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SUMMARY

Influence of swimming, hydro kinesiotherapy, and kinesiotherapy on sagittal plane postural deficiencies in 8-12-year-old children

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2023

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Key words: Swimming, hydrokinesiotherapy, kinesiotherapy, adolescents, postural deficiencies, kyphosis, lordosis, sagittal plan.

Importance and topicality of the theme

Swimming is a sporting discipline many specialists recommend to treat various health problems, including postural deficiencies. Due to the different opinions on correcting these deficiencies in the literature, with this paper, we wanted to analyze which of the three methods significantly influence postural deficiencies and whether there are notable differences between these methods.

Nowadays, the tendency to adopt a sedentary lifestyle is on the rise and is a significant factor in the deterioration of the population's health worldwide, leading to an increasing number of cases of postural disorders. This lifestyle is defined by a long period spent in static positions, such as sitting on a bench, watching television, or using gadgets, all of which occur in insufficient physical activity (Magnon et al., 2021).

The importance of this study is even more significant in the context of increasing rates of musculoskeletal conditions, many of which are directly proportional to the adoption of poor posture (Lewis et al., 2019). As these conditions can largely be prevented or ameliorated by appropriate physical therapies and exercise, it is essential to investigate different intervention methods such as swimming, hydrokinetic therapy, and kinesiology.

In this context, swimming, hydro kinesitherapy, and kinesitherapy, as forms of physical therapy, have the potential to improve posture significantly. Although these methods are known and applied in various therapeutic contexts, most research studies separately study their impact on sagittal plane postural deficiencies (Karaleic et al., 2014; Johnson, 2016; Benedek, 2017). Therefore, this paper aims to investigate the therapeutic potential of these methods and contribute to a deeper understanding of how they can prevent and correct postural deficiencies.

The topicality of the topic proposed for this paper is, therefore, exceptionally high, given the need to better understand the therapeutic potential of these methods in preventing and correcting postural deficiencies.

Elements of Novelty and Originality

A novel element of this thesis is implementing the intervention method in swimming groups for children with postural impairments. It had an original character through the implementation and selection of complex swimming exercises, predominantly towards learning and strengthening the cradle and backstroke procedures, considering the particularities of postural deficiencies in the sagittal plane. Also, the structure of the intervention plan regarding the volume of swimming, the intensity of the physical effort, and the rest time contributed to the originality of the proposed program.

Although known and validated, the chosen posture assessment methods have been used separately in other literature. Therefore, the use of the Zebris device together with the PosturePro8 software is another element of originality. With their help, we were able to have a complex picture of children's posture due to the many variables analyzed, and it contributed significantly to the realization of the intervention program.

After reviewing the literature, we concluded that most research examines one, at most, two methods of correcting postural deficiencies (swimming, hydrorkinesiotherapy, kinesiotherapy). Another novel element in our work was the analysis of the three methods and the differences between them.

Summary of capitol 1. The impact of swimming on the human body.

All sports offer health benefits when done correctly. However, swimming has some unique features that other aerobic exercises do not (Pendergast et al., 2015). Here are some of these particular aspects of swimming:

1. Increases cardio-pulmonary endurance - swimming trains and strengthens the cardiovascular system, increasing the ability of the heart and lungs to deliver oxygen to muscles and remove carbon dioxide (Muniz-Pardos et al., 2022).
2. Stimulates blood circulation - swimming improves blood circulation throughout the body, facilitating the distribution of nutrients and oxygen to tissues (Alberton et al., 2015).
3. Helps maintain stable blood pressure - by improving circulation and cardiovascular health, swimming helps maintain stable blood pressure (Yardley et al., 2012).
4. Reduces the risk of cardiovascular disease - swimming helps lower the risk of cardiovascular diseases, such as heart attack and stroke, by strengthening the heart and improving blood circulation (Igarashi & Nogami, 2018).
5. Develops most muscle groups - swimming trains almost all muscle groups, increasing muscle strength and endurance (Żukowska & Szark-Eckardt, 2017).
6. Strengthens ligaments - swimming strengthens ligaments and helps prevent injuries caused by excessive stress on them (Muniz-Pardos et al., 2022).
7. Develops flexibility - swimming helps to improve joint and muscle flexibility, thus preventing injuries and facilitating recovery after exertion (Muniz-Pardos et al., 2022).
8. Helps manage anxiety and relieve symptoms of depression - by swimming, you can reduce stress and improve your general wellbeing, thus having beneficial effects on mental health.
9. Stimulates physical and mental growth and development - swimming supports the harmonious development of children and adolescents, both physically and mentally (Nugent et al., 2017).
10. Enhances psychomotor development - swimming helps develop coordination, balance, and fine motor skills (Nugent et al., 2017).

The use of water to prevent and treat diseases or illnesses has ancient origins. Initially, the Chinese, through the doctrine of fasts and body movements developed by Confucius, and later the Greeks and Romans, through Euripides, Galenus, and Aurelianus, established the basis for the indications and application of the benefits of exercises carried out in the water (Olaru, 1982).

A significant benefit of swimming is that, in the aquatic environment, the body 'decreases' in weight according to Archimedes' principle, corresponding to the volume of water displaced. This facilitates the execution of movements and allows for more efficient recovery of deficient muscle groups due to more favorable conditions in terms of mechanical stress (Cumming, 2017).

Medical professionals have, in recent years, increasingly begun to recommend swimming as a recovery strategy for a variety of conditions. Thus, swimming benefits bronchial asthma, musculoskeletal pain, herniated discs, stress, growth promotion, controlled weight loss, and specific physical and motor disabilities (Valeriani et al., 2016).

Physical exertion directly influences the cardiovascular system, depending on its nature, volume, and intensity. The heart constantly pumps blood enriched with nutrients and oxygen to the muscle fibers, where the energy needed for muscle contractions is generated, and waste substances from metabolic processes are eliminated (Stoica, 2013).

Regular swimming improves the functional capacity of the respiratory system (total lung capacity, expiratory reserve volume, and inspiratory reserve volume), as well as maximal oxygen uptake and consumption during exercise (Shei, 2018). Numerous literature studies have demonstrated significant increases in VO_2 due to practicing aerobic exercise systematically (Pendergast et al., 2015). Vital capacity is developed by increasing breathing through inspired oxygen (Illi et al., 2012). Due to the increased volume of inspired oxygen improves lung elasticity, which leads to increased oxygen in deep inspirations due to toning of the respiratory muscles (diaphragm, intercostals) (Simmons et al., 2013).

Among the late effects of swimming, it can be observed that the breathing rate decreases, but by increasing the amplitude of breathing movements, the same volume of oxygen is obtained in the blood. Thus, the cardiovascular system is toned, and heart activity improves because, through a reduced number of myocardial contractions, a more significant amount of blood is pumped, ensuring body oxygenation with increased nutrient intake (Pendergast et al., 2015).

Aquatic exercise provides a degree of mobility that cannot be achieved in a land-based environment and helps to strengthen the bone system, including in older people, as long as the aerobic effort is age-appropriate. The aquatic environment protects the osteoarticular system from pressures, pulls, strains, and compressions, having positive effects on the joints and preventing potential injuries (Stoica, 2013).

Swimming, by engaging several muscle groups and due to the predominant aerobic effort, tones the muscles and significantly reduces the percentage of adipose tissue (Nazarov, 2021). Regular swimming increases the amount of glycogen in the stressed muscles, thus improving energy reserves (Grünert et al., 2020). Trained muscles use glycogen efficiently during physical exertion and produce less lactic acid, which delays the onset of fatigue (Philippou et al., 2017). During swimming, hypertrophy of red (slow) muscle fibers occurs, which shows higher vasodilation and increased mitochondria and myoglobin content, allowing for higher oxygen consumption (Vasile, 2013; Grünert et al., 2021).

The complexity of muscle actions during swimming has positive influences on movements in different planes (Borioni et al., 2022). The main advantage of swimming is that the pressure on muscles and joints is reduced during training, allowing muscles to develop flexibly without overstraining the joints. Ligaments strengthen and develop, and together with a well-developed musculature, contribute to correct posture (Stoica, 2013; Nazarov, 2021).

The short cold-water program increases the output of the striated muscles, so fatigue sets in later (Knechtle et al., 2020). If the duration of the cold water program is increased, it can lead to increased muscle tone, and externalized clonic contractions occur as involuntary tremors (Knechtle et al., 2020). Warm applications decrease both muscle strength and tone but have a beneficial effect on muscle contractions (Cotton, 1997).

Summary of Chapter 2: The beneficial effects of hydrostatics and hydrodynamics on the body

The upward force (Archimedes' force) is designed to partially mitigate the impact of gravity on bodies submerged in water. Thus, the apparent weight of a body submerged in water decreases in proportion to the depth at which it is submerged, thereby reducing the stress and strain on joints and the musculoskeletal system (Haupenthal et al., 2013).

Exercises used in correcting deficiencies can be adjusted for difficulty by means of upward force. This approach can produce the following beneficial effects (Torres-Ronda & Alcazar, 2014):

- promotes movement - as a body segment approaches the horizontal position (i.e. rises), the Archimedes force intensifies, helping to reduce the effort required for movement. To achieve this effect, the segment in question must be completely submerged in the water so that it benefits from the support provided by the Archimedes force. This force reaches its maximum value in the horizontal position, providing additional support to the limb in this position.

- Resistance element - the resistance to movement reaches its maximum value when the body segment is in a horizontal position; the resistance will decrease as the segment descends and will become zero when it reaches a vertical position...

Pascal's law states that a body submerged in water will be subjected to equal hydrostatic pressure over its entire surface. This pressure is directly proportional to the depth at which the body lies. According to Pratt (2002), hydrostatic pressure increases by about 2 mmHg for every inch of depth.

The influence of water on the body

The temperature of the water in which most swim training takes place is 5-10°C lower than the human body temperature, and in open water, it can reach up to 15-18°C (Stjepanovic et al., 2017). This temperature difference can lead to changes in the body aimed at limiting heat loss. Capillaries play an important role in temperature regulation, as initially vasoconstriction occurs to decrease heat loss and then dilation, which induces a sensation of warmth (Stjepanovic et al., 2023). However, if the time spent in the water increases, passive dilation of the capillaries can lead to a decrease in temperature and poor blood circulation to the capillaries, which can put swimmers at risk of illness (Alexiou, 2014). Therefore, it is important for swimmers to take care of their body temperature and take regular breaks to warm up and avoid prolonged exposure to low temperatures in the water (Rust et al., 2012). Heat loss is very important for swimmers, as water is almost 30 times better at conducting heat than air. While in water at 20°C we feel cold and at 26°C cool, in air at 20°C we feel comfortable and at 26°C warm (Bradford et al., 2015).

In order to implement a water exercise program, we must also take into account the specifics of the aquatic environment. Thus, water with a temperature of 30-34°C, which reduces body tension and muscle pain, is an optimal environment to work in. Muscle elasticity, together with pain reduction, positively influences the patient psychologically (Mooventhan & Nivethitha, 2014).

The practice of hydrokinetic therapy, in a systematized, directed and controlled way by specialists in the field, leads, undoubtedly, to the improvement of some diseases/illnesses such as neurological disorders such as paralysis, paresis, sequelae hemiparesis, poliomyelitis, post-traumatic disorders, degenerative rheumatic disorders, rheumatic joint diseases, cardiovascular diseases and, last but not least, some segmental or global impairments of the locomotor system (Lambeck, 2017).

The latter category also includes physical deficiencies or deviations of the spine with different etymologies, either inborn/congenital, as a result of transmission through genetic inheritance of malformations, morpho-functional and structural disorders, or acquired, as a result of deficient habitual positions and attitudes, or, ultimately, as a result of trauma that has structurally and functionally altered, globally or segmentally, the entire musculoskeletal-tendon apparatus/system (Mahjur et al., 2016).

Summary of Chapter 3. Physical deficiencies of the spine in the sagittal plane

Due to the segments of the locomotor system, the spinal column is of particular importance, both for its static function of supporting the upper body and for its dynamic function, ensuring the mobility of the trunk, head, and neck. The position of the spine is not straight but sinuous in orthostasis, with a series of curves in the anterior-posterior plane which help maintain balance and reduce vertical shocks. (Johnson, 2015).

Posture varies from individual to individual and is influenced by several factors such as gender, age, level of fatigue, occupation, and lifestyle. In the first year of life, the spine adopts a kyphotic position when the child sits. Around the age of 1, as the spine adopts an upright position, lordotic curvature is formed. Around the age of 7, the structure of the spine becomes similar to that of an adult. (Ganciu, 2010).

Antero-posterior spinal deviations can be lordotic when the convexity is anteriorly oriented, kyphotic when the convexity is posteriorly oriented, or ky-pho-lordotic when there is a combination of the first two situations (Scataglini, 2019).

According to Gangiu (2010), these deviations can be:

1. Typical deviations, exaggerations of physiological curves
   - Dorsal kyphosis;
   - Lumbar lordosis;
   - Cypho-lordosis;
2. Atypical deviations, reversals of physiological curves
   - Back plan;
   - Lumbar kyphosis
   - Reverse kyphosporosis;
3. Changes occurring due to the extension of curves
   - Total kyphosis;
   - Total fat;
   - Dorsolumbar kyphosis.

Postural deficiencies are common musculoskeletal problems that affect people of all ages and can negatively impact their quality of life (Kim et al., 2021). The incidence of postural deficiencies refers to the number of new cases occurring in a given population in a specific time frame (Alexander et al., 2017). The prevalence of postural deficiencies, on the other hand, refers to the total number of cases existing in a given population at a given time (Bjelica et al., 2021). These measurements are important to understand the extent of the problem and to plan and implement effective prevention and treatment strategies (Ali et al., 2022). Factors such as age, gender, lifestyle, and environmental factors can contribute to the development of postural deficiencies, making the problem a complex one that requires a multidisciplinary approach (Wang et al., 2016).

In the study by Maciałczyk-Paprocka et al. (2017), in a group of 888 boys and girls aged 7-12 years, thoracic kyphosis, lumbar lordosis and flat back were diagnosed in only 1.8% of subjects. Jankowicz-Szymańska et al. (2020) found that two-thirds of a total of 685 children aged 10-12 years had incorrect sagittal plane posture, with lumbar lordosis being more common in girls and thoracic kyphosis in boys. Another study looked at 150 children, 60% of whom were girls and 40% boys, with an average age of 11.28 years. Of these children, 38.7% were diagnosed with kyphosis, while 61.3% had normal curvature of the spine. The results of the study showed a significant relationship between backpack weight and the prevalence of kyphosis, which was very high in children carrying heavy backpacks (Akhter et al., 2022).

The principles of treatment and rehabilitation for spinal impairments may vary depending on the type and severity of the condition as well as the individual needs of the patient (Moustafa et al., 2022). However, there are some general principles that are applied in many cases (Haldeman et al., 2018):

- Accurate assessment and diagnosis: In order to establish an appropriate treatment plan, an accurate assessment and diagnosis is crucial. This involves a detailed physical examination and the use of imaging tests such as X-rays, MRI, or CT scans. These investigations help to identify the type and severity of spinal impairment.
- Conservative treatment: In many cases, initial treatment focuses on conservative methods. These may include physiotherapy, muscle-strengthening exercises, manual therapy, hydrokinetic therapy, and lifestyle changes. The aim of these methods is to reduce pain, improve mobility and increase spinal stability. Kinesiotherapy may involve postural muscle strengthening exercises, flexibility improvement, and posture correction techniques.
- Medication and minimally invasive interventions: In some situations, medication may be necessary to control pain and inflammation associated with spinal deficiencies. Analgesics and anti-inflammatories may be recommended depending on the patient's individual symptoms and needs. In some cases, minimally invasive interventions such as corticosteroid infiltration may be needed to relieve symptoms and provide short-term relief.

- Surgery: In severe or progressive cases, when conservative treatment does not provide satisfactory results, surgery may be recommended. This may involve correction of the deformity, stabilization of the spine, or other specific procedures depending on the diagnosis. The decision to perform surgery is based on a careful assessment of the benefits and risks, as well as detailed discussions with the patient.
- Rehabilitation and recovery: After surgery or during conservative treatment, rehabilitation and recovery play an essential role. This may include physiotherapy sessions, muscle strengthening and flexibility exercises, occupational therapy, and other rehabilitation techniques. Their aim is to restore spinal functionality and prevent relapse.

It is important to note that treatment and recovery for spinal impairments should be tailored to the individual needs of the patient. Consultation and advice from the spine specialist is essential to establish an appropriate treatment plan and to monitor the patient's progress (Kolar et al., 2014).

There is a wealth of research in the literature recommending the use of physiotherapy to treat postural deficiencies (Oakley et al., 2021; Rahimi et al., 2020; Feng et al., 2018; Magee et al., 2015; Sung et al., 2015). There are also specialists who recommend hydrokinetic therapy as an integral part of the treatment program for patients with postural deficiencies, as this type of therapy due to its environment offers significant benefits in reducing the impact on joints, improving mobility and flexibility and correcting posture and body alignment (Sarvinoz & Muzaffar, 2022; Liang et al., 2021; Iliescu et al., 2020; Carrol et al., 2020; Clerici et al., 2019)

Summary of Chapter 4. Study on correlations between physical activity, body posture, backpack weight, and parents' knowledge of children's posture

Good posture is a state of balance of the whole body segments. In children, posture is influenced by physical development, which depends on several factors: nutritional, congenital, and environmental (Batista et al., 2016). It is important to diagnose postural deviations as early as possible because children's skeletal system is still susceptible to changes, and incorrect posture is easier to correct at this stage of development (Penha, 2009). Thus, postural assessment should become a common practice in schools to detect and treat postural deviations in students (Zaina et al., 2009).

Wearing a backpack begins with schooling and continues into adulthood, and wearing a backpack is correlated with spinal damage, so it is important to take appropriate measures and pay attention to posture and pain that may occur in the back (Janakiraman et al., 2017).

In 2023, including both smartphones and basic feature phones, the number of mobile phone users is 7.33 billion, which means that 91.40% of people in the world own a mobile phone (How many smartphones are in the world? 2023)

In the digital age we live in, sedentary lifestyles seem to be becoming increasingly common among children and beyond. From an early age, children tend to spend their leisure time using phones, tablets, computers, etc., which leads to a significant reduction in physical activity (Barkley & Lepp, 2016; Brzek, 2016). It is essential to understand how smartphone use affects spinal posture and pelvic position to prevent future musculoskeletal problems (Betsch et al., 2021). Previous studies have shown that smartphone use leads to a significant increase in head flexion angle (Han et al., 2019). This can cause hyperkyphosis of the thoracic spine (Edmondston et al., 2011; Abelin-Genevois et al., 2014).

The aim of this study was to examine whether physical activity, weight, backpack wearing, and time spent using different gadgets is associated with changes in children's posture.

Collection and analysis of lifestyle information from which to identify: students' adoption of prolonged postures that favor postural deficiencies, quantity and quality of physical activity performed, time spent using different gadgets, the importance given by the family and school environment to preventing and correcting postural deficiencies through a questionnaire.

We start from the premise that postures adopted during school or at home, together with long-term use of various gadgets, can cause changes in the spine.

1. Physical activity influences children's posture in different situations.
2. Knowledge about posture and the attention parents pay to their children's posture.

The research took place between May and June 2018 on a group of 152 children (74 girls and 78 boys), randomly selected from 3 schools (two in Timisoara and one in Dumbravița). The agreement to participate in this study was made by filling in a form by the parents, respecting all GDPR rules and laws.

Inclusion criteria:

- Be between 7 and 14 years old
- Completion of the participation agreement (Annex 3)

The instrument used to collect data in this study was a questionnaire administered to parents (Appendix 3), regarding their children, with 25 questions, of which **9 questions** were related to physical activity, how they participate in physical education classes at school, whether the children practice another sport separately in an organized way, i.e., weekly frequency and a number of hours spent in these activities, how parents perceive their children in terms of physical activity (energetic, less energetic or sedentary), **8 questions on the** posture adopted by the children, from the parent's point of view, during the time spent at home and at school, how the children carry their school bag, i.e., how much weight it carries. If parents believe that their children's posture is poor, or if they believe that they have a deficiency in their own right, they should consult a specialist for diagnosis and treatment. If they were referred from school or sports activities to see a physiotherapist, **4 questions** were related to time spent on the phone and doing homework during the week and weekends, i.e., the time children go to bed and the number of hours they sleep and **4 of the questions asked** about the children's gender, age, height and weight. Our questionnaire also contains questions from The physical activity questionnaire for children (PAQ-C) (Kowalski et al., 1997) and Smartphone addiction scale (SAS)(Kwon, 2013).

Students' daily activity

From the descriptive statistics, we can see that the age of children is between 7 and 13 years (10.05 ± 2.35 years), and the body mass index shows an average = 16.22, ± 2.61 kg/m^2 . Out of the total number of respondents, 137 practice at least one sport in an organized setting with an average of 2.03 (hours/week).

The time allocated to homework during the week is between 0-8 hours/day and between 0-6 hours/day on weekends.

2. *How to wear the rucksack and its weight*

We find a weak positive correlation between the way the backpack is carried by children (in the hand, on one shoulder, on both shoulders) and the practice of a sport in an organized setting (r = 0.17, p = 0.036). Thus, playing an eavesdropped sport is directly proportional to wearing the backpack on both shoulders. Whereas, a very weak negative correlation is observed between the way of wearing the backpack and sagittal plane deficiencies, so wearing the backpack in one hand or on one shoulder can lead to postural deficiencies. (r= -0.18, p=0.023). The average weight of the backpack is 3.46 ± 2.4 kg.

3. *Parents' opinions and knowledge on different aspects of posture*

From the results obtained for the questions on children's posture, we find a negative correlation between parents' opinion on children's correct posture and the posture deficiencies they associate with their children, both in the frontal plane, where r = -0.40, p<0.001, and in the sagittal plane (r = -0.56, p<0.001). Thus, although parents state that their children's posture is appropriate, they associate various deficiencies with their children. We can observe a negative correlation between the level of information parents have about posture and the adoption of correct posture during home time (r= -

0.26, p=0.002). Thus, the more information parents know about the adoption of correct posture, the more they think it is not applied correctly.

The results of the question on the parents' opinion on the posture of their children revealed that 37.5% of the 152 children show a poor attitude or a posture deficiency, while 62.5% of the children adopt a correct posture.

Of the 57 children who have, in the parents' opinion, a poor posture, 45 have a sagittal plane deficiency, 8 have a frontal plane deficiency, and 4 have a poor posture in both planes, in the parents' opinion.

4. *Physical deficiencies found*

When asked whether anyone recommended posture control to their children, Figure 2 shows that 27 of the 152 respondents (17.76%) answered yes. While 25 of the children (16.44%) were diagnosed following a postural assessment test performed by a physiotherapist, and 24 respondents received an intervention plan to correct postural deficiencies. Following the assessment by the physiotherapist, the following results were obtained: out of 25 respondents, 10 subjects had kyphosis (40%), 7 subjects had scoliosis (28%), 6 subjects had lordosis (24%), and 2 subjects had flat back (8%). Therefore, the most common deficiencies were in the sagittal plane.

5. *Aspects of playing sport in an organized setting*

From the data analysis, we observed that there is a negative correlation between playing a sport in an organized way and postural deficiencies, both in the sagittal plane (r = -0.25, p = 0.002) and in the frontal plane (r = -0.22, p = 0.005). Thus, children who regularly practice a sport acquire a more correct posture than less physically active children. On the other hand, a strong positive correlation was found between the practice of an organized sport and the parent's opinion of the correct posture adopted by their children (r= 0.26, p=0.001). From the results of this study, we observe that although most children are physically active, both in school physical education classes (mean = 2.13 hours/week) and by practicing a sport in an organized setting (mean = 2 hours/week), the most common being swimming, karate, dancing, football, basketball, they spend up to 8 hours during the week and 6 hours on weekends doing homework. A study in Australia states that time spent on social media and doing homework significantly reduces physical activity both in an organized setting and in children's free time (Kemp et al., 2020).

There is a negative correlation between parents' knowledge of the correct posture their children should adopt and how it is applied. Thus, we observe the importance of awareness of adopting correct attitudes and postures by society in order to improve the quality of life among children (Lafond, 2007; Latalski, 2013; Queka, 2015). There is also a negative correlation between parents' opinion of their children's posture and the frontal and sagittal plane deficiencies associated with them. It is important to point out that out of 152 respondents, 27 children were advised to consult a specialist in posture assessment. Of these, 25 children have a diagnosis of postural deficiency (10 cases of kyphosis, 7 cases of scoliosis, 6 cases of lordosis and 2 cases of flat back). It should also be noted that of the 25 children diagnosed with a postural deficiency, 24 of them have followed an intervention plan for correction. So the recommendation to be seen by a specialist proved to be beneficial, as most of the children assessed by the specialist had a physical deficiency.

From the analyzed data, we observe a positive correlation between the practice of a sport in an organized way and the parents' opinion about the posture of their children, but also a negative correlation with postural deficiencies, both sagittal and frontal. This reinforces the idea that regular sports practice has a positive influence on posture. The research presented examined whether physical activity, the weight of the backpack, and its carrying correlated with the posture adopted by children, as well as how parents' knowledge correlated with the application of these postures.

The results confirm that children's posture is correlated with physical activity, lifestyle, the way they carry and the weight of their backpacks, and the time spent on homework; and although parents know about posture, it is not correctly applied at home and at school. It should be noted that most of the recommendations for postural analysis were unfounded; the subjects showed a deficiency in the assessment itself. This information also allows us to understand the children's lifestyle, as well as the amount of homework and activities they have to do both during the week and on weekends. This data also provides information about the time spent in front of various electronic devices.

Summary of Chapter 5. Pilot study on the influence of swimming on sagittal plane postural deficiencies in 8-12-year-old children .

Swimming is recognized as one of the most beneficial physical activities, largely due to the specific conditions of the aquatic environment: body position and physical demands involved in moving through the water (buoyancy, immersion, movement), all of which can contribute to a balanced development of the locomotor system, cardiorespiratory functions, and metabolism. (Eider et al., 2014)

Swimming can be implemented as an additional tool in various therapies, as a utilitarian means, for prophylactic, recreational or sports activities. Regardless of how swimming is used as a motor activity, it affects the body through the demands it imposes, contributing to harmonious growth and development, maintaining an optimal morpho-functional status, and providing increased resistance to pathogenic factors. (Waller et al., 2014 ; Zarzeczny et al., 2022).

At the same time, the influence on the body posture is determined by the regular practice of swimming through the stress exerted on the locomotor system, especially the musculoskeletal system, the joints being relieved of the weight of the body (according to the principle of Archimedes) the muscular effort can be reduced or increased depending on the exercises approached. (Tate et al., 2020 ; Taşkıran, 2020).

It is known that specialists are divided on the effects of swimming on postural deficiencies, so the **aim of** the research is to analyze the effects of a swimming and hydro kinesiotherapy plus kinesiotherapy program on postural deficiencies in children aged 8 to 12 years.

Objectives

1. Evaluation and analysis of postural deficiencies among children selected for motor activities in the aquatic environment.
2. Analysis of the progress made in the training process with exercises specific to the Swimming sport branch.
3. Analysis of the progress made in the training process with specific Hydrokinetotherapy exercises
4. Promoting a healthy lifestyle by understanding the importance of correct posture, showing the beneficial effects of exercise, and combating sedentarism.

The starting point for this research is the difficulty of accurately determining the effects of a swimming program on postural impairment.

Assumptions:

1. There is a statistically significant difference between the score obtained by participants in the swimming intervention at post-test compared to pre-test on all variables measured with the Zebris
2. There is a statistically significant difference between the score obtained by participants in the intervention consisting of hydrotherapy at post-test compared to pre-test on all variables measured with the Zebris
3. There is a statistically significant difference between the score obtained by the participants in the swimming intervention at post-test compared to pre-test on all variables measured with the Posture Pro

4. There is a statistically significant difference between the score obtained by the participants in the hydrotherapy intervention at post-testing compared to pre-testing on all variables measured with the Posture Pro

The pilot study is designed to evaluate the hypotheses and proposed intervention methods. It provides an opportunity to rectify or adjust any errors identified.

The test was conducted on a group of 14 athletes of the Timisoara Swimming Team, 8 male and 6 female; they were divided into 2 groups: swimming group (GÎ), N = 7, and hydrokinetic therapy group (GHK), N = 7.

Participants in this research met the following

- *Inclusion criteria*: to present a deficient attitude or a deficiency per se, to present written consent, completed by the parents, for the participation of the children in this study (Appendix 1), to be willing to carry out a training program determined afterward, to be between 8 and 12 years old, to present a medical certificate that they are allowed to carry out physical exercises in an aquatic environment and to present the indication and consent of the physiotherapist to carry out these activities.
- *Exclusion criteria*: non-participation in the proposed program and/or assessment sessions, re-assessment, medical contraindications to the intervention program, expressing a desire to drop out of the program, presence of water phobia, age less than 8 years or more than 12 years.

-The research was conducted over a period of 6 months, from 1.07.2018 to 18.12.2018. Thus the initial testing took place on 1-2.07.2018 and the final testing on 17-18.12.2018. The evaluation methods were the same for all subjects

Participants will be assessed using the following tools and methods:

- *Posture Pro System*: for the assessment and quantification of postural deviations, spinal overloads due to poor posture, posture score (PosturePro8, 2012).
- *Zebris system:* Digital ultrasound mapping is based on determining the exact position of significant points belonging to the bone system. An ultrasonic marker is applied to these points, and its signal is compared with a reference signal. The parameters evaluated are kyphotic angle, lordotic angle, total tilt angle, lateral tilt angle, and sacral angle (Zebrsi CMS, 2004).

Intervention programme

In the intervention program of the swimming group, specific expertise in the learning and consolidation process in the sport of swimming was provided. Subjects participated in 3 training sessions per week, each session lasting approximately 60 minutes. Meanwhile, the subjects in GHK were intervened with a plan established and implemented by the hydrokinetic therapist, having in the weekly plan 2 sessions of hydrokinetic therapy and 1 session of physiotherapy of about 50 minutes each. The descriptive statistics show that the averages between the 2 groups regarding age, weight, and height are similar, thus in the swimming group, the average age is 10.28 years, and the standard deviation is 1.48, while in the hydro kinesitherapy group, the average age is 10 years and the standard deviation In terms of height, in GÎ the mean is 1.36 cm (AS=0.07 cm) and in GH the mean is 1.37 cm (AS=0.06cm). The average weight in GÎ is 28.42 kg, while in GH 27.14 kg. In order to perform statistical analysis of the data, we used a t-test for paired samples, so after analyzing the data obtained with the Zebris machine, we can observe for the kyphosis variable of the swimming group that the mean at the initial test is 44.7° and at the final test 39.51°, comparing the means between the two moments, we could observe a significant difference where the value of p=0.02. It can be observed an improvement of the values obtained in the final test on the kyphosis parameter at GÎ, carried out with the Zebris apparatus, so these results have a positive trend in terms of deficiency, taking into account the scale of the apparatus that classifies normal kyphosis values between 33°-43° (Zebris). The values measured at the initial test for the lordotic variable M=28.17 and that at the final test M=24.45; differ significantly t=0.38; df=6; p=0.04. Thus, it can be observed the tendency of postural improvement, taking into account the scale of normal values (22°-28°) for lordosis of the swimming group. As for the other variables, there were no statistically significant differences, but it is worth mentioning the scoliosis variable where the result, although statistically insignificant, is marginal, t = 1.71, p=0.07.

The results recorded in the *hydrokinetic therapy* group on the kyphosis variable show that the values measured with the Zebris machine present highly significant differences (p<0.01) between the two tests. It can also be seen that the mean of the final test 33.68° falls within the normal range of kyphosis values (33°-43°) (Zebris). The mean values and standard deviation of the variable lordosis of the hydrokinesis group were calculated and presented in Table 8. We observed that there was a significant difference (t=2.19; df=6; p=0.03), between the lordosis values obtained at the first test, compared to the final test. The scale that frames the normal values of lordosis is between 22°-28°, and the mean at the final test (M=30.18) is 2.4° lower than the mean at the first test (M=32.58), so it is possible to observe the improvement of lordotic posture in GH subjects.

For the measurements made with the Posture Pro, the variables analyzed were: posture score, total postural deviation, and cervical spine load. In the group in which specific swimming exercises were used, there were significant results for the posture score and total postural deviation. The difference between the means of pre-test (M=19.85) and post-test (M=17.28) are highly significant, t=4.87, df=6, p=0.00, for posture score. We also observed a highly significant difference between the total postural deviation values from pre-test(M=22.18°) and post-test(20.01°), where t=4.9, df=6, p=0.00. In contrast, cervical spine load values did not differ significantly between the two tests (p=0.27).

The results obtained in the group where hydrokinetic therapy and kinesiotherapy exercises were used showed statistically significant differences in all 3 variables. Thus, for the postural score variable, the mean measured before the intervention was M=35.04 and M=27.78 after the final test, the difference being highly statistically significant t=8.17, df=6, p=0.00. The total deviation values at pre-test M=34.37°, respectively M=27.91° at post-test, show a statistically significant difference, t=7.22, df=6, p=0.00. Also, the load measured at the cervical spine shows a significant difference between the mean at the pre-test (M=46.25 N) versus the post-test (M=40.71 N).

Comparing the means of the final test with those of the initial test, we could observe an improvement in both groups (Table 10). However, GH showed greater improvement than GÎ. The posture score variable improved by 20.71% in GH, compared to 12.94% in GÎ; the total posture deviation improved by 18.79% for GH, compared to 9.78% in GÎ, and the cervical spine load variable worsened in GÎ, so the load of subjects in this group increased by 19.7%, while in GH it improved by 11.97%.

Hypothesis 1 is confirmed. The results show that there was a statistically significant difference from the pre-test to the post-test in kyphosis, $t = 2.49$, $p<0.05$, and Cardoza, $t = 0.38$, $p<0.05$. For the other variables, there were no statistically significant differences.

Hypothesis 2 is confirmed. The results show that there was a statistically significant difference from pre-test to post-test in kyphosis, $t = 3.24$, $p<0.05$, and lordosis, $t = 2.19$, $p<0.05$. following the hydrokinetic therapy intervention. In contrast, the variables trunk tilt, lateral tilt, and sacral angle did not differ statistically significantly between the 2 tests.

Hypothesis 3 is partially confirmed. Variables tested with the Posture Pro machine showed statistically significant changes from pre-test to post-test following the swimming intervention for the variables score $t = 4.87$, $p<0.00$ and deviation, $t = 4.9$, $p<0.00$. There were no statistically significant differences for the cervical load variable.

Hypothesis 4 is fully confirmed. Variables tested with the Posture Pro machine showed statistically significant changes from pre-test to post-test following hydrokinetic therapy intervention: posture score, $t = 8.17$, $p<0.00$; total deviation, $t = 7.22$, $p<0.00$; cervical load, $t = 9.27$, $p<0.00$.

The pilot test is intended to give us the opportunity to check the whole research process, including the equipment used in the evaluation and analysis of posture, as well as the intervention plan implemented in the swimming group; it should be remembered that in the hydro kinesiotherapy and kinesiotherapy group, the intervention plan was created by the physiotherapist.

Thus, after 6 months of training and implementation of the intervention programs, the 2 groups had similar results, the differences between the initial and final measurements being statistically significant for the variables kyphosis and lordosis, with the exception that in the group of hydorkinetotherapy and kinesiotherapy, the progress in correcting these deficiencies was greater. As for the other variables, there were no statistically significant differences, but it is worth mentioning the scoliosis variable in the swimming group, where the result, although statistically insignificant, is marginal, $t = 1.71$, $p=0.07$. Given that the mean differences between the parameters kyphosis and lordosis were significantly improved gives us the possibility to conclude that our hypothesis is confirmed.

The results obtained for the variables measured with the PosturePro device show that both groups had statistically significant differences in posture score and total deviation, while the load on the cervical spine in the swimming group increased compared to the hydrokinesis and kinesiotherapy group, and from this premise, we can conclude that the head posture during swimming is deficient, which leads to greater pressure on the cervical spine.

Based on our analysis, we believe that the parameters of shearwater and Cardoza have improved, but this improvement could be greater if the intervention plan were implemented over a longer period of time. We are also concerned that the other variables have not corrected significantly, and in some cases, the results from the final test show a worsening compared to the initial test.

Summary of Chapter 6. Influence of swimming, hydrokinesiotherapy, and kinesiotherapy on sagittal plane postural deficiencies

Postural changes are considered an important public health issue, especially those affecting the spine, as they can contribute to the development of degenerative spine conditions in adult life; moreover, depending on their severity, these changes can adversely affect the ability to perform certain daily activities (De Vitta et al., 2011).

Lack of emphasis on the supervision of correct posture formation in children can have a significant negative impact on the health of the spine and can be a contributing factor to the development of spinal deformities(Šćepanović et al., 2017). Consequently, it is our duty to closely monitor vicious postures in children and intervene appropriately to prevent them from developing into more severe impairments and conditions (Dimitrijević et al., 2022). This can be achieved by improving postural education and promoting a healthy and active lifestyle, as well as providing ergonomic and appropriate furniture for children in schools and at home (Johnson, 2016). By taking these steps, we can help promote healthy spinal development in children and prevent the development of postural problems in the younger population (Johnson, 2016).

Swimming is a sport in which the influence of gravitational force on the spine is minimized; the posture during swimming does not accentuate the curves of the spine. Also, the increased curvature of the spine, creates more resistance and negatively affects the body movement during swimming (Karaleic et al., 2014). Swimming is a cyclic and symmetrical sport in which it is expected that both parts of the body perform the same movement at the same time or alternately, depending on the swimming style; so due to this principle, regular swimming practice positively influences the asymmetry of the body (Torlaković et al., 2013).

Due to the fact that the opinions of specialists are divided, the aim of this paper is to observe and analyze the effects of the three intervention programs (swimming, physiotherapy, and hydrokinesiotherapy) on the postural deficiencies of children aged 8 to 12 years.

The intervention programs will be applied to three different groups, taking into account the particularities of the posture deficiencies presented by each subject, in order to analyze and quantify the influence of these methods. These programs contain exercises specific to swimming, kinetic therapy, and hydrokinetotherapy.

Objectives

1. Evaluation and analysis of postural deficiencies among children selected for motor activities in the aquatic environment.
2. Analysis of progress in the aquatic training process.
3. Analysis of progress in kinetic recovery.
4. Analysis of progress in hydrokinetic recovery.
5. Analysis of the impact of these rehabilitation methods on postural impairments.

6. Promoting a healthy lifestyle by understanding the importance of correct posture, showing the beneficial effects of exercise, and combating sedentarism.

Hypothesis

1. There is a statistically significant difference between the score obtained by participants in the swimming intervention at post-test compared to pre-test on all variables measured with the Zebris
2. There is a statistically significant difference between the score obtained by the participants in the intervention consisting of hydrokinetic therapy at baseline compared to the final test on all variables measured with the Zebris machine.
3. There is a statistically significant difference between the score obtained by participants in the intervention consisting of physiotherapy at baseline compared to endline on all variables measured with the Zebris
4. A statistical significance is identified in the variation of the scores recorded by the participants of the swimming group, comparing the post-intervention results with the pre-intervention ones in the context of all the variables analyzed using the Posture Pro 8 device.
5. There is a statistically significant difference between the score obtained by the participants in the hydrotherapy intervention at the initial test compared to the final test on all variables measured with the Posture Pro
6. A statistically significant difference is observed between the score obtained by the participants in the physiotherapy intervention at the initial test compared to the final test on all variables measured with the Posture Pro 8 machine.
7. There is a statistically significant difference between the three intervention groups on all variables measured with the Zebris machine at post-test
8. There is a statistically significant difference between the three intervention groups on all variables measured with the Posture Pro 8 at the final test

To carry out this research, we collaborated with 3 physiotherapy clinics in Timisoara and Dumbravita, respectively. From which 45 children with different posture deficiencies were selected.

Inclusion criteria: In order to participate in this study, parents of children were required to complete a participation agreement. Inclusion criteria were as follows: subjects to be diagnosed with a postural impairment; willing to participate in rehabilitation programs as assigned; aged 8-12 years; medical certification that they are fit to perform exercise in an aquatic environment; no water phobia.

Exclusion criteria: Non-participation in the proposed program and/or assessment sessions, re-assessment, medical contraindications to the intervention program, expressing a desire to drop out of the established program, presence of water phobia, age less than 8 years, or more than 12 years.

The sample was randomly assigned to three groups as follows:

- Swimming group (GÎ), N=15; in this group, we intervened with specific swimming exercises;
- Kinesiotherapy group (GK), N=15, the intervention plan consisted of kinesiotherapy exercises;
- Hydrokinesitherapy and kinesitherapy group (GHK), N=15; in this group, we intervened with a combined plan between hydro kinesitherapy and kinesitherapy exercises.

It should be noted that all subjects in the swimming group were able to swim one length of the pool (25m) without any problems**.**

The scientific research carried out was structured as follows: initial testing, intervention program implementation period, and final testing. The initial testing took place between 10-12.01.2019, while the final testing was carried out between 13-14.12.2019. The implementation period of the intervention methods was approximately 1 year.

To assess the posture of the subjects, the three-dimensional Zebris machine was used to analyze the sagittal plane of the thoracic kyphosis angle, lumbar lordosis, trunk tilt, and sacral angle. Using PosturePro 8 software, postural deviations, postural score, and, Q-angle, the center of gravity projection were quantified.

The initial testing was spread over three days, so on the first day, the subjects, together with their parents, were informed about the structure of the intervention plans (weekly schedule, duration of the intervention, location, necessary equipment, etc.), assessment methods (non-invasive) used in this research. Also, the parents of the subjects completed a participation agreement, where they were presented with the inclusion and exclusion criteria for this study. On the second day, the subjects were scheduled for postural assessment with the Zebris machine, and on the third day, to take pictures for analysis with PosturePro8 software.

The final testing was split into two days; the first day was for evaluation with the Zebris machine, and the second day was for analysis with the PosturePro8 software. It should be noted that both at the initial and final testing, the anatomical landmarks for postural analysis with the 2 assessment methods were located and marked by the physiotherapist.

Participants were randomly assigned using a letter table into three groups, namely the swimming group (GÎ), the physiotherapy group (GK) and the hydrokinesiotherapy plus physiotherapy group (GHK).

An annual swimming training plan for learning crawl and backstroke procedures can be organized in three stages. Each stage has specific objectives and activities to learn and refine basic techniques in the two styles.

Stage 1: Getting used to the avian medulum and initiation to the craul and back procedures (4 months) Objectives:

- Improving general fitness
- Familiarisation with the aquatic environment
- Learning the basics of the cradle and back technique

Activities:

1. Warm-up exercises and joint mobility on land
2. Floating and breathing exercises in the aquatic environment
3. Learning basic arm and leg technique for the two swimming styles (crawl and backstroke)
4. Arm and leg coordination exercises
5. Body recovery after exercise

Stage 2: Overall consolidation and coordination (4 months)

Objectives:

- Perfecting the cradle and back technique
- Developing endurance and speed in the water
- Improved coordination and reaction time

Activities:

1. Warm-up exercises and joint mobility on land
2. Breathing and coordination exercises for the neck and back
3. Exercises to develop speed and endurance in the water
4. Learning turns and starts for cradle and back
5. Body recovery after exercise

Stage 3: Perfecting the craul and back processes (4 months)

Objectives:

- Strengthening the cradle and back technique
- Improved strength and speed in water

Activities:

1. Warm-up exercises and joint mobility on land
2. Simulation of competition conditions (start, turns, sprints)
3. Breathing and coordination exercises for the neck and back.

Analyzing the descriptive statistics, we can state that the means of the three groups regarding age, height, and weight are similar. So, in the hydrokinesitherapy+kinesitherapy group, the mean age is M=10.46 years, and the standard deviation is AS=1.8 years. In the swimming group, the mean age is M=9.93 years, with AS=1.53 years, while the mean age in the physiotherapy group is M=9.33 years and AS=1.39 years. Regarding the height of the three groups, we have the following data, GHK, the mean is M=144.66 cm, and the standard deviation AS=10.67 cm. In the GÎ group, M=142.20 cm and AS=9.19 cm. While in GK, the mean is M=136.53 cm, with standard deviation AS=8.55 cm. Weight is also similar between GHK and GÎ, where mean M=31.38 kg (AS=7.99 kg) respectively M=30.80 kg (6.77 kg), while in the GK group, the mean is M=25.93 kg, with standard deviation AS=5.54 kg. In order to determine the type of test to analyze the collected data, the Shapiro-Wilk test was used to observe the distribution of data . It could be observed that the data are normally distributed in the three groups. In order to determine the differences between the means at the initial test and at the final test of the variables assessed with the Zebris apparatus. The Paired t-test statistical technique was used. The significance threshold was set at $p<0.05$. After the statistical analysis of the **swimming** group for the variable, kyphosis, it could be observed that the mean presented at the initial test M=41.91 (AS=13.11), t=2.12, df=14, differed statistically significantly p=0.03, compared to the mean at the final test where M=40.11 (AS=11.82). Analyzing the values at the final test, it can be seen in Figure 36 that they have improved in terms of impairment, the results being within the range of values considered normal for the Zebris 33°-43°. The variable lordosis of the swimming group recorded the following values, at the initial test, M=37,54 (AS=11,16), while at the final test, the average is M=33,66 (AS=9,62). The difference between the two means is statistically significant, where the value of p=0.02, t=2.36, df=14. After analyzing the values recorded by the subjects in the swimming group at the final test, although the difference is statistically significant and the values have progressed, they still do not fall within the normal range of the Zebris 22°-28°.

In the initial and final tests in the group where **hydrokinesis and kinesiotherapy** exercises were used, the following values were recorded. For the variable kyphosis, a statistically significant difference can be observed between the two means (initial test M=45.61, final test=38.31), where the value of p=0.00, t=4.89, df=14 . Note that the mean at initial testing M=45.61 is outside the normality scale of the Zebris apparatus for the kyphosis variable (33°-43°), while after the intervention plan was applied the mean at final testing (M=38,31) is within the normality standard. A statistically significant difference was also recorded for the lordoosis variable p=0.01, t=3.99, df=14, with the mean at the initial test M=30.50 (AS=7.45) and at the final test M=25.45 (AS=4.36) (Table 15). Analyzing the two means can be observed the improvement in terms of impairment at the final test, with this value falling within the normality scale of the Zebris apparatus for the variable lordosis (22°-28°). Regarding the variable trunk inclination, we can observe that the differences between the means at the initial and final test are significant, where the value of p=0.00, t=-2.91, df=14 regarding trunk inclination. It is also worth mentioning the parameter lateral trunk tilt, where the value of p=0.06 is marginal. For the other variables, there were no statistically significant differences. The results obtained from the evaluation of the posture with the Zebris apparatus at **GK** and comparing the means obtained using the paired t-test as a statistic technique; we can observe that for the kyphosis parameter, the mean at the initial test (M=41.26, AS=13.17) differs significantly from the final test (M=36.16, AS=8.93), where the value of p=0.00, t=3.47, df=14. Analyzing the final values of the subjects in this group, we can state that there has been progress in terms of postural deficiency, falling within the range of values considered normal 33°-43°. Also, for the lordosis parameter, we find a statistically significant difference between the two means, where the value of p=0.01, t=3.57, and df=14. Analyzing these results, we can observe that the values measured in the final test M=29.96 (AS=8.91) are close to the Zebris machine's scale for this variable (22°-28°). Thus we find an improvement in terms of posture compared to the initial test M=33.52 (AS=11.29) . We also find the variable lateral tilt, which although not significant, recorded a marginal result t=1.74, p=0.06 (incl.lat.). The other variables did not show statistically significant differences from the pre-test to the post-test following the intervention.

Following the evaluation using **PosturePro 8** software, the following variables were identified and analyzed: posture score, calculated total deviation, and load felt in the cervical spine. It should be noted that for a correct posture, the values of the three parameters must be equal to 0. Thus, in the **GÎ** following the initial test on the variable posture score, the calculated mean was M=16.86 (AS=10.10), while the values recorded in the final test were M=13.45 (AS=9.28). In order to determine whether the difference between the 2 means was statistically significant, the paired t-test was used, and the significance threshold was set at p<0.05. We can see in table no... that there is a statistically significant difference between the two tests in the posture score parameter, where the value of p=0.04, t=1.96, df=14. We also find a statistically significant difference in the variable total deviation, p=0.05, t=1.77, df=14, where the mean calculated in the initial test is M=19.16°

(AS=9.67°), and in the final test M=16.94° (AS=9.01°). On the other hand, in the parameter cervical load, the result, although marginal, does not represent a significant difference, where its value is p=0.08, t=1.46, df=14. The mean value at the initial test was M=15.34 N (AS=34.45N) and at the final test M=12.1 N (AS=26.92N). Following the **GHK** tests, where a hydrokinetic plan was intervened, the following results were obtained, for the posture score parameter, the arithmetic mean recorded at the initial test is M=17.8 (AS=7.19), while at the final evaluation the arithmetic mean being M=12.26 (AS=6.15), so it can be seen that the difference is highly statistically significant p=0.00, t=8.86, df=14. The values recorded for the total postural deviation of the GHK subjects show a statistically significant difference between the two tests p=0.00, t=10.4, df=14, the arithmetic mean from the initial test is M=19.77° (AS=6.76°), respectively M=13.13° (AS=5.16°) from the final test. Also, a high statistical difference can be observed for the cervical load variable, where the mean at initial testing is M=25.28N (AS=32.43), and at final testing M=18.5M (23.21N), where the value of p=0.01, t=2.73, df=14. Statistically similar results were recorded in **GK**, where the intervention plan consisted of kinetic exercises. Thus for the variable posture score, the arithmetic mean at the initial test is M=18.67 (AS=8.48), while at the final test the mean is M=12.2 (AS=7.02), this difference is highly statistically significant (p=0.00, t=11.38, df=14). The values of the total deviation on the difference between the two tests are also statistically significant (p=0.00, t=6.87, df=14), where the mean in the initial test is M=22.71° (AS=10.56°) and M=15.68° (AS=7.86°) in the final test. A statistically significant difference between the means of the two tests (initial test M=11.92N, AS=19.61 N, final test M=8.25N, AS=14.89N) is also found for the cervical load parameter, where the value of p=0.02, t=2.61, df=14.

For the analysis of the comparison between the studied groups, we used the Ancova statistical technique by controlling for the score recorded by the participants in the three types of intervention: kyphosis, F = 2.64, p>0.05; lordosis, F = 1.99, p>0.05; scoliosis, F = .14, p>0.05; trunk tilt, F = 2.66, p<0.05; sacral angle, F = 0.93, p>0.05; lateral tilt, F = 0.49, p>0.05.

To see if there were still differences between participants in the three types of interventions, we conducted Bonferroni posthoc tests. Statistically significant results were obtained between the swimming group and the hydrotherapy group for the variable trunk inclination, Bonferroni = -1.66, p < 0.05. For the analysis of the results recorded with the PosturePro 8 software, we used the Ancova statistical technique by controlling for the score recorded by the participants in the three types of intervention. Statistically significant differences between the three groups were recorded on the variable total deviation, F = 5.61, p < 0.001. Insignificant but marginal result towards 0.005 was obtained on the variable score, F = 2.67, p = 0.008. The cervical spine load variable did not differ statistically significantly. To see if there were differences between participants in the three types of interventions, we performed post hoc Bonferroni tests. Statistically significant results were obtained between the swimming and hydrotherapy groups for the total deviation variable, Bonferroni = -4.31, p < 0.05. Another statistically significant difference was obtained between the physiotherapy group and the hydrotherapy group in terms of the deviation variable, Bonfferoni = 3.76, p < 0.05

The results of this study confirm the research hypotheses:

Hypothesis 1 is partially confirmed. Results in the GÎ show that there was a statistically significant difference from pre-test to post-test in kyphosis, t=2.12, p<0.05; lordosis, t = 2.48, p<0.05. For the other variables, there were no statistically significant differences .

Hypothesis 2 is partially confirmed. GHK results showed that there were statistically significant differences from pre-test to post-test for the following variables: kyphosis, t = 4.89, p<0.01; lordoosis t = 3.99, p<0.05; trunk tilt, t = -2.91, p<0.05. We also have one variable, lateral tilt, which, although not significant, came out with a marginal result t=1.59, p=0.06. The other variables did not show statistically significant differences from the pre-test to the post-test following the hydrotherapy intervention.

Hypothesis 3 is partially confirmed. The GK results showed that there were statistically significant differences from pre-test to post-test for the following variables: kyphosis, t=3.47, p<.05; lordoosis t=3.57, p<.05 . However, there was one variable with a marginal result towards the significance threshold: lateral tilt, t=1.74, p=0.06. The other variables did not show statistically significant differences from the pre-test to the post-test following the physiotherapy intervention

Hypothesis 4 is confirmed. Variables tested with the Posture Pro machine showed statistically significant changes from pre-test to post-test in GÎ: score, t = 1.96, p<0.05; deviation, t = 1.77, p<0.05; incr cerv, t = 1.46, p=0.08.

Hypothesis 5 is confirmed. Variables tested with the Posture Pro machine showed statistically significant changes from pre-test to post-test following the hydrokinetic therapy intervention: posture score, t = 8.86, p<0.01; total deviation, t = 10.4, p<0.01; cervical load, t = 2.73, p<0.01.

Hypothesis 6 is confirmed. Variables tested with the Posture Pro machine showed statistically significant changes from pre-test to post-test following the physiotherapy intervention: posture score, t = 11.38, p<0.01; total deviation, t = 6.87, p<0.01; cervical load t = 2.61, p<0.0 5.

Hypothesis 7 is partially confirmed. To analyze the comparison between the groups studied, we used the Ancova statistical technique by controlling for the score recorded by participants in the three types of intervention: kyphosis, $F = 2.64$, $p>0.05$; lordosis, $F = 1.99$, $p>0.05$; trunk tilt, $F = 2.66$, $p < 0.05$; sacral angle, $F = 0.93$, $p>0.05$; lateral tilt, $F = 0.49$, $p>0.05$. To see if there were still differences between participants in the three types of interventions, we performed Bonferroni posthoc tests. Statistically significant results were obtained between GÎ and GHK for the trunk tilt variable, Bonfferoni = -1.66, $p<0.05$

Hypothesis 8 is partially confirmed. For the analysis of Hypothesis 8, we used the Ancova statistical technique by controlling for the score of participants in the three types of intervention. Statistically significant differences between the three groups were recorded on the variable total deviation, $F = 5.61$, $p<0.01$. Insignificant but marginal results within 0.05 were obtained on the variable postural score, $F = 2.67$, $p=0.08$. To see if there were still differences between participants in the three types of interventions, we conducted post-hoc Bonferroni tests. Statistically significant results were obtained between GÎ and GHK for the deviance variable, Bonferroni = -4.31, $p < 0.05$. Another statistically significant difference was obtained between GK and GHK with respect to the total deviation variable, Bonferroni = 3.76, $p < 0.05$.

Our research conducted on a sample of 45 children, divided into three groups, allowed us to conclude the following:

1. The use of methods such as swimming, kinesiotherapy, and hydro kinesiotherapy + kinesiotherapy positively influence impairments such as kyphosis and lordosis, the differences between initial and final tests being significant, and the final results are within or close to the values considered normal by the Zebris and PosturePro8 assessment devices.
2. Although there are no statistically significant differences between the 3 methods, it can be noted that the combined hydrokinetic and kinesiotherapy program improved more of the variables studied than either GÎ or GK.
3. A program of specific swimming exercises, if technically correctly implemented, has positive effects in treating postural deficiencies, even though more and more studies question this.
4. The use of non-invasive posture assessment devices (Zebris and PosturePro8) is a viable and more acceptable alternative to X-rays for parents.

Research limitations

Our research has the following limitations:

1. The low number of participants is explained by difficulties in identifying children with sagittal postural deficiencies, willingness to participate in intervention programs, and inclusion criteria (due to work schedules, costs, etc.).

2. The application of the questionnaire method is highly subjective.
3. Lack of a control group due to the difficulty of asking subjects diagnosed with a posture deficiency not to intervene for a period of 6 or 12 months to treat these deficiencies.

Summary of Chapter 7. Final conclusions and future research directions

Divided opinions on the influence of swimming on postural impairment set the stage for this thesis. We believe that this topic is not sufficiently addressed in the Romanian literature. As a result of our research, we wanted to find out whether swimming has a positive influence on sagittal postural deficiencies and to compare this method with hydrokinetic therapy and kinesiotherapy, as there are more and more specialists who refer both children and adults to swimming pools when detecting problems in the spine and not only.

From our results, we could conclude that all three methods improve sagittal plane postural deficiencies significantly, and the differences are not statistically significant between these methods, although we can observe that the combined hydrokinesis and kinesiotherapy program had a better result compared to those in which only specific exercises from swimming or kinesiotherapy were worked. We, therefore, recommend the use of a combined and complex program to correct these deficiencies.

Also, as regards the intervention plan with specific swimming exercises, it must be adapted according to the particularities of the deficiencies in question. At the same time, emphasis should be placed on technique during swimming, as poor technique can have a negative influence on the correction of these deficiencies. We consider it advisable for both coaches and swimming instructors to collaborate at all times with a physiotherapist in order to maximize the process of postural correction.

Postural assessment methods are also important in this process, and the use of non-invasive devices is more accepted by parents and less harmful than the X-ray method. Thus, by using the Zebris device together with the PosturePro 8 software, we can obtain concrete data about the posture of patients, which is very important in the development and implementation of intervention plans.

Future research directions could be directed towards:

- To develop a combined intervention program comprising the three methods outlined above to correct postural deficiencies.
- Studying the influence these methods have on several posture deficiencies. (scoliosis, flat back, sunken thorax, genu varum, valgum, etc.).

- Use of various aids during swimming to correct postural deficiencies (flippers, paws, breathing tubes, wireless headsets for communication with the subject during swimming).
- To study the differences in the effects of swimming in correcting postural deficiencies, depending on the level of swimming (beginner, intermediate or advanced).

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