the results was carried out using descriptive statistical methods, without applying inferential tests and without including a control group. **Results:** The plumb line assessment showed a cumulative improvement of 0.70 cm from initial to final testing. The goniometric assessment showed a cumulative improvement of 4.00 degrees. Variability indicators also decreased, suggesting a more homogeneous postural response to the intervention. **Conclusions:** The results support the use of hydrokinetotherapy as a useful complementary method for improving postural alignment in children with kypho-lordosis, provided that the program is progressive, supervised and adapted to the participants' functional level.

Keywords: postural alignment; pediatric rehabilitation; therapeutic swimming; spinal assessment; motor education

1. Introduction

Correct body posture during childhood is an important component of physical development and motor education. The school period is characterized by rapid growth, frequent changes in body proportions and increasing exposure to prolonged sitting, carrying loads and sedentary

activities. These factors can contribute to postural deviations when they are not balanced by systematic physical exercise, postural education and early corrective intervention (Ahmadi et al., 2020; Calb, 2000; Cîrlă, 1992; Plas & Hagron, 2001).

Corrective aquatic programs may represent an alternative or a complement to classical physical therapy in the prevention and correction of postural deviations in children and adolescents. The properties of the aquatic environment—buoyancy, hydrostatic pressure, and water resistance—facilitate the performance of movements with reduced joint impact, allow postural control, and promote activation of the trunk muscles. Recent studies have highlighted the positive effects of corrective exercises performed in water on hyperkyphosis, forward head posture, and rounded shoulders, while the literature on postural disorders in children emphasizes the importance of conservative, individualized, and early interventions (Ahmadi et al., 2020).

Xiang et al. (2024) present a scoping review is presented that supports the use of aquatic therapy in children and adolescents, emphasizing that the properties of water—buoyancy, hydrostatic pressure, and hydrodynamic resistance—facilitate therapeutic exercise and functional recovery (Iordan et al., 2025). The specialized literature highlights the limited number of applied studies on the effects of hydrokinetic therapy on the posture of younger school-aged children.

Swimming and aquatic exercise are often recommended in physical education and rehabilitation because the aquatic environment reduces mechanical load, facilitates movement control and offers graded resistance through water viscosity. The buoyancy of water supports the body, decreases joint loading and can help children perform movements that are more difficult or less comfortable on land (Baciu, 1981; Cordun, 1999; Dănoiu, 2006). These properties are relevant in corrective programs that aim to improve spinal alignment, trunk control, respiratory function and general motor confidence

Kypho-lordosis is a postural deviation in the sagittal plane that combines dorsal kyphotic accentuation with lumbar lordotic accentuation. The two deviations can appear successively, with one curve developing compensatory characteristics in relation to the other (Barczyk et al., 2009; Drăgan et al., 1994). The corrective approach must therefore address both the dorsal and the lumbar regions, while also improving abdominal tone, back extensor control, pelvic position and breathing mechanics.

The scientific rationale of the present research derives from the need to use school- and community-accessible methods for postural correction. Previous literature on corrective gymnastics, kinesiology and aquatic therapy indicates that corrective exercise can influence postural control when it is applied regularly, with appropriate dosage and individualized progression (Ahmadi et al., 2020; Badiu et al., 2003; Barczyk et al., 2009; Bighea, 2013). The aim of this study was to evaluate whether a six-month hydrokinetotherapy program could improve measurable postural indicators in children aged 9-10 years diagnosed with kypho-lordosis.

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2. Materials and Methods

Study design

The study was organized as a longitudinal pedagogical experiment. The intervention lasted six consecutive months, from October 2022 to March 2023, and included three testing moments: initial testing, intermediate testing and final testing. The research design was based on repeated measurements of the same participants before, during and after the application of the corrective program.

Participants

The sample included eight pupils aged 9-10 years, selected from schools in Arad municipality. The research group consisted of 8 male students. All participants had been diagnosed with kypho-lordosis and were recommended corrective exercises and swimming-based therapeutic activity. Sex distribution was not used as an inclusion criterion or an analysis variable in the original data set; this aspect should be considered when interpreting the results.

The inclusion criteria were: age between 9 and 10 years; diagnosis of kypho-lordosis; ability to follow a common corrective program; participation in the same exercise structures; and readiness to respond to the requirements of the sessions. The children had previously acquired basic swimming skills, including floating, gliding, breathing and elementary crawl and backstroke technique.

The small number of subjects was determined by the local recruitment conditions, the children's availability, and parental consent. The small sample size is explained by the exploratory nature of the research and by the specific limitations related to participant recruitment in the local context, with the study serving as a basis for future research on larger samples.

Setting and intervention

The diagnosis of kypholordosis and the study were carried out in the private practice office of the Izvorul Sănătății Treatment Center in Arad, owned by Dr. Iulian Cibotaru, senior physiotherapist. The Izvorul Sănătății Treatment Center in Arad is equipped with various devices used in the treatment of physical deficiencies, including some with support-pulley systems, exercise benches, melacart tim boards necessary for promoting movement, ergometric bicycles, medicine balls, small and large dumbbells, sandbags, wall bars, gym benches, a skateboard-type movement board, etc.

The assessment was performed using a plumb line and a goniometer. These students are registered in the records of the sports medicine office of the Arad Municipal Hospital and have medical exemptions from physical education and sports classes, in accordance with the law. However, they were recommended by the specialist physiotherapist to perform corrective exercises both during physical education lessons and through swimming.

The aquatic sessions took place at the Subcetate swimming pool in Arad, a 25 m pool with five lanes, with shallow water of approximately 0.7 m at one end and deeper water of

approximately 1.8 m at the other end. Complementary assessment and land-based corrective activities were conducted in a private treatment facility in Arad equipped with therapeutic exercise apparatus, gym benches, wall bars, medicine balls, weights, pulleys and other materials used in postural rehabilitation.

The intervention consisted of three sessions per week, on Monday, Wednesday and Friday. A 14-day consolidation period was initially used to harmonize the participants' swimming skills. After this preparatory stage, corrective exercise structures specific to kypho-lordosis were applied until the winter break, followed by continuation of the program after the break until final testing. The program combined static corrective positions, dynamic exercises for the trunk and limbs, respiratory exercises, basic swimming drills and corrective tasks performed in shallow and deep water.

During the entire six-month intervention period, the pupils performed corrective exercises specific to kypho-lordosis both in the aquatic environment and on the poolside. The exercises were selected from basic gymnastics and adapted for execution in shallow or medium-depth water, as well as through specific swimming techniques, particularly front crawl and backstroke.

The specific means used included static exercises, dynamic exercises targeting the trunk, upper limbs and lower limbs, and breathing exercises (Cordun & Cîrlă, 1999).

In designing the exercise structures, the following aspects were considered: the specificity of the means in relation to the objectives of swimming; the possibility of applying these means in school settings and their applicability by other coaches or specialists interested in this topic; the possibility of both quantitative and qualitative evaluation; and their recognized effectiveness in the instructional and educational practice of therapeutic swimming.

The main means used for the correction of kypho-lordosis are presented in Table 1.

Table 1. Main means used for the correction of kypho-lordosis

Type of exercise	Reference
Physical training exercises performed in water	Calb, 2000
Exercises performed on the poolside	Cordun, 1999
Exercises performed in shallow water	—
Exercises performed in medium-depth water	Cîrlă, 1992; Culda et al., 2000
Respiratory gymnastics program	—

The dosage parameters applied throughout the intervention are presented in Table 2.

Table 2. Dosage parameters of the exercise intervention

Parameter	Value
Duration of one session	1 hour
Weekly frequency	3 times per week
Number of repetitions	8 repetitions
Number of sets	2 sets
Exercise intensity	Below average
Progression	Gradual increase in difficulty over six months, in accordance with participants' adaptation and positive progress

The selected exercises aimed to increase the tone of dorsal and abdominal muscle groups, improve the length-tension relationship of the sacro-lumbar region and anterior thoracic wall, and form a correct postural reflex of the trunk and lower limbs (Barczyk et al., 2009; Bitang, 2009a; Drăgan, 2002; Jeleascov, 2000; Sbenghe, 1986). Exercise positions included standing, kneeling, sitting, lying and hanging variations. Movements included bending, stretching, thoracic extension, rotations and controlled trunk actions. Portable and fixed materials included sticks, elastic cords, medicine balls, small sandbags, wall bars, gym benches and inclined planes.

Measurements and investigated parameters

Two measurement procedures were used. The plumb line test was performed in the sagittal plane to determine deviations in relation to the dorsal region. Goniometric measurement was used to quantify angular changes associated with the postural deviation. The investigated parameters were the arithmetic mean, amplitude, coefficient of variability and standard deviation for each testing moment and each measurement method.

To reduce measurement variability, all assessments were performed by the same evaluator, under similar conditions, using the same instruments and the same working procedure.

Statistical analysis

The statistical analysis was descriptive. The arithmetic mean was used to estimate the central tendency of the group values. Amplitude described the range of values observed in the group. The coefficient of variability was used to estimate the relative homogeneity of the sample, while standard deviation described dispersion around the mean. The available manuscript data allow

interpretation of the differences between initial, intermediate and final testing, rather than inferential testing. Because the sample was small (n = 8), the results should be interpreted as preliminary and exploratory.

Ethical considerations

All investigations involving children should conform to the Code of Ethics of the World Medical Association, Declaration of Helsinki. Participation should be documented as having been based on medical recommendation and parental/legal guardian consent.

3. Results

The results are presented according to the two assessment methods used in the study. The most important findings were the progressive improvement observed between initial and final testing and the reduction of variability indicators, suggesting a more consistent postural response among participants.

Table 3. Study design and assessment moments

Stage	Period/date	Main activity	Assessment
Initial assessment	30 September 2022	Baseline clinical-functional assessment	Plumb line and goniometer
Preparatory stage	3-16 October 2022	Consolidation of swimming fundamentals	Technical observation
Intervention stage I	October-December 2022	Corrective aquatic and land exercises	Intermediate testing on 19 December 2022
Winter break	December 2022-January 2023	Interruption according to school calendar	No testing
Intervention stage II	16 January-21 March 2023	Continuation of corrective program	Final testing on 21 March 2023

The plumb line test indicated a gradual improvement in postural deviation. The difference between initial and intermediate testing was 0.2875 cm, while the difference between intermediate and final testing was 0.4125 cm. The cumulative improvement from initial to final testing was therefore 0.70 cm. The amplitude did not change between the first two measurements but changed by 0.30 at final testing. The coefficient of variability decreased by 2.07 points between initial and final testing. Standard deviation changed by 0.10 between initial and intermediate testing and by 0.25 between intermediate and final testing.

Table 4. Evolution of plumb line indicators in the sagittal plane

Indicator	Initial to intermediate	Intermediate to final	Initial to final	Interpretation
Arithmetic mean	0.2875 cm improvement	0.4125 cm improvement	0.70 cm improvement	Progressive reduction of postural deviation
Amplitude	No change	0.30 change	0.30 change	Range became more favorable at final testing
Coefficient of variability	-	-	2.07 decrease	Greater group homogeneity
Standard deviation	0.10 change	0.25 change	0.35 cumulative change	Reduced dispersion tendency

The goniometric assessment showed a larger numerical change than the plumb line assessment because it quantified angular deviation. The difference between initial and intermediate testing was 2.08 degrees, and the difference between intermediate and final testing was 1.92 degrees, resulting in a cumulative improvement of 4.00 degrees. The amplitude changed by 1.10 between initial and intermediate testing and by 0.50 between intermediate and final testing. The coefficient of variability changed by 3.20 and 1.66 respectively, while standard deviation changed by 0.51 and 0.31.

Table 5. Evolution of goniometric indicators

Indicator	Initial to intermediate	Intermediate to final	Initial to final	Interpretation
Arithmetic mean	2.08 degrees improvement	1.92 degrees improvement	4.00 degrees improvement	Consistent angular correction
Amplitude	1.10 change	0.50 change	1.60 cumulative change	Improved range of values
Coefficient of variability	3.20 change	1.66 change	4.86 cumulative change	More homogeneous group response

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Standard deviation	0.51 change	0.31 change	0.82 cumulative change	Lower dispersion of results

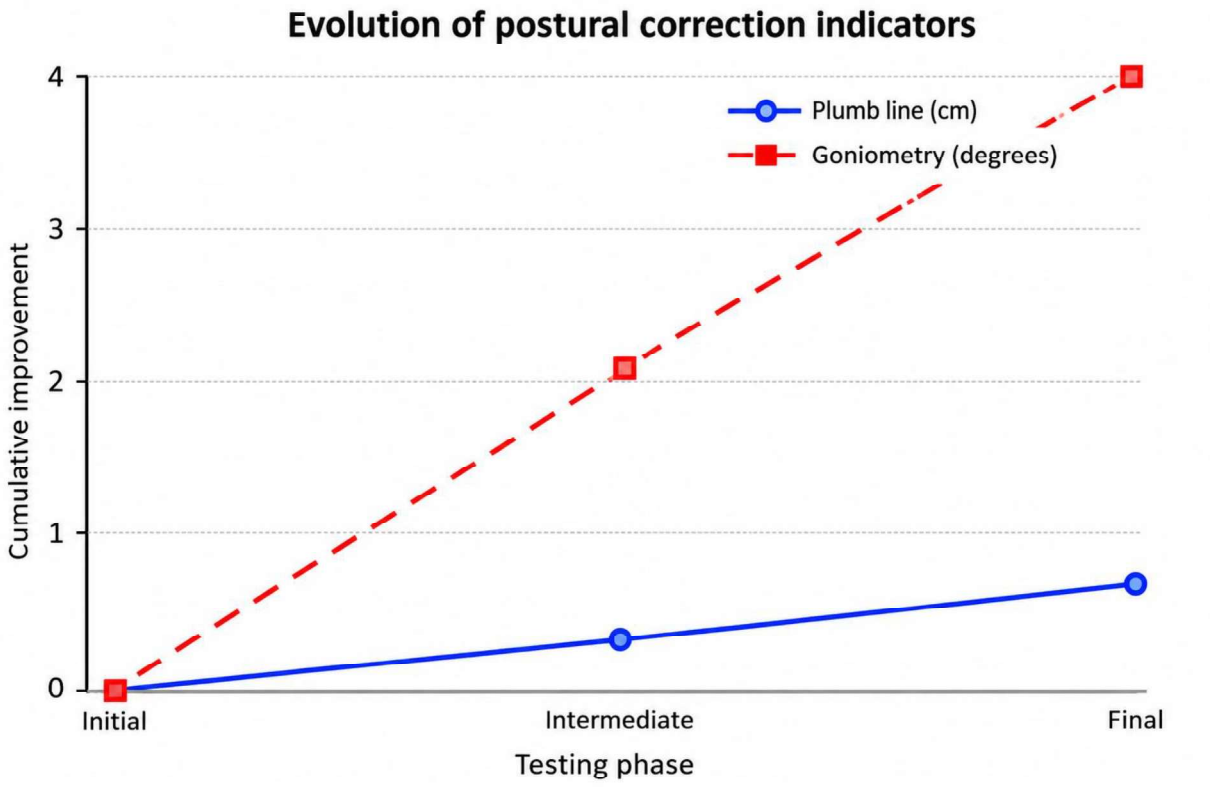

Figure 1. Cumulative improvement of postural indicators between testing moments. Values are presented in their original measurement units: centimeters for the plumb line test and degrees for goniometry.

In the absence of clear clinical thresholds for this age category, the results should be interpreted with caution.

A particular feature of the program implementation was the interruption caused by the winter holiday. This break may have influenced the pace of progress; therefore, the evolution of the results between the intermediate and final assessments should be interpreted with caution.

4. Discussion

The findings indicate that the six-month hydrokinetotherapy program produced favorable changes in both linear and angular indicators of postural deviation. Although the sample was small, the direction of change was consistent across the two measurement methods. This supports the practical value of combining aquatic exercise, corrective gymnastics and respiratory work in children with kypho-lordosis.

The improvement observed in the plumb line test suggests better sagittal alignment and postural control. In practical terms, this may reflect improved awareness of trunk position and more balanced activation of the muscle groups involved in spinal support. The goniometric improvement of 4.00 degrees provides additional support for the corrective effect of the program. Because kypho-lordosis involves both dorsal and lumbar components, the combined use of trunk extension control, abdominal strengthening, respiratory gymnastics and swimming drills is methodologically justified.

The aquatic environment may have facilitated these changes through several mechanisms. Buoyancy decreases loading and allows children to perform movements with less fear and less compensatory tension. Water viscosity provides continuous resistance, which can support symmetrical muscle activation and controlled movement execution. Hydrostatic pressure and the sensory characteristics of immersion may also contribute to postural awareness and respiratory control (Baciu, 1981; Bitang, 2009b; Marcu, 2000; Ogonowska-Słodownik et al., 2024). These mechanisms are consistent with contemporary descriptions of aquatic therapy as a rehabilitation environment that supports postural control, motor learning and functional participation in children (Becker, 2009; Culda et al., 2000; Mureșan et al., 2006; Sbenghe, 1986).

The results are also consistent with the broader literature on corrective exercise in water. Barczyk and colleagues reported that corrective exercises performed in a water environment can influence antero-posterior spinal curves and the functional status of the locomotor system in children with spinal deviations (Becker, 2009; Firică, 1998; Fozza, 2002; Fozza & Nicolaescu, 1980). The present study does not claim generalizable clinical efficacy because it did not include a control group, but it provides applied pedagogical evidence that aquatic corrective programs can be implemented in school-aged children when the program is supervised and progressively dosed.

A strength of the study is the duration of the intervention and the repeated assessment design. The program lasted six months and included three sessions per week, which is a sufficient pedagogical framework for observing postural adaptations. Another strength is the use of both land-based and water-based corrective means, which made it possible to address posture, breathing and swimming skill consolidation together.

The study also has limitations. The number of participants was small, sex distribution was not recorded as an analysis variable, and the available data were summarized descriptively. Future studies should include larger samples, a control group, standardized photographic or digital postural analysis, individual raw values and inferential statistical testing. It would also be useful to evaluate whether improvements are maintained several months after the end of the intervention.

5. Conclusions

The six-month hydrokinetotherapy program was associated with measurable improvements in postural indicators among children aged 9-10 years diagnosed with kypho-lordosis.

The plumb line assessment showed a cumulative improvement of 0.70 cm, and goniometry showed a cumulative improvement of 4.00 degrees from initial to final testing.

The combined use of corrective exercises on land, exercises in shallow and deep water, respiratory gymnastics and swimming drills appears to be a useful method for supporting postural correction in primary school children.

The findings support the inclusion of supervised aquatic corrective programs in school and rehabilitation contexts, while future studies with larger samples and control groups are needed to strengthen the evidence base.

Given the small sample size, the absence of a control group, and the exclusive use of descriptive statistics, the results should be interpreted as favorable trends observed within this sample, without being generalizable to the entire school population.

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