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# EXAMINATION AND DEVELOPMENT OF BACK CARE KNOWLEDGE AND SPINE DISEASE PREVENTION AMONG 6-10 YEARS OLD CHILDREN

**Ph.D. Dissertation**


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## List of Abbreviations

| | |
|---|---|
| BSP | Back school program |
| BMI | Body Mass Index |
| C1,2 | Category 1,2 |
| CI | Confidence Interval |
| GEPT-6-10 | Gerinchasználattal és -prevencióval kapcsolatos tudást felmérő kérdőív 6–10 éves gyerekek számára |
| HEQBACK-6-10 | Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6–10 Years Old Children |
| HF | Hip flexor |
| ICC | Intraclass correlation coefficient |
| KF | Knee flexor |
| LBP | Low back pain |
| LMC | Lumbar motor control ability |
| MDC95 | Minimal detectable change at 95% |
| mHealth | Mobile Health |
| PE | Physical education |
| PRISMA | Preferred Reporting Items for Systematic Reviews and Meta-Analyses |
| pre | At the baseline, before the program |
| post | After the program |
| Q | Question |
| sec | Second |
| SD | Standard deviation |
| SEN | Special education needs |
| SEM | Standard error of measurement |
| TESM | Trunk extensors' static muscle strength |
| TFSM | Trunk flexors' static muscle strength |
| x | Multiplicity |

# 1 Introduction

In Hungary, the age of 6-7 means the start of primary school. Going to school significantly increases the number of hours spent on sitting, children sit 35-40 hours per week, which causes static overload on the spine [1-4]. This age group is exposed to a variety of risk factors during daily activity. Such intrinsic risk factors may include personal characteristics (gender, age, height, weight, faster growth, etc.), functional status (curvature of the spine, asymmetries, inadequate flexibility, muscle strength, etc.), lifestyle (sedentary lifestyle, lack of physical activity, inactivity, inadequate exercising, etc.) or even psychosocial factors (self-image, somatic symptoms, beliefs, disability, etc.) and extrinsic factors can be risk factors associated with the school environment (unfavorable loading conditions, improperly designed school environment, furniture, long-term sitting, improper sitting position, school bag carrying, and its overload, etc.) [5,6]. These factors contribute to the development of muscle weakness, inappropriate flexibility of muscles, later poor posture, and finally to postural disorders and deformities [4,7-9]. The prevalence of posture deformities and musculoskeletal weakness among preschool-age children is 60-62%. In primary school-age children, studies reported, that the prevalence of spinal problems and posture deformities continues at a high rate, 50-65% [10-12]. In terms of age groups the prevalence of postural impairments is 65% among children 7- to 12-year-olds, 25-55% in children 10- to 15-year-olds, and 27-47% among 11- to 15 years old children [13]. The high prevalence of musculoskeletal problems implies a high social and economic charge and restrains a considerable part of the population in their personal psychosocial and functional life [5].

According to Hungarian and international research, in order to prevent spine deformities and damage at a later age, but even at a young age, we need to raise awareness of correct spine use at a younger age, in which the back school (BSP) programs can have a prominent role [4,14-16].

## 1.1 Background

The back school programs are frequently used methods for prevention [17], applied in numerous countries [15,18-24], develop special knowledge and skills in primary, secondary, and tertiary prevention among adults and children, healthy and ill [25]. Nowadays back school programs for children are primary prevention programs developed as an educational intervention, intending to develop a lifestyle favorable to spine protection, promotion of the correct posture [4]. Sheldon recommends using back school program principles in early childhood as a proactive method of prevention of back pain, it should begin proactively in elementary schools where it could reach the greatest number of people [26]. According to Geldhof et al., primary prevention should focus on good back functioning, instead of being focused on back pain prevalence [5]. In normal development, a 6-year-old child reaches the integration at the brain level of codification of several stimuli (visual, auditory, kinesthetic, motor), which allows the amelioration of higher forms of cognitive activity (symbols, reasoning). At this phase, posture adapts to changes in the body and to psychological factors, that affect it. The practice and entrapment of inadequate postures and movement patterns of the spine leads to musculoskeletal disorders, which behavioral factors at that early age are modifiable, but most importantly they are preventable [13]. In second grade, everyday activities are automated, thus it is the best to incorporate spine-friendly lifestyle, movement patterns, and correct posture in the preceding life stage [1,3,4].

The back school programs include theory in the topic of back care knowledge, anatomy, biomechanics, ergonomics, and practice. Elements of childhood education are to develop the children's sense of personal responsibility, the ability to recognize adverse spine motions [27,28], and learn about one's own body, muscle tone through body sensation and body experience, perceive muscle activity types, and evolve functionally, biomechanically correct posture, recognize muscle balance, acquire spine-friendly lifestyle and apply at school, work, and leisure. The content of the back school programs may be necessary to ensure children have sufficient back care knowledge and trunk state for more effective prevention.

Our habits determine our health, as does disease-specific knowledge. Back care and spine disease prevention knowledge, back care-related behavior, or firmer fear-avoidance beliefs also have a direct impact on the activity of daily living, posture, and muscle state [29,30]. If we get to know the background of something, and we are aware of it, it is easier to develop new, good habits instead of bad ones. In the improvement of posture habits, the first is the habits [31], besides, the development of back care knowledge is important, which can also affect the evolution of good habits and aid in the prevention of spine problems [32,33]. Teaching proper movement patterns and posture habits to elementary school children is very important to be able to integrate them into their daily behavior. Studies on the integration of back school programs into the educational context have shown that changing children's back care knowledge, beliefs, habits, attitude, and abilities can significantly improve public health [34-36].

Child back school programs are recommended from the age of 4 [14,15], during which back care knowledge is developed, thus it would be useful to examine children's back care knowledge at an early age [14,25]. Questionnaires are suitable tools for examining back care knowledge. Before developing a questionnaire, it is essential to know what back care knowledge questionnaires exist for children and what age they are adapted to, is there any age group for which there is no adapted back care knowledge questionnaire. Concerning age groups, the content, wording, number, and type of questions and answers should be examined when designing the questionnaire. There is no validated questionnaire in the literature examining the back care and spine disease prevention knowledge of children aged 6–10 years.

# 2 Literature review

## 2.1 Theoretical framework: the structure, function of the spine, role of motor control

The skeletal system is the primary supporting structure of the body, particularly the spinal column, which is the axis of the trunk. It has two prominent mechanical properties, it must be stable, and rigid, but at the same time mobile, and plastic. The rigidity of the spine is extremely important, it forms the basis of the vertically upright position, it serves as a stable foundation since it holds the head, internal organs, protects the spinal cord, it serves as a stable basis for the muscles and ligaments, in order to move our heads and limbs freely in space. The moment we make the slightest displacement, our spine, while constantly providing a stable foundation, each spine part must move harmoniously, and plastically, coordinated in different directions. The displacement of each of our spinal parts may be different when they occur in a closed or open kinematic chain. Naturally, this complex movement and coordination of the spine requires a very complex nervous system organization, planning, and management, and last but not least, a very complex constructional structure is needed [5].

The conceptualization of the stabilizing system of the spine is originated from Panjabi (1992), who specified three subsystems: the spinal column, the spinal muscles, and a neural control unit (Figure 1).

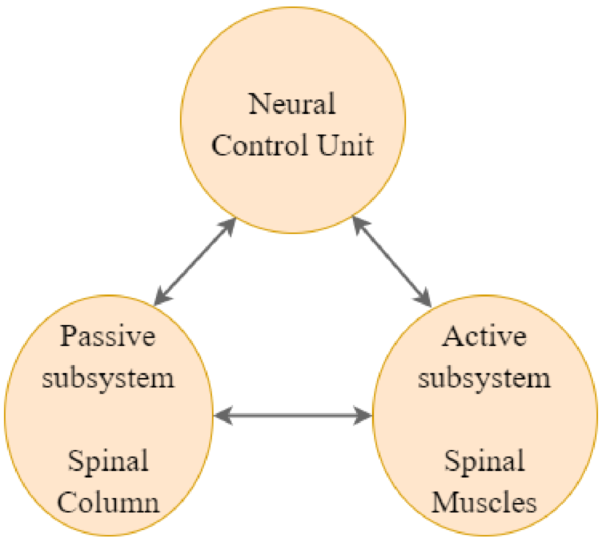



***Figure 1 - The subsystems of the stabilizing system according to Panjabi [37]***

The vertebrae, discs, and ligaments are passive, all muscles and tendons surrounding the spine are active, and the nerves and central nervous system are the neural subsystems. In the concept these three subsystems interact and function together in the following way: the spine provides intrinsic stability, has a loadbearing function, and ensures information about the position, motion, and loads of the spinal column. The neural unit provides that the information of the spinal column is transferred into action, determines the requirements for stability, and directs the muscle reaction. The trunk muscles, fascia, and ligaments provide dynamic stability, where the fascia and ligaments function as mediators to promote muscle activity. Besides the activity of the trunk muscles, the dynamic changes in the posture of the spinal column and load have to be taken into account during the stabilizing function of the spine [5,37].

In 2001, Danneels modified the model of Panjabi concerning the stabilizing system to a concept of functional spinal stability, in which the neural control was divided into a neuromuscular control and a postural control subsystem (Figure 2). The neuromuscular control is responsible for the concerted action between the afferent input (proprioception) and the efferent output of the nervous system (coordination) and coordinates muscle function by controlling muscle contraction with the right strength and time. Postural control is the capability to keep the body's center of gravity within the base of support, maintain, achieve and restore a state of balance during any position. This is possible with the interaction of the passive structures (spinal column), muscular characteristics (spinal muscles), and postural and neuromuscular control, which provides adequate stability to the spine during changes of postures and static and dynamic loading [38]. Mechanical stability refers to functional stability, which means, that the spinal column has to fill sometimes two opposing roles at the same time, namely the intrinsic stability and the dynamic stability. The system works in harmony, under normal conditions providing the required intrinsic and dynamic stability [5,38].

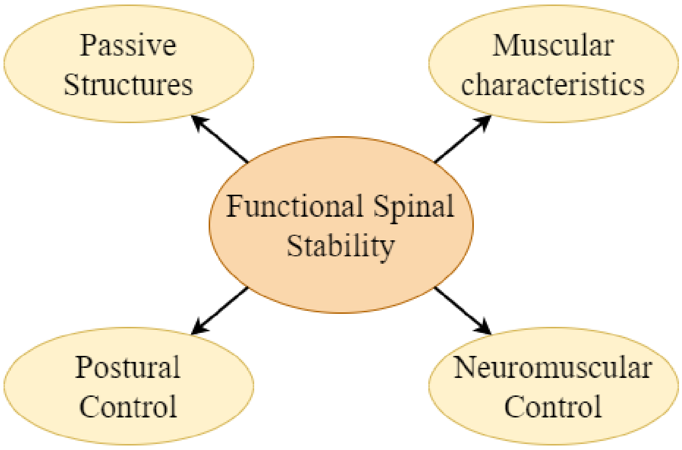



***Figure 2 – The functional spinal stability according to Danneels [38]***

The nervous system component of joint stability is the motor control, which, in cooperation with the active (muscle) and passive (ligaments, cases, etc.) systems, ensures optimal stability. Lumbar motor control is the static and dynamic motor control and dynamic stabilization function of the lumbopelvic (lumbar and pelvic) complex. The trunk functions as an effective "bridge" between the upper and lower limbs, enabling the development of lumbar motor control ability through the motions of the trunk and limbs, as well as proper muscle coordination [24].

McGill (2002) describes the role of motor control in the lumbar bracing concept, accordingly, motor control is a significant element in the coordination of the recruitment of muscles during functional and daily life activities, and in the execution of adequate muscle contractions in order to toughen the joints, finally to determine joint stability. For this reason, with the activation of the trunk muscles coordinated by the motor control system, the spine can withstand load and sustain postures, movements, and activities. In addition, the joints have stiffness due to passive capsules and ligaments. Therefore, the motor control system has to ensure that these passive structures should not become overloaded.

In summary, according to the lumbar bracing concept of McGill, the motor control system controls the stability of the joints by coordinating muscle activation and placing joints in positions that facilitate passive toughness contribution. The motor control system is responsible for the synchronicity of balanced stiffness, the activation of synergist and antagonist muscle groups, ensuring harmonization of muscle activation for stability, generation of the necessary moment, and desirable joint motion [5,39].

## 2.2 Child back school, back care, back health, and postural education programs

Back school programs for children are primary prevention programs, aiming to prevent spine problems, through theoretical and practical education. The purpose of the back school program is the recognition of inappropriate movements that increase the pressure within the intervertebral disc, and to apply the correct movement forms to decompress the spine [25], in parallel to use "spine-friendly" forms of exercises and movements at the skill level. The ability to use the spine correctly is the "automated component of conscious activity" [40], which is known through the knowledge and multiple applications of spine protection rules, partial-, progressive-, isolation-, global-, applying- or processing practicing, over and above it can be developed by analyzing-, global-, or transferable learning methods [25,40,41].

Back school programs are not standardized, there are many back school model variations, few of them include the entire back school program (knowledge and skill development, theory and practice).

Child back school programs are available in many countries (United States of America, Germany, Belgium, Brazil, Poland, Spain, Turkey, Australia, Iran), in „class" groups (20-30 children/ group), with varied duration (3 weeks-2 years), frequency (1-2 occasion/week), time (30-90 minutes/ occasion) and follow-up (3 month-2 years).

The effectiveness of back school programs is intensity and content-dependent. In terms of intensity, short-term, short-time programs are ineffective, for example, The research of Lankhorst et al. investigated a 4x45-minute back school program that was ineffective [42]. Longer-term programs than the 100-hour multidisciplinary rehabilitation program are more effective.

The main topics of the child back school program concerning the theory are: back care and spine disease prevention knowledge, which contains anatomy, biomechanics, ergonomics mainly focusing on the spine, and spine-friendly school and free time, in summary, spine-friendly lifestyle; concerning the practice are: trunk muscle strengthening, muscles stretching of the muscles responsible for posture, sensation and automatization of correct posture, lumbar motor control ability improvement, and the spine-friendly school and leisure time also connect to the practical part [7,17,21,29]. The structure and the elements of the back school program are shown in Figure 3.

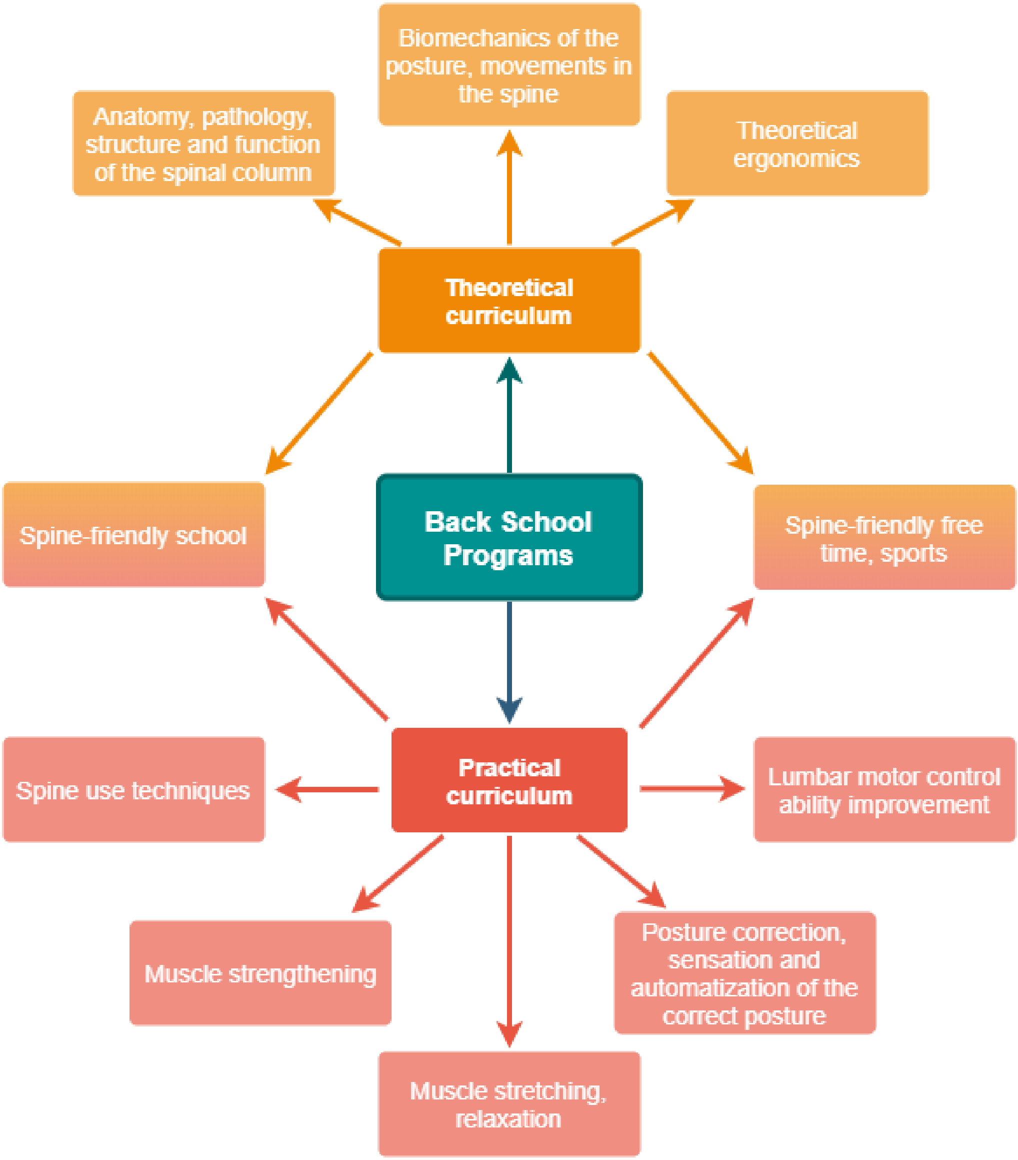



***Figure 3 – The structure and elements of the back school program [own source]***

The most common child back school programs, do not last for a whole school year, for this reason, our aim with the applied back school program was, to provide a long-term program, lasting for 1-school-year. Besides, there are few complex back school programs in the literature, that include theory and practice, and in several cases, participants received only written materials providing theoretical and practical information. We aimed to provide material for both the theoretical and practical parts, and practice together, to be able to monitor the movements of children, and make corrections, if it is needed. As the child back school programs are complex and have several elements, we also aimed to evolve a complex test system, measuring all the components of the program, such as back care knowledge, muscle strength, flexibility, posture, and lumbar motor control ability.

### 2.2.1 National child back school, back care, back health, and postural education programs

In Hungary, 6-7 years old is the age of getting to school for a child, which requires a lifestyle change. Positive steps have already been taken in Hungary to eliminate harmful effects on the musculoskeletal system of children. In 1995, the Hungarian Society of Spine Medicine (Magyar Gerincgyógyászati Társaság) started a prevention program called Posture Correction (Tartáskorrekció), which aimed to implement daily physical education and to integrate the program of the development, automation, and maintenance of biomechanically correct posture with the help of physical education teachers. This program has been part of the National Core Curriculum of Hungary since 2003-2004, the implementation of daily physical education started in 2011 [4].

The posture improvement prevention program of the Hungarian Society of Spine Medicine includes a special set of exercises to improve muscle strength and flexibility, also isometric exercises, that can be performed in school desk to strengthen and stretch muscles responsible for the posture, and a special set of tests to examine the effectiveness. Biomechanically correct posture exercises take 12-13 minutes from the 45-minute physical education class, 2-3 minutes of warm-up, 10 minutes of special gymnastics, lasting for 10 sessions [43]. Exercises are significantly influenced by learning and automating the correct center position of the pelvis and restoring muscle balance. In fact, the 12 tests to examine the effectiveness can be considered as target exercises. These are the following ones: (1) examination of stand-squat in terms of strength and flexibility, (2) examination of the flexibility of the shoulder-shoulder-girdle, (3) strength examination of the trunk and hip extensors, (4) strength examination of the abdominal muscles by abdominal crunch exercises, (5) strength examination of the abdominal muscles by leg crunch exercise, (6) strength examination of the frontal thigh muscles, (7) forward bending examination of the lumbar part, (8) backward bending of the lumbar part, (9) rotational examination of the lower thoracic and lumbar part of the spine, (10) flexibility examination of the dorsal thigh and shin muscles, (11) flexibility examination of the hip flexors, (12) flexibility examination of the hip joint. According to Somhegyi et al., as part of physical education, students need to perform regularly the special posture corrector exercise to help develop and automate the biomechanically correct posture [43].

Somhegyi et al. examined the effect of Posture Correction exercises integrated into physical education among 6-14 years old children, at a primary school in Békéscsaba, between 2001 and 2002. 200 children took part in the program with the help of physical education teachers, while 213 in the control group did not. The muscle strength and flexibility of the intervention group measured after the program were significantly ($p<0.001$) improved compared to the values measured before the program and the values of the control group. In the control group, the results measured at the end of the program were significant ($p<0.05$) worse, than the values measured before the program, besides they were significantly ($p<0.001$) worse, than in the intervention group. The study has proven that the program integrated into physical education improves the strength and flexibility of muscles responsible for the posture of children [44].

Closely related to Posture Correction is the book of Classroom Posture Corrections: a collection of exercises (Osztálytermi Tartáskorrekció: Gyakorlatgyűjtemény), which proves to be very useful in addition to the introduction of 5 physical education classes per week, as there is not always an empty gym, but there are many useful and imaginative solutions to the content of extracurricular physical education classes, and correction of mass posture errors carried out by physical education teachers. It includes multiple tests for posture, muscle strength, and flexibility, and a series of posture correction exercises in the classroom [45].

The health preservation program, called Porci Berci is looking for friends (Porci Berci barátokat keres, Egészségmegőrző oktatóprogram kisiskolásoknak), which has been existing since 1998, is a very famous and successful back school program for children that is developed for lower grade students. The program includes six sessions with a sevens repetitive occupation, theoretical and practical knowledge of health education, covering anatomy and physiology of the spine, muscle training, describing spine-friendly movements, and automating correct movements directly and indirectly (role play, fairy tale). An educational workbook for children, informative material for educators, and parents have been produced. The effectiveness of the program was measured by self-developed questionnaires and the Matthias test. A self-made questionnaire was prepared for children, parents, and also for teachers [4,16,46].
In 1998, an effectiveness study of Porci Berci among 111 students, 8 months after completing the program, showed that children gave correct answers in 79.33% for the

questions related to the spine and 93% in recognition of correct and incorrect posture. 79.01% received a good evaluation when evaluating the automation of spine-friendly motions [46].

A useful complementary book of Porci Berci, and Posture Correction program is the Back School Program of Conscious Seating for primary school children (Tudatos ülés gerinciskolája általános iskolásoknak), which includes a theoretical and practical part, primarily recommended for pedagogues [4]. The book mentions the social and individual determinants of low back pain, ergonomics, posture and assessment tests, muscle strengthening and stretching, and the importance of spine school programs. The primary purpose of children's back school programs is to teach them the facility of sitting and bearing the burden of their body correctly, as these activities pose an increased load on children and a risk factor for future lower back pain. Thus, child back school programs are considered to be primary prevention back schools, where we deal with individuals who have no subsequent incidental diseases. In contrast, adult back school programs are primarily aimed to prevent patients with spinal problems from worsening their disease, maintain functions, and facilitate the healing process by transferring theoretical knowledge and practical exercise material. The essence of the theoretical curriculum is that patients learn to use their spine in a spine-friendly way during everyday life. Practical exercise material refers to the adequate exercises learned from the physiotherapist, which are compiled for each patient according to his or her condition and should be performed regularly to be effective. However, the back school program for children with childhood spine disease will already be secondary prevention for them, so we can say that there is a back school program that serves secondary prevention. In summary, the concept of child back school programs must include the achievement of motor, cognitive, emotional, and social goals [4].

Besides, I would also mention a Hungarian book from Tóth, The protection of the musculoskeletal system in childhood (A mozgásszervek védelme gyermekkorban), which deals with among preschool and primary school children, the spine protection, the correct use of the spine, and the importance of back schools at a theoretical level, and the transfer of some practical advice, ideas, alternatives [47].

Another research was conducted by Gangel and Járomi, who used a climbing wall among children with kypholordotic back. 127 children (64 boys, 63 girls) were enrolled in the study, their average age was 8.5 (7-9) years. During the climbing

program, they used bouldering, which is a lower artificial wall that can be climbed relatively safely without a rope. The rehabilitative program lasted 4 months, with twice-hourly sessions a week, including 5 minutes of warm-up, 40 minutes of climbing, and also strengthening of trunk muscles on the floor, and 10 minutes of cool-down with stretching and breathing exercises. The Matthias test examined the stamina of trunk muscles, the flexibility of the hamstring muscles by the Thomas test, and also the flexibility test of the rectus femoris muscle was performed.
According to the results, poor posture was found in 65 out of 127 children (51.2%). 25 of them completed the entire program, so their results could be evaluated. Thus, the Matthias test showed that they all had poor posture, which was 100% rehabilitated by the end of the program. In the case of the Thomas test, 10 children had a positive result before the program, and only two children had a positive result at the end of the program. The stretch test for the rectus femoris muscle was positive in half of the children before the program and not in any of them after the program. Research has shown that the climbing wall can be used effectively for posture correction in children with poor posture [48].

Other preventive and rehabilitative programs for the spine exist, such as the research of Némethné et al., conducted for preschoolers at the University of Debrecen Medical and Health Sciences Center No. 1 Kindergarten (Debreceni Egyetem Orvos és Egészségtudományi Centrum 1. számú Napköziotthononos Óvoda). The research lasted 3 months, having occupations twice a week. A questionnaire was completed with parents asking about the characteristics of their child's movement development, regular sports, leisure activities, their inactivity, and also the sports habits of the parents, the importance of a physiotherapist as a specialist in the rehabilitation of musculoskeletal problems. Physical examination of the children was performed: wall-occiput distance, Delmas index, the distance of inferior angles of scapulas, presence of calcaneal valgus/varus were measured. During the applied preventive back school program, the children learned the correct sitting, standing, and relaxed lying positions, as well as spine-friendly lifting techniques. The applied exercise therapy was playful, with the emphasis on exercises to correct posture disorders, to develop good muscle condition, muscle awareness, and to improve their physical abilities. Elongation, the sensation of the position of the pelvis, correct adjusting the position of the trunk-shoulder girdle- pelvis, and improving coordination were all part of the exercise program. They worked with children in different positions, with and without equipment. A total of 15 questionnaires were evaluated, showing that children have a high level of physical activity, but few do regular sports activities, only 33% of them. Parents do not exercise every week. About 60% of responding children watch TV or play on the computer for 1.5-3 hours. 53% of the families have had posture deformity. 73% consider the role of physiotherapists necessary. The head-occiput distance changed significantly ($p<0.05$) as a result of the program. Other parameters showed an improvement, but not significantly ($p>0.05$) [49].

Szilágyi et al. evolved and examined the effectiveness of a 10 week long back school program among 6-7 years old children. The intervention group (26 children) took part in the back school program, which contained a theoretical curriculum to develop back care knowledge and spine disease prevention, anatomy, function, biomechanics, and ergonomics of the spine, and practical exercises to improve posture, strengthen the trunk muscles, stretch the lower limb muscles, and develop lumbar motor control ability. The control group (22 children) participated in the regular physical education classes. Back care knowledge was tested by Health Questionnaire on Back Care Knowledge and Spine Disease Prevention, habitual posture and posture deemed correct were examined by photogrammetry test, trunk flexor and extensor static muscle strength and muscle flexibility of hip and knee flexors were examined by Lehmann tests, lumbar motor control ability was tested by Sitting Forward Lean test. For the end of the back school program in the intervention group there were significant ($p<0.001$) improvement in the back care knowledge, concerning all the questions and categories of the questionnaire, and also there were significant ($p<0.001$) differences in all the questions and categories between the intervention and control groups. All the parameters of the habitual posture, except the cervical part from the side view, significantly ($p<0.05$) improved, and all the parameters of the posture deemed correct significantly ($p<0.05$) improved in the intervention group after the back school program. There were significant ($p<0.05$) differences in all the measured parameters of both types of postures between the intervention and control groups for the end of the back school program. There were significant ($p<0.05$) differences between the pre and post results of the trunk static muscle strength and lower limb flexibility tests in the intervention group, and also in the post-test results between the intervention and control groups. The lumbar motor control ability significantly ($p<0.001$) improved in the intervention group, and there was a significant (p=0.001) difference between the intervention and control groups for the end of the back school program [23,24].

***Table 12 and 13 (see pages 89-90, 91)*** present the features of the national back child back school, back care, back health, and postural education programs.

### 2.2.2 International child back school, back care, back health, and postural education programs

Improper posture, spinal problems, and the effects of different postures on the disc began to be addressed as early as the 1960s, first in Sweden. Group, course-type sessions were launched, which were named back school. The first back school program ran under the name “Svenska Ryggskola”, which included theoretical and practical educational curricula. The essence of the program is the acquisition of anatomical knowledge, favorable postures, movement habits for the spine, unloading, and stabilizing exercises. In recent decades, the adaptation of these programs to childhood, their primary preventive value, has become more and more critical. Children need and can be taught spinal movements, to develop and automate correct posture, and to continue a spine-friendly lifestyle. It is essential to be able to recognize the difference between incorrect and correct posture and movement patterns and to be able to correct their posture. Since the Swedish program, back school programs for children have been launched in several other countries [4]. I would like to expound on the most prominent ones here, in the international context.

In Germany, a book was published by Lehmann, called “Rückenschule für kinder”, targeted to the 4-14 years old age group. He also confirmed that poor posture, protracted shoulders, flatfoot, various postural defects, and abnormal muscle tension could be discovered in early childhood. At that age, when we can do the most and it is the easiest way to eliminate them. An even, balanced load on the spine from the birth of the child provides a solid foundation for later painless adulthood. Playfully, we improve movement coordination, movement skills, and automate correct posture. The conditions for the activity of preschool and school-age children are provided if they can exercise in a calm, serene atmosphere, according to their abilities and age. Natural movements (crawling, sliding, climbing, jumping, walking, running, throwing, hanging, rolling, turning) should be practiced in a variety of forms, in different directions, with and without tools. The author seeks answers to the question of how fit preschool and school-age children are. The book contains ten simple tests to examine the physical state of the children. Tests are used to assess muscle strength, flexibility, motor ability, posture, balance, and coordination. The tests include Matthias's functional, semi-objective test, which is suitable for obtaining information on posture quickly and is used in connection with the back school program. There is also a unique set of exercises to develop the examined parameters. The book contains more than seventy games that guarantee children’s motivation. The most effective is learning during individual, pair, and group exercises, from which it is obvious how active the back muscles of children are. By marking funny cartoon characters, they point out how easy to sit, lift, and stand correctly, in a spine-friendly way. This is a good basis for children to learn the proper posture and certain everyday activities, performing them with a straight back, sparing the spine. Postural deformities occur in school-age children, thus it is recommended to include in their physical education the posture-correcting movement material designed to evolve, automate, and maintain the biomechanically correct posture. Regularly done posture correction exercises put the muscles responsible for posture in such a condition that the children are able to maintain the correct posture. While performing the series of exercises consciously and attentively, the children understand the function and position of their muscles, and at the same time, their body consciousness develops. In classroom sessions, children can learn more about their spine and the different right and wrong postures that affect the spine [14].

Kempf and Fischer are credited with the child adaptation of the adult back school model in Karlsruhe. According to Kempf, automated movement-dynamic stereotypes of everyday life are often engraved and consolidated in the lower grades, for this reason, there is a high chance of learning physiological movement patterns at that age. The structure of Kempf's child back school program: lasts 10 weeks, is made up of 60-minute lessons, and parents can also take part in the lessons. Comprise of a little play, with or without tools, learning of functional movements (correct positions, transfer, and lifting techniques), posture training, relaxing, and informational group discussions [1,4].

The author of another German book is Kollumβ, who says that in today’s fast-paced world, a parent does not always pay enough attention to their child, his or her development. The child should be allowed to unfold month after month in both his or her movement and mental development. By the beginning of school age, a significant proportion of them cannot be burdened according to their age. Scoliosis, posture disorders, chest and spine deformities, flatfoot are prevalent, which have become popular diseases. In school and adolescence, children grow by leaps and bounds, but their muscles cannot follow the growth at such a rapid pace, so it is advisable to load their bodies with regular exercise gradually. Regular exercise not only has a positive effect on certain parts of the musculoskeletal system, but it improves concentration, coordination, problem-solving ability, and helps the child to get to know his or her body image. The main task of skills development exercises is to help the youngest preschool children to develop optimal fitness and coordination. For children, movement in the form of plays is critical. They still lack the motivation to move in their free time. Developing and raising awareness of the right posture is inevitable. Sabine's concept is that it is essential to implement the back-protector movements playfully and to incorporate them into physical education classes. For children, exercise should be fun, rich in experience, bringing their bodies to the fore. The theoretical part presents the knowledge about the function of the spine, structure, and construction of the discs. There are illustrative pictures about what an intact, smiling disc is like, a strong bone, where the spine is located, where the discs reside in the spinal column, how the disc can smile and be sad, and there are pictures of the position of the spine by sitting at a desk, in a correct sitting position, and in a spine-friendly sitting position. Also, of smiling and sad disc during bending and standing position. To memorize the theoretical parts, children had to build a spinal column, repeat the formulas from a skeleton, and learn to mark formulas on their bodies. Besides, the book contains several practical examples of posture-improving exercises. The practical material consists of exercises performed in a playful form: spine-friendly exercises with or without tools (ballon, sandbag, stick, chair), in pairs, in small and large groups. The concept can be integrated for teachers and, last but not least, for parents. The exercises must occupy the children, and this is best encouraged by the parents so that a kind of spine-friendly movement can develop in the family life [15].

***Table 14 and 15 (see page 92-98, 99)*** show the features of the international child back school, back care, back health, and postural education programs.

### 2.2.3 E-learning based back school program

In the 21st century, infocommunication has conquered many areas, not least in education. E-learning is a collective term that encompasses multimedia, applications, Internet websites, and occasionally social media. Studies have shown that these technological tools can have many benefits, they can help with critical thinking, problem solving, they can develop the ability to learn collaboratively, and they can arouse the interest of unmotivated learners [50].

Another term that is definitely worth mentioning appeared in the 2010s, the term "mHealth" (mobile Health). In summary, it refers to telephone applications that have been scientifically developed by various research groups to help prevent or rehabilitate certain disease groups in this way [51]. Using the applications, patients can independently monitor their physical or even psychic parameters (physical activity, mood swings, pain levels, medication) and view various educational videos and animations [52,53].

The term blended learning is a relatively new form of education that combines so-called traditional, face-to-face teaching with the tools of E-learning. The advantage of a personal presence can be that students have the opportunity to discuss the issues in person with the teacher and with each other, while web- or application-based learning materials can have the advantage of being available and reviewable, even at their own pace, they can explore each part of the curriculum in more detail according to their interests [54].

In terms of the content of the applications, they are primarily aimed at the adult community, most of them already focus on the rehabilitation of low back or neck pain in case of established disease, or the prevention of possible progression in the case of chronic low back pain. More and more validated telephone applications have emerged to treat this disease, and some wearable devices (smart watches or the LUMOback belt) are also associated with some of them [55]. These programs are completed with psychological methods that assist in coping with pain. The programs also include trunk strengthening exercises and various recommendations for maintaining or increasing the level of daily physical activity [52,53,56].

Pozo-Cruz et al. tested the effectiveness and usability of a 9-month web-based multidisciplinary program among office workers with nonspecific subacute low back pain. The study involved 100 subjects selected from 342 interested workers applying from the administrative offices of a University in the South of Spain. Inclusion criteria were age 18-64 years, diagnosed subacute nonspecific low back pain, lack of neurological deficit, physical inactivity, employee status, and at least 6 hours of computer work per day. Those who had an infection that caused spinal pain, a tumor, a disc herniation associated with a neurological symptom, osteoporosis, Bechterew's disease, an inflammatory process or cauda equina syndrome, had chronic back pain or any other serious illness, or it meant an exclusion if someone did not speak Spanish fluently. Participants were randomly assigned to a study and control group in a 1:1 ratio using a computer-generated method. The control group received basic care, so they were able to access non-web-based services. In addition to the basic care, the members of the intervention group had access to a website, through which they were instructed in the form of online videos every weekday (Monday to Friday) for 9 months to set up and establish the correct posture, adapt the work environment, besides strengthening, flexibility, mobilization, and stretching exercises were given focusing on the major muscle groups needed for proper posture. They received a reminder email about this every day at 10 am. Examinations were also performed before and after the intervention in the intervention and control groups. The trunk flexor and extensor muscle endurance were tested by Shirado-Ito lumbar and abdominal test, the level of disability associated with the subacute nonspecific low back pain with the Roland-Morris Disability Questionnaire, and the health-related quality of life by European Quality of Life-5 Dimensions-3 Levels. Sociodemographic and health characteristics of the workers as well as the number of nonspecific subacute low back pain episodes occurring during the 9 months before the program and the 9 months intervention were also recorded. In the intervention group, there was a significant improvement in the abdominal endurance ($p<0.001$), and in the lumbar endurance test ($p=0.001$). The Roland-Morris Disability Questionnaire scores in the intervention group decreased an average of 7.36±3.53 points after the program, which was a significant change ($p<0.001$), whereas the control group post-intervention scores increased by 1.89±3.18 points ($p=0.001$). Regarding the results of the European Quality of Life-5 Dimensions-3 Levels, in the intervention group, there was a significant ($p<0.001$) improvement between the pre- and post-test results, in addition, there was a significant ($p<0.001$) difference between the scores of the intervention and control groups in the post-test results. In summary, the web-based intervention was feasible and effective in the treatment of subacute nonspecific low back pain among office workers, it improves the function and health-related quality of life can decrease the episodes of low back pain [57].

In our research, we considered it important to keep up with the changing, modern world, to integrate technological tools into health education, and to place even greater emphasis on prevention, so that people are not only guided in the treatment of established diseases and spinal disorders. In addition, due to age specifics, the population we target (6-10 years old) moves more homely in the digital space, which may also be an advantage for the widespread use of these preventive educational materials. In terms of teaching methods, we wanted to test the back school program in an online environment, and the fact that we could evolve an e-learning based back school program, was due to the application and winning of the New National Excellence Program of the Ministry for Innovation and Technology thanks to which we could develop a website where the curriculum was available. In parallel, the global pandemic of coronavirus disease 2019 started, and there was no other possibility to carry out an intervention. The online form of education has become even more prominent. The theoretical curriculum and exercise material of the e-learning back school program we applied was available in a similar way as in the research discussed above, on a specific website from which we gave tasks to the children each week. The website was available to them at any time.

## 2.3 National and international validated back care knowledge questionnaires for children

In the international literature, back care knowledge summarizes the knowledge needed to prevent spinal diseases and choose consciously therapies. The back care knowledge can concern the anatomical and biomechanical, structural and functional knowledge of the spine, pathologies of the spine, and also the possibilities for preventing spinal diseases, the pathomechanism of low back pain and the causes of pain, as well as the advantages, disadvantages, short and long-term effects of therapeutic options. This knowledge also includes opportunities to develop a "spine friendly" lifestyle based on spine protection rules, ergonomics knowledge, spine protection at work, leisure activities, and spine friendly sports opportunities [58,59]. International surveys show that having better back care knowledge, results in better functional spine status, better preservation of spinal health, and faster and more effective treatment and rehabilitation in case of occurred low back pain (chronic nonspecific low back pain syndrome) [33,60,61]. In the study of Kovács-Babócsay et al., the low back pain disease specific knowledge of an adult population in Hungary measured by the "Low back pain knowledge questionnaire" is inadequate [32]. 30-40% of the maximum knowledge is provided by adults in Hungary. This knowledge is scarce enough to allow children within the family to get the right amount of information for proper and conscious spine use. In the study of Szilágyi, the back care knowledge of 6-10 years old Hungarian children was between 11.6-22%, which also shows an inadequate level [60]. In terms of knowledge about the spine, in the Hungarian national core curriculum, the spine as a concept first appears in primary school, where they first learn about vertebrates and invertebrates, in general about bones and anatomy, but the concept of vertebrae or disc does not come up, they do not learn about muscles, muscular system, in addition, the correct posture is learned within the framework of physical education class, around one time a year, which they learn with gymnastics. In contrast, the content of the back school program helps the development of back care knowledge and skills necessary for spine protection. The back care and spine disease prevention knowledge may be necessary to ensure children have sufficient back care knowledge, and it needs to be developed in addition to posture habits for the improvement of more effective spine prevention [60]. Observing the back care knowledge of children after the back school program, according to the research of Szilágyi, is between 87.3-95.1%, which is appropriate [60].

Questionnaires are suitable tools for examining back care knowledge. Before developing a questionnaire, it is essential to know what back care knowledge questionnaires exist for children and what age they are adapted to, is there any age group for which there is no adapted back care knowledge questionnaire. Concerning age groups, the content, wording, number, and type of questions and answers should be examined when designing the questionnaire. There are two validated Spanish questionnaires on the topic of back care knowledge: the Health questionnaire about knowledge for health and back care related to the practice of physical activity and exercise for adolescents (HEBACAKNOW-PAE) for 13–18-year-olds. It is a valid and reliable tool to evaluate the level of specific knowledge about health and back care related to physical activity and exercise in adolescents (Cronbach's alpha, α=0.80) [6]. The Health questionnaire on back care knowledge concerning physical activities in daily life (HEBACAKNOW) for adolescents for 14–17 years old children, whose version has not yet a cross-cultural adaptation in English, but it is available. The categories according to conceptual knowledge: topographical-anatomical knowledge, functional–anatomical knowledge, habits in standing posture, or seated, or lying, habits in carrying heavy objects in a backpack, and how to move heavy loads. The questionnaire is good for the assessment of back care knowledge among adolescents (Cronbach's alpha, α=0.82) [34]. The Back-care Behavior Assessment Questionnaire (BABAQ) for school children is also a validated questionnaire in Iranian, measures the theory-based, healthy spine-related back-care behavior including behavioral capability (skills, knowledge), self-efficacy, expectation beliefs, and performance spine among fifth-grade girls. The Iranian version is not available, and has no cross-cultural adaptation in English, however that version is available. The instrument is valid for measuring healthy spine-related behaviors among schoolchildren (Cronbach's alpha, α=0.84 and 0.93) [62].

# 3 Objectives of the study

The study aimed to develop a questionnaire examining back care knowledge and spine disease prevention for children aged 6–10 years and testing its psychometric properties, which includes the main groups of the content of back school programs: anatomy, biomechanics, ergonomics, spine use habits, spine-friendly lifestyle.
Besides our purpose was to assess the back care knowledge and spine disease prevention of children in this age group, among those who attended back school program, e-learning back school program, or none.

We aimed to evolve a 1-school year back school program with theoretical and practical education for 6-7 years old children.

Besides we aimed to measure the back care knowledge and spine disease prevention, habitual posture and posture deemed correct, the trunk static muscle strength, the lower limb flexibility, and the lumbar motor control ability of 6-7 years old primary school children and examine the change of the measured parameters after the 1-school year back school program.

In addition, we aimed to compare the scores of back care knowledge and spine disease prevention, and the measured physical parameters of the back school program (intervention) and control groups.

## 3.1 Hypothesis

1) We assume, that the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children is a suitable tool for the measurement of back care knowledge and spine disease prevention among 6-10 years old children.

2) The back care knowledge and spine disease prevention, the habitual posture and posture deemed correct, the trunk static muscle strength, the lower limb muscle flexibility, and the lumbar motor control ability are not appropriate for 6-7 years old primary school children.

3) In the intervention group, the back care knowledge and spine disease prevention will significantly improve after the 1-school year back school program.

4) In the intervention group, the habitual posture, and posture deemed correct, the trunk static muscle strength, the lower limb muscle flexibility, and the lumbar motor control ability will significantly improve after the 1-school year back school program.

5) In the control group, the back care knowledge and spine disease prevention will not significantly improve after the 1-school year back school program.

6) In the control group, the habitual posture, and posture deemed correct, the trunk static muscle strength, the lower limb muscle flexibility, and the lumbar motor control ability will not significantly improve after the 1-school year back school program.

7) There will be significant differences between the intervention and control groups in the results measured at the end of the back school program regarding the back care knowledge and spine disease prevention.

8) There will be significant differences between the intervention and control groups in the results measured at the end of the back school program regarding the habitual posture and posture deemed correct, the trunk static muscle strength, the lower limb muscle flexibility, and the lumbar motor control ability.

# 4 Materials and methods

## 4.1 Ethical approval

The development and psychometric evaluation of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children was approved by the Institutional Review Board of the Regional Research Committee of the Clinical Center, Pécs, Hungary (No.: 8342-PTE 2020) (Appendix 1). The implementation and examination of the 1 school-year back school program were also approved by the Institutional Review Board of the Regional Research Committee of the Clinical Center, Pécs, Hungary (No.: 6125) (Appendix 2).

The director of the schools provided a Declaration of Support (Appendix 3). All the parents were informed about the objectives of the study, the advantages, and the purpose of the back school program and have provided written consent permitting their children to participate in the study (Appendix 4). The data were processed anonymously and confidentially based on the Data Protection Act of Hungary.

## 4.2 Study design and setting

The development and psychometric evaluation of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children was conducted between 2016 and 2020, the implementation and examination of the 1-year back school program took part between 2016 and 2018, in Pécs, Hungary. The participating schools were the following: János Apáczai Csere Primary School No.1; Ferenc Deák Gymnasium and Primary School of University of Pécs Practice Primary School, Gymnasium and Secondary Technical School; Grammar School, Primary School and Kindergarten of the Reformed College in Pécs; Republic Square Primary School.

## 4.3 Study groups

### 4.3.1 In the development and psychometric evaluation of the Health Questionnaire of Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children

A post-hoc sample size estimation (using G*power) for the correlation analysis (significance set at 5%, power set at 0.8, effects size at 0.15, and the number of predictors at 2) showed that the sample size was optimal, given the study power, i.e.

99.99% [63]. A total of 469 children were selected in the study by convenience sample selection. One of the participants left the school during the program, and five of them were excluded, because of missing data. Data of 463 children (220 boys, 243 girls) were processed in the study, their mean age was 7.51 ± 1.32 years. During the division of the groups, it had to be taken into account that children in one class could not be separated from each other, as they participated in the program together. During the survey, we distinguished three groups according to age and grade, and three subgroups accordingly took part in a back school program, e-learning back school program, or none of them (Table 1). We considered it important to test the back school program also in an online environment.

1. 230, 6–7 years old, 1. grader children (108 boys, 122 girls; mean age: 6.530 ± 0.500 years).
2. 119, 7–8 years old, 2. grader children (62 boys, 57 girls; mean age: 7.487 ± 0.502 years).
3. 114, 9–10 years old, 4. grader children (50 boys, 64 girls; mean age: 9.526 ± 0.502 years).

***Table 1 – Groups and subgroups in the examined population***

| Age, Class | Participated in BSP (persons) | Participated in e-learning BSP (persons) | Did not participate in BSP (persons) | Total (persons) |
|---|---|---|---|---|
| 6-7 years, 1. grader | 26 | 0 | 204 | 230 |
| 7-8 years, 2. grader | 28 | 0 | 91 | 119 |
| 9-10 years, 4. grader | 26 | 27 | 61 | 114 |
| 6-10 years, 1.- 4. grader | 80 | 27 | 356 | 463 |

BSP: back school program

### 4.3.2 In the implementation and examination of the 1 school-year back school program

At the baseline examination, 102 (52 boys, 50 girls) primary school first-grader (age: 6.549±0.500 years) children were tested.

26 children (11 boys, 15 girls) were chosen in the intervention group, who took part in the back school program.

In the control group, 22 (12 boys, 10 girls) children were included, who did not participate in the back school program, they only took part in the regular physical education classes. Data from the intervention and control groups were collected at the baseline and the end of the intervention.

Table 2 shows the mean values of the characteristics of the examined population.

***Table 2 - Mean values of the age, body height, body weight, and the body mass index (BMI) in the examined population***

| | **The examined population (n=102)** | | **Intervention group (n=26)** | | | | **Control group (n=22)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | mean pre | SD | mean pre | SD | mean post | SD | mean pre | SD | mean post | SD |
| **Age (years)** | 6.549 | 0.500 | 6.577 | 0.504 | 7.308 | 0.679 | 6.591 | 0.503 | 7.318 | 0.716 |
| **Body height (cm)** | 126.549 | 5.140 | 126.558 | 5.013 | 130.654 | 7.322 | 126.500 | 5.198 | 131.364 | 6.433 |
| **Body weight (kg)** | 26.135 | 3.467 | 26.377 | 3.515 | 27.531 | 5.459 | 26.118 | 3.405 | 27.600 | 4.642 |
| **BMI ($kg/m^2$)** | 16.291 | 1.766 | 16.445 | 1.827 | 15.968 | 1.723 | 16.311 | 1.879 | 15.867 | 1.426 |

SD: standard deviation; BMI: body mass index; pre: baseline, before the program; post: after the program

Inclusion criteria: For the questionnaire development 6–10 years old primary school children, for the back school program 6-7 years old children.

Exclusion criteria: Congenital or acquired spinal disease, severe locomotor, internal or neurological illness, non-mature children for school, children with special education needs (SEN), certified athletes, sports club members, non-native speaker [7,14,15,25].

## 4.4 The development procedure of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children

Development of the Hungarian version of the questionnaire "*Gerinchasználattal és -prevencióval kapcsolatos tudást felmérő kérdőív 6-10 éves gyerekek számára (GEPT-6-10)"* (Appendix 5) was based on using the validity criteria of the Delphi method [6,34,64], which phases were the following (Figure 4):

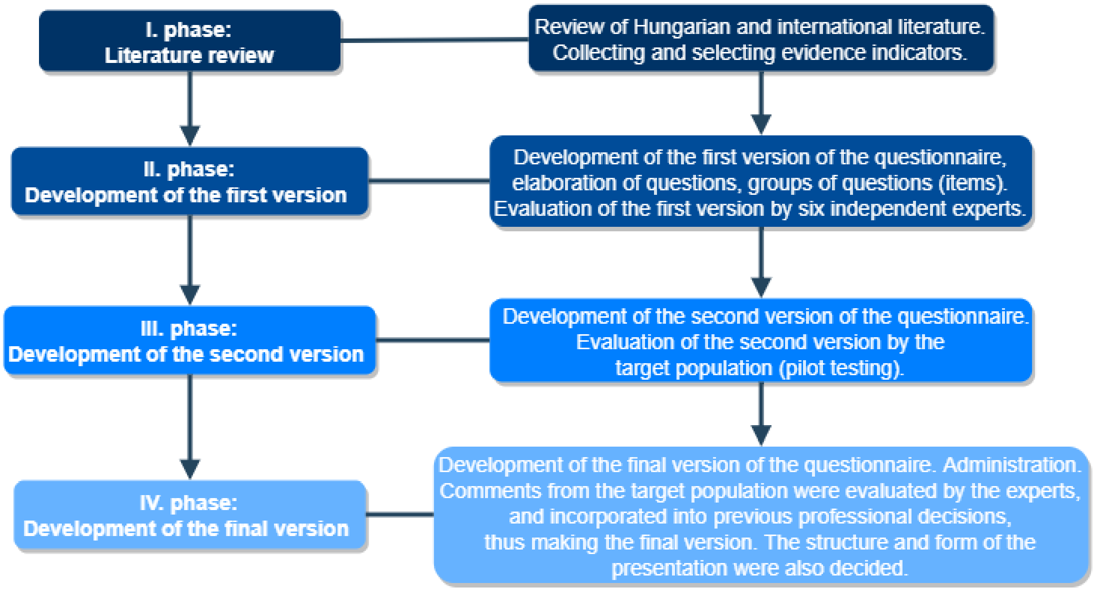



***Figure 4 – The development procedure of the questionnaire [own source]***

I. Phase: Review of Hungarian and international literature. Collecting and selecting evidence indicators.

We performed a literature review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [65] concerning the English and Hungarian literature, examining the back care knowledge by questionnaire among children. We excluded studies that examine pain, since our focus was on prevention. Records were identified through databases (PubMed, Scopus, Science Direct, Web of Science, Embase, Cochrane Library, MATARKA) and additional records were identified through other sources (Ph.D. thesis, congresses, etc.). Finally, we found three validated questionnaires [6,34,62] in the field of back care knowledge. For wider mapping, we also reviewed several sources related to disease-specific knowledge [32], postural habits [66], low back pain [58], back pain [17,67], among adults and children, and studies in the field of back school, back/posture education

[14,15,30,68]. We aimed to evaluate the knowledge that back care programs provide: anatomy, spine use habits, biomechanics, ergonomics, and spine-friendly lifestyles.

II. Phase: Development of the first version of the questionnaire, elaboration of questions, groups of questions (items). Evaluation of the first version by six independent experts.

The task of the six independent experts (a physiotherapist; a Ph.D. graduate physiotherapist; a Ph.D., assistant professor; and a doctor having experience and making research in the field of spine problems, low back pain; a pedagogue, and also a child psychologist) was to include the most relevant issues in the questionnaire connected to back care and spine disease prevention knowledge based on the scientific evidence found in the literature review. They assessed professionally, the content and linguistic adequacy of the questions, suitable for the age group, without causing difficulty in understanding, and considered how many questions children can be burdened with. They assessed in terms of content the level of difficulty of the questions and commented which response method would be the most appropriate.

III. Phase: Development of the second version of the questionnaire. Evaluation of the second version by the target population (pilot testing).

After the expert’s opinions, the complied sets of questions were tested by a total of 15 children from different age groups. The most important, useful suggestions were registered. They were asked about the content, the ease, the form of the questionnaire, the number of questions, and lucidity of the language, and the interpretability of symbols given as answers.

IV. Phase: Development of the final version of the questionnaire. Administration.

Comments from the target population were evaluated by the experts, and incorporated into previous professional decisions, thus making the final version. The structure and form of the presentation were also decided.

The English version “HEalth Questionnaire on BAck Care and Spine Disease Prevention Knowledge for 6-10 years old children (HEQBACK-6-10)” (Appendix 5) of the questionnaire was translated by two experts, a synthesis was made from the two translated versions, and finally, a retranslation was carried out. Besides, the questionnaire was filled out by English bilingual voluntary children from the target population to make proposals for a better understanding of the questions in English. This version has not yet a cross-cultural adaptation.

## 4.5 Data collection

**Back care knowledge by Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children**

Those who participated in the development procedure of the questionnaire, and did not take part in any back school program, filled the questionnaire once and a week apart (test-retest). Those who took part in a back school program (personal back school program or e-learning back school program) filled the questionnaire after the program once and a week later (test-retest).

Those who took part in the baseline measurement before the 1 school-year back school program filled the questionnaire once. Children from the intervention and control groups filled out the questionnaire before and after the back school program. As the questionnaire was used for 6-7 years old children who could not read or write yet, the questions have been read aloud for them and were illustrated by drawings, pictures, and figures. Four questions addressed the anatomical and biomechanical properties of the spine, three questions were about spine utilization and ergonomics.

Scoring:

1. Question: Children had to draw in the spine on four different pictures. A maximum of 7 points could be scored in case of the spine was fully drawn from head to pelvis.
2. Question: Children had to color one vertebra blue, and one disc red. A total of 2 points could be scored.
3. Question: Children had to sign two correct body positions for TV watching from five pictures. Two They could score a maximum of 2 points.
4. Question: Children had to choose three correct positions during playing from six pictures. 3 points could be scored.
5. Question: Children had to link vertebra and disc with a toy, that has similar hardness properties. According to the task, one vertebra needed to be linked with Lego and one disc with the ball for a maximum of 2 points.
6. Question: Children had to sign the picture, where the disc had enough place between the vertebrae, where the boy was demonstrating the correct movement, and where he performed lifting with a straight back. One answer was right so that they could score a maximum of 1 point.

7. Question: We asked children to sign the drawing, showing what was holding and moving the spinal column. The correct answer was the muscle, thus 1 point could be scored.

The total possible score was 18 points, for anatomical and biomechanical questions (1,2,5,7) 12 points, for spine use and ergonomic questions (3,4,6) 6 points could be awarded. Between 100-80%, the knowledge is appropriate, between 79-60% it needs to be developed, and between 59-0%, it is inappropriate [6,16,30,32,34,69].

**Habitual posture and posture deemed correct by New York Posture Rating Chart**

Those who took part in the baseline measurement before the 1 school-year back school program were examined once. Children from the intervention and control groups were examined before and after the back school program.

Three pictures were taken from the children, one from the back view and two from the side views. While taking the photo, children had to be barefooted, in a tight fit, or with a naked upper body; for girls, long hair had to be tied to avoid covering the neck and shoulders. Children were standing in front of a black background and behind a plumb line that almost reached the ground. From the back view, the plumb line had to go through the head, spine and had to end between the two legs in the middle. From the side view, the plumb line had to go through the ear, lumbar I. and V. vertebrae, and the lateral ankle. Pictures were taken 3.048 m far from the student, with a NIKON D3400 camera (Figure 5).

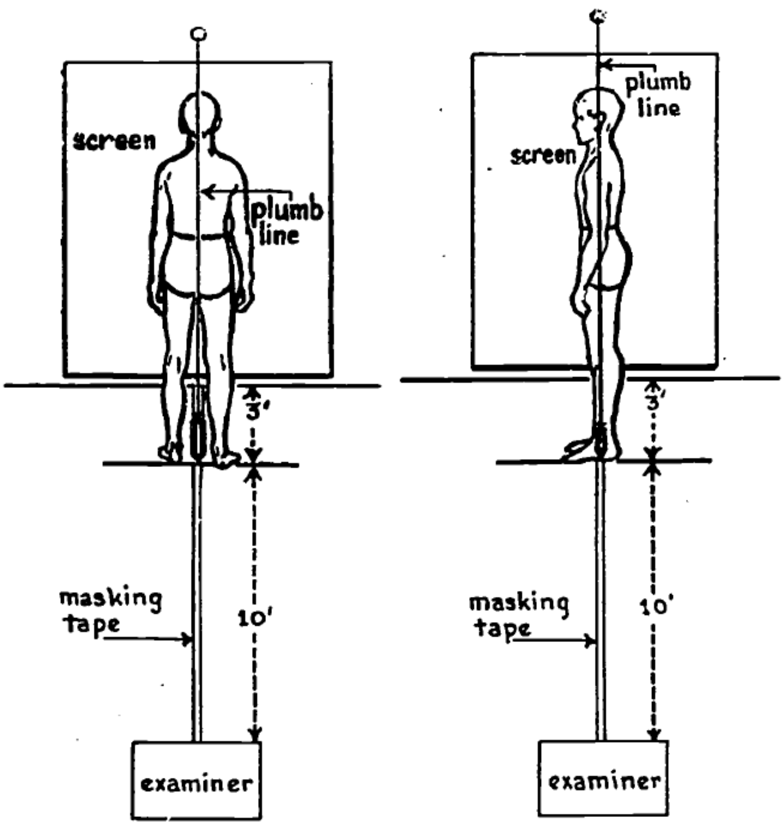



***Figure 5 - The positing for the examination of New York Posture Rating Chart [70]***

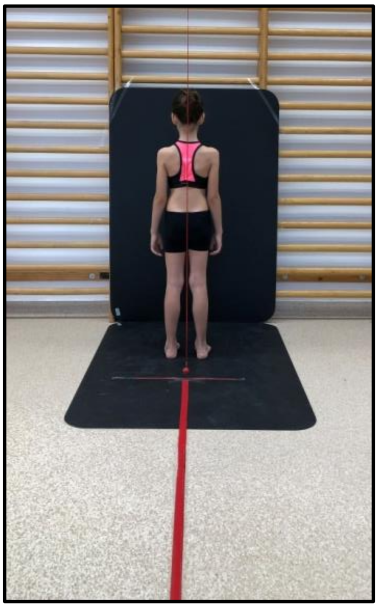
For showing habitual posture, we asked the children to stand in front of the screen, to show how they usually stand in everyday life.

For posture deemed correct, we asked the children to stand in front of the screen as they think it was correct [70-72].

Scoring:

First, the New York Posture Rating Chart was published in 1958 (New York, 1972), then in 1992 Howley and Franks modified it, instead of 13 segments, 10 segments were examined and scored independently from each other by a qualified examiner. From the back view (frontal plane), the head, shoulders, spine, hips, and legs were examined and scored. From the side view (sagittal plane) cervical, upper thoracic, and lower thoracic parts (trunk), the abdominal part, and lumbar part were examined and scored. Writing a short comment was allowed for each segment. According to the modified rating, 10 points meant correct posture, 5 points fair posture, and 0 point poor posture. The maximum score was 100 points for the correct posture of each segment [71] (Figure 6).

**Posture - back view**



| **Posture - right side view** | **Posture - left side view** |
|---|---|

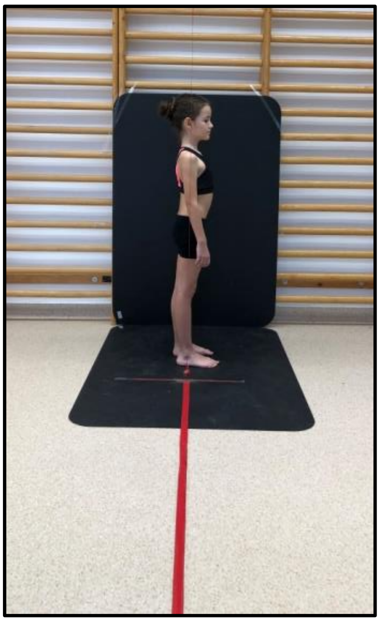


*Figure 6 - Back and two side views of the posture [own source]*

### Trunk static muscle strength and lower limb muscle flexibility by Lehmann test

Those who took part in the baseline measurement before the 1 school-year back school program were tested once. Children from the intervention and control groups were tested before and after the back school program.

#### *Trunk flexor static muscle strength*

Children are supine lying on a mattress, the hips and knees are in 90° flexion at both lower limbs. Shoulders stay on the ground, upper limbs have an angle of 45° with the trunk, they are straight, lifted 3-5 cm from the ground, palms are looking upwards. The position of the head: stretch with the head, the face is looking to the ceiling, the chin does not approach the chest. The head is lifted 3 cm from the ground, beside the kept of the upper and lower limbs in the correct position, the lumbar part is pressed down to the ground and must be kept on the ground during the examination. We measure the time in seconds to maintain the correct posture during the examination. The examination is finished, in case of the lumbar part comes up from the ground, or the position of the lower, upper limbs change.

Scoring:

Keeping the correct posture for 10 seconds means normal muscle strength for a 7-year-old child. Less than 10 seconds means not normal muscle strength for a 7-year-old child [14] (Figure 7).

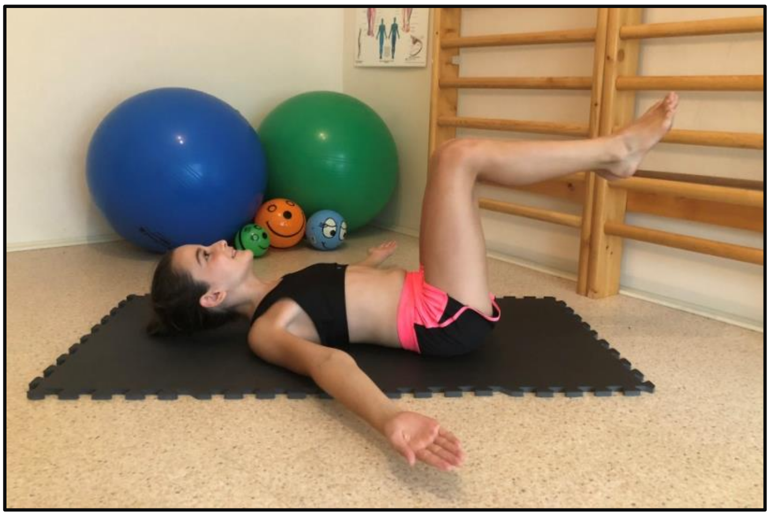


***Figure 7 - Trunk flexor static muscle strength test [own source]***

*__Trunk extensor (scapula retractors) static muscle strength__*

Children are prone on a mattress, the lower limbs are straight and in a little straddle, the foot leans on the floor, knees are on the floor. Upper limbs are at the level of the shoulder, the elbow is in $90^0$ flexion, the palms face each other, the fingers are straight, the thumb looks upwards. The head (nose-ground) is lifted 2 centimeters from the ground, the upper limbs are lifted 5 centimeters from the ground. During the examination, we measure the time in seconds to maintain the correct posture. The examination is finished, in case of the position of the head, upper or lower limbs change.

Scoring:

Keeping the correct posture for 10 seconds means normal muscle strength for a 7-year-old child. Less than 10 seconds means not normal muscle strength for a 7-year-old child [14] (Figure 8).

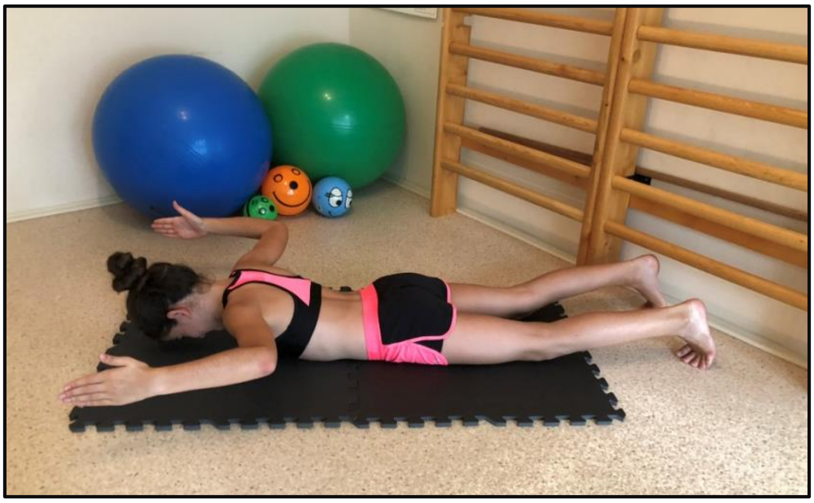


*__Figure 8 - Trunk extensor (scapula retractors) static muscle strength test [own source]__*

### *Hip flexor muscle flexibility*

The child is sitting at the end of the treatment bed, embracing the left lower limb from below, slowly leaning back to supine, the left hip is in 90° flexion. The right lower limb is relaxed, the knee is in 90° flexion. In this case, the right lower limb is tested. We perform the test on the other lower limb.

<u>Scoring:</u>

The flexibility of the hip flexor on the tested side is appropriate if the longitudinal axis of the femur is at least horizontal, and the longitudinal axis of the shin is in the vertical plane. The hip flexors are shortened if the longitudinal axis of the femur is elevated above the horizontal or the axis of the shin is not in the vertical plane [14] (Figure 9).

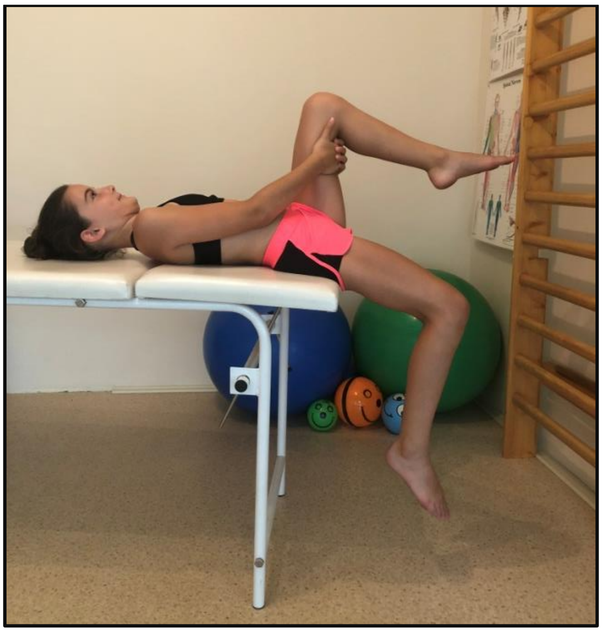


***Figure 9 - Hip flexor muscle flexibility test [own source]***

*Knee flexor muscle flexibility*

The child is supine, both legs are on the floor. Arms are straight beside the body. The right leg is straight raised to 90° hip flexion, while the left leg is loosely on the ground. In this case, we examine the flexibility of the right knee flexor.

<u>Scoring:</u>

The flexibility of the knee flexor is appropriate if the lifted lower limb beside the extended knee reaches 90° flexion in the hip, or the lower limb (knee) on the ground does not lift off. The flexibility of the knee flexors are inappropriate, when there is flexion in the knee of the raised lower limb, the hip flexion is less than 90°, or the lower limb on the ground rises from the ground the knee will be flexed [14] (Figure 10).

***Figure 10 - Knee flexor muscle flexibility test [own source]***

**Lumbar motor control ability by Sitting Forward Lean test**

Those who took part in the baseline measurement before the 1 school-year back school program were measured once. Children from the intervention and control groups were measured before and after the back school program.

The child is sitting on a treatment bed or chair, the soles do not touch the ground, the knee bend touches the edge of the bed, the hip and knee are in 90$^{o}$ flexion, the spine, including the lumbar part, is in the neutral position. We help the child to have the correct posture. We sign the upper endplate of the first sacral vertebra and measure 7 centimeters upwards in the middle of the spine, that point is also signed. After the checkmarks, we ask the child to pull up the lower limbs after each other five times, equally raise the upper limbs straightly together beside the ear. After the exercises, we ask the child to have the correct sitting posture, then we measure the distance with a tape measure between the two markers, the obtained value is recorded in millimeters. The obtained value is the difference between the two values, given in millimeters, results are calculated by the absolute value of the numbers obtained.

Scoring:

The result is considered normal, meaning good lumbar motor control ability, when there is a positive or negative deviation of 3 mm or less after the exercises ($73mm \geq x \geq 67mm$, where x is the normal/physiological range). An inappropriate lumbar motor control ability indicates a difference of more than 3 millimeters in a positive or negative direction. If there is a difference in the positive direction, that is, the distance between the two points is bigger than 70 millimeters, the lordosis will be straight or kyphotic; if there is a deviation in the negative direction, so that the distance between the two points is less than 70 millimeters, the lordosis increases at the lumbar part [73,74] (Figure 11).

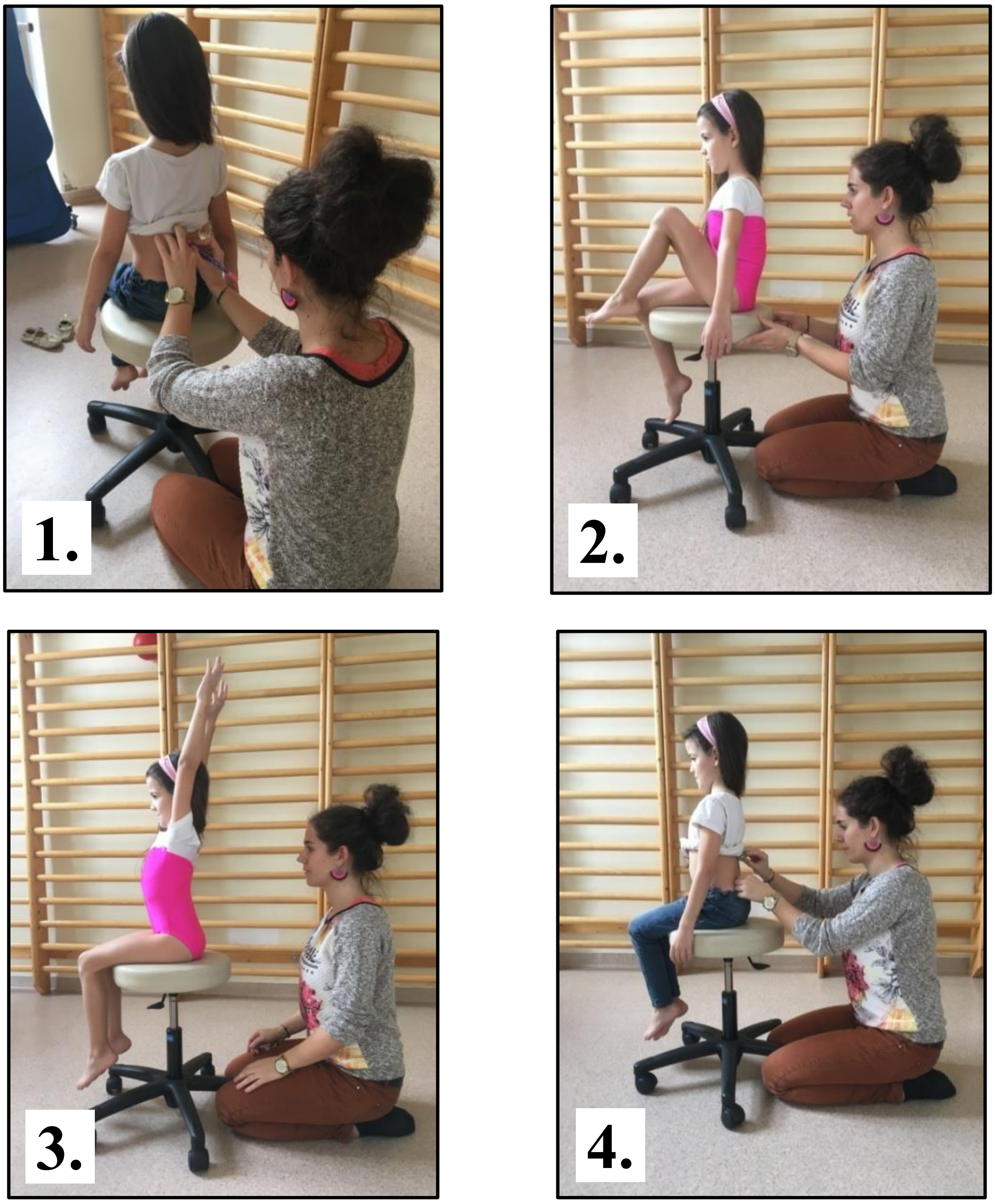



*Figure 11 - Lumbar motor control ability test [own source]*

### The content of the applied back school programs

The 1-school year back school program, the personal and e-learning back school programs applied during the development procedure contained the same material.
The material of the back school program was registered as a "voluntary scientific work" in the Hungarian Intellectual Property Office (Appendix 6). The material was published as a book in Hungarian and English (Appendix 7), under the name of "Mesés Gerinctúra" [76], and "The Amazing Spinal Trip" [25]. The Hungarian book is 96 pages, the English book is 100 pages long, and both of them consist of 7 chapters, 7 tales, 159 pictures, 39 figures, 51 playful tasks, practice. The book was made by physiotherapists, a writer, a nursery school governess and instructress, and an infantile clinical psychologist, family therapist.
The content and material of the e-learning back school program was based on the book, and was available on the website of https://gerincsuli.hu/, which has been developed by us. The website provides 10 animation videos, 10 theoretical videos, 8 practical videos, 9 conversations primarily for children, and there is useful information for the parents, pedagogues about the importance, content, and aims, there is also information about us, publications, and references [75].

### The back school programs applied during the development procedure of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children

During the development procedure of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children, we applied a personal back school program and an e-learning back school program. Both the programs lasted for 12 weeks. The same content from the 1-school year back school program was divided into this interval. The method of teaching was different.

#### *E-learning back school program*

For 12 weeks, once a week, we gave the children assignments from the website [75], theoretical videos, animations, and videos about practice, as well as a series of exercises that could be done at home. Every week we processed different theoretical material, children always learned something new, as we gave more and more difficult tasks in the practice line, which included muscle strengthening exercises, stretching, posture, and lumbar motor control ability improving exercises.

### The 1-school year back school program

#### *The theoretical, educational curriculum*

Children were provided with 15 minutes of theoretical curriculum each week within the class. We started the lessons with easy introductory games, followed by theoretical knowledge, with the aid of devices designed for demonstration of spine functions. Children had to show the bony markers on themselves and each other through play. During the theoretical course, we taught anatomical, biomechanical, ergonomical, and spine-related knowledge to the children [7,14,15,21,25] ***(Table 16; see pages 100-102)***.

#### *The exercise program*

The exercise sessions lasted 30 minutes each week within the class, under the leadership of two physiotherapists, separated into groups. Additionally, children spent four times a week, 10 minutes with exercises connected to the back school program in physical education classes, under the leadership of the teacher. These exercises were designed by physical therapists. Finally, seven times a week, we asked them to spend 10 minutes exercising based on instructions included in the didactic material for home [7,14,15,21,25] ***(Table 16; see pages 100-102)***.

#### *The didactic material for home*

The didactic material for home included review questions from the theoretical curriculum learned in the previous lesson, questions to control knowledge, as well as the exercise material of games played during the lessons. In the didactic material, children had to indicate how many times a week, with how many repetitions, and how many minutes they did each exercise [7,14,15,21,25] ***(Table 17; see pages 103-104)***.

## 4.6 Data analysis

### 4.6.1 Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children

The scores of the questionnaire were calculated, the mean and standard deviation values of the questions and categories were obtained. The normality of the continuous variables was tested by Kolmogorov-Smirnov tests, a p-value higher than 0.05 was considered a normally distributed score [77]. We used SPSS (v.27) software for Windows to make different statistical analyses.

**Validity and reliability testing of the questionnaire**

Internal consistency was tested by Cronbach's alpha, which value could have been excellent (0.93–0.94), strong (0.91–0.93), reliable (0.84–0.90), robust (0.81), fairly high (0.76–0.95), high (0.73–0.95), good (0.71–0.91), relatively high (0.70–0.77), slightly low (0.68), reasonable (0.67–0.87), adequate (0.64–0.85), moderate (0.61–0.65), satisfactory (0.58–0.97), acceptable (0.45–0.98), sufficient (0.45–0.96), not satisfactory (0.4–0.55) and low (0.11) [78].

Test-retest reliability was tested by intraclass correlation coefficients (ICC), using 95% of confidence interval in 463 participants [79]. The ICC values can range from 0 and 1 and, the values of less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 are indicative of poor, moderate, good, and excellent reliability, respectively [80]. The form of data collection was the same in the back school programs and non-back school program groups. All the children from the non-back school group filled the questionnaire twice with an interval of 7 days. As well, all the children from the back school program groups filled the questionnaire twice, first at the end of the back school program, then 7 days later.

The standard error of measurement (SEM = standard deviation of all scores × square root of (1 − ICC) and 95% of minimal detectable change were calculated to multiply SEM by 2,77) estimates the absolute reliability [79].

The mean difference between the two measurement intervals and the 95% limits of agreement (LoA) was calculated by LoA = mean difference (d) ± 1.96 SD of the mean differences. The Bland–Altman (BA) plot was used to visually examine the 95% limits of agreement between the test and retest total scores, where narrower LoAs suggested better agreement at the individual level [81,82]. This association was examined by linear regression analysis [34]. The convergent validity was tested by Spearman's rank correlation coefficients [83].

The discriminant validity pertains to the ability of a measurement system to determine differences between two groups that are diverse differently from each other concerning the parameter that is tested [84]. In the study, the discriminant validity was tested to compare the results of the questionnaire's scores between the non-back school and back school groups of different age groups to examine the difference between them.

#### 4.6.2 1-school year back school program

SPSS software (v.27) was used for statistical analyses. The results are presented in frequency and confidence interval, as well as in mean±standard deviation, median and interquartile range values. Based on the results of the normality tests (Kolmogorov-Smirnov test), the distribution of the data does not imply normal. Differences between the intervention and control groups were examined by chi-square test and the Mann-Whitney U test, while the effectiveness of the program was examined by chi-square test and Wilcoxon test. The results were considered significant at $p<0.05$ level.

# 5 Results

## 5.1 Validity and reliability

### Content validity questionnaire

Development of the questionnaire started with the selection of topics related to back care and spine disease prevention knowledge included in back school programs, specified by several back schools, back education programs, and questionnaires examining back care knowledge. Table 3 shows the validated questionnaires of back care knowledge for children, found in the Hungarian and English literature [60].

***Table 3 – The list of validated back care knowledge questionnaires until the age of 18, found in the Hungarian and English literature***

| Author (year) | Examined population | Questionnaire |
|---|---|---|
| Miñana-Signes et el. (2015) [6] | • 230 students<br>• 13-18 years | Conocimientos sobre la Salud y Cuidados de la Espalda relacionados con la Actividad y Ejercicio físico (COSACUES-AEF)<br>Health questionnaire on back care knowledge concerning practice physical activity and exercise for adolescents (HEBACAKNOW-PAE) |
| M. Monfort et al. (2016) [34] | • 171 students<br>• 14-17 years | Health questionnaire on back care knowledge in daily life physical activities (HEBACAKNOW) |
| Akbari-Chehrehbargh et al. (2020) [62] | • 610 students<br>• 5th grade | Back-care Behavior Assessment Questionnaire (BABAQ) |

Main topics included in a back school program: anatomy, biomechanics, ergonomics mainly focusing on the spine, spine use, and spine-friendly lifestyle. Formulation of the items started accordingly, and ten preliminary items were prepared for the questionnaire. According to the suggestions of the experts, we minimalized the numbers of the questions for this age group, not to overload them, and we highlighted the most essential issues, for this reason, seven questions were left. Linguistically, the first wording of the seven questions has been transformed, which developed as follows: Question 1 “Draw the spines in the pictures!” “Draw all the spinal columns in the pictures!”, Question 2 “Completely color all the vertebrae blue and all the discs red!” “Color one vertebra to blue and one disc to red!”, Question 3 “What are the correct postures while watching TV? More answers are possible!” “Mark 2 correct postures during watching TV!”, Question 4 “Circle the correct postures! More answers are possible!” “Mark 3 correct postures!”, Question 5 “Connect those with similar hardness!”, Question 6 “Circle where the boy lifts the bag correctly!” “Mark where the boy is correctly lifting the bag!” and Question 7, “What holds and moves the spine?” “Mark what holds and moves the spinal column?”. As the questionnaire can be filled by children who cannot read or write, we have provided pictures and symbols at most of the questions for choosing the answer. After the changes, the assessment of 15 children followed. In their opinion, the last question where children had to figure out for themselves what holds and moves the spine, instead, it would be better if they could choose the correct answer from two drawn symbols. They also confirmed that the questions were understandable. An adult read aloud the questions, that already included the instructions, highlighting what to do, how to answer, if more than one answer were correct, it was given how many. The accepted final version included a total of 7 questions, of which question 1, 2, 5, 7 goes under the category of “anatomy and biomechanics (category 1)”, and question 3, 4, 6 are in the category of “spine use, ergonomics and spine friendly lifestyle (category 2)”. There are questions, with more correct answers, for every correct answer a point can be given, thus who can find all the correct answers a total of 7 points can be given for question 1, 2 points for question 2, 2 points for question 3, 3 points for question 4, 2 points for question 5, 1 point for question 6, and 1 point for question 7. For the wrong answer, 0 point was given. A maximum of 18 points can be obtained in the questionnaire and a minimum of 0 point. The criteria for the correct answers to each question are provided in Table 4 [60].

***Table 4 – Criteria and correct answers in the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children***

| Question | Criteria and correct answer |
|---|---|
| 1 | The spinal columns have to be drawn from head to pelvis and also the shape of the spinal columns have to be drawn correctly. |
| 2 | One vertebra has to be colored to blue, and one disc to red. |
| 3 | *Number 4 and 5 are correct. |
| 4 | *Number 2, 3, and 4 are correct. |
| 5 | One vertebra has to be connected to the Lego, and one disc to the ball. |
| 6 | *The boy is correctly lifting the bag on the first drawing. |
| 7 | *The muscles hold and move the spinal column, the second drawing shows a muscle. |

*The numbering of the images in the questionnaire should be considered line by line from left to right for each question, starting with the number 1.

**Internal consistency**

The internal consistency of the questionnaire was determined using Cronbach's alpha values. For the total 7 items, Cronbach's alpha was $\alpha$=0.797 (0.768–0.824), the questions correlated well with each other, confirming our hypothesis. The pairs of each question, category, and total scores correlated significantly ($p<0.001$). The results corroborated, that the questionnaire showed good internal consistency [60].

### Test-retest reliability

The reliability of the questionnaire was also examined using the test-retest method by intraclass correlation coefficient (ICC). The correlation coefficient was strong (0.989) for the total scores, and ranged from moderate to strong (0.742–0.975) for the questions (p<0.001), with minimal SEM and MDC95 (0.606 and 1.680 respectively) (Table 5) [60].

***Table 5 – Test-retest reliability of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children***

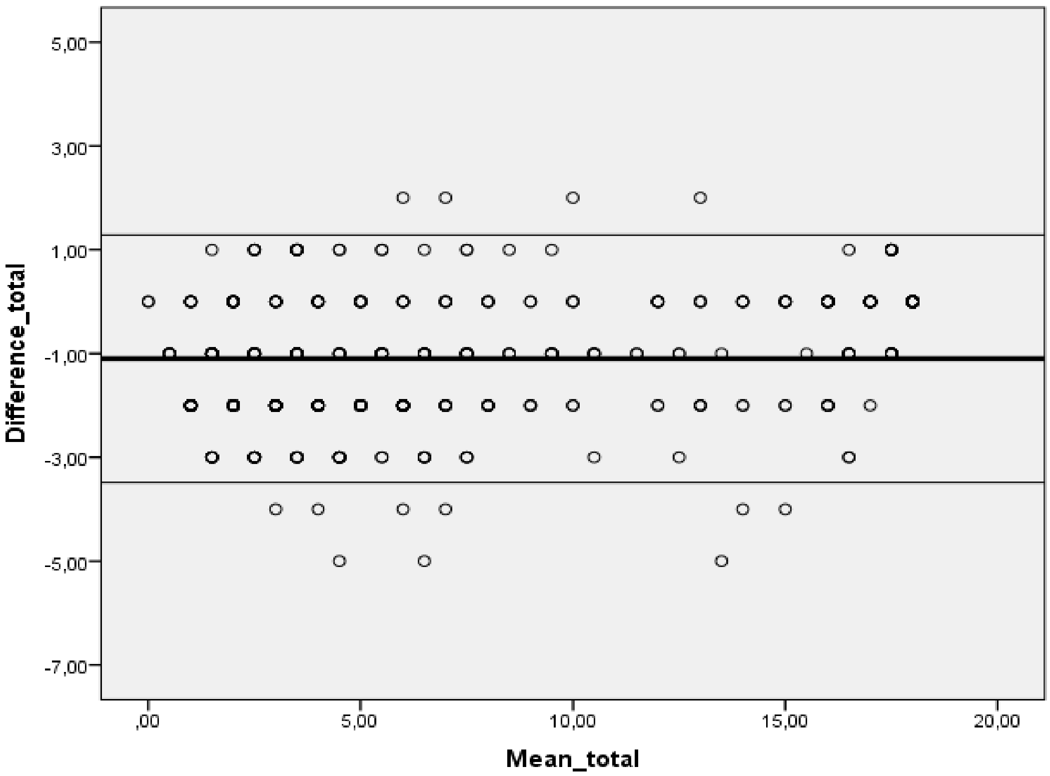
| | Mean test (SD) (point) | Mean retest (SD) (point) | Difference between test, retest (SD) (point) | ICC | CI 95 % lower | CI 95 % upper | p | SEM (point) | MDC95 (point) |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 2.063 (2.639) | 2.413 (2.558) | -0.350 (0.808) | 0.975 | 0.970 | 0.979 | p<0.001 | 0.411 | 1.139 |
| **2** | 0.851 (0.950) | 0.952 (0.910) | -0.102 (0.456) | 0.936 | 0.923 | 0.947 | p<0.001 | 0.235 | 0.652 |
| **3** | 0.706 (0.830) | 0.877 (0.830) | -0.171 (0.482) | 0.908 | 0.889 | 0.923 | p<0.001 | 0.252 | 0.698 |
| **4** | 1.240 (1.214) | 1.382 (1.182) | -0.143 (0.544) | 0.946 | 0.935 | 0.955 | p<0.001 | 0.278 | 0.771 |
| **5** | 0.849 (0.951) | 0.937 (0.906) | -0.089 (0.459) | 0.935 | 0.922 | 0.946 | p<0.001 | 0.237 | 0.656 |
| **6** | 0.788 (0.409) | 0.801 (0.399) | -0.013 (0.254) | 0.890 | 0.868 | 0.908 | p<0.001 | 0.134 | 0.372 |
| **7** | 0.330 (0.471) | 0.564 (0.496) | -0.233 (0.438) | 0.742 | 0.690 | 0.785 | p<0.001 | 0.246 | 0.681 |
| **Total** | 6.827 (5.979) | 7.927 (5.577) | -1.099 (1.218) | 0.989 | 0.987 | 0.991 | p<0.001 | 0.606 | 1.680 |

CI: confidence interval, ICC: intraclass correlation coefficient, SEM: standard error of measurement, MDC95: minimal detectable change at 95%

The value of mean difference was − 1.10 (SD ± 1.22), and the limits of agreement for the total questionnaire scores were − 3.49 and 1.29 points (Figure 12) [60].

The test-retest differences of the total score increased as the acquired sum of score increased (F=56.89, p<0.001, Constant: 9,10, Beta coefficient=1.56; p<0.001).

***Figure 12 - The Bland–Altman plot and the limits of agreement concerning the total score of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children (− 1.10; − 3.49-1.29–0.30 points)***




x-axis: Mean of the total scores of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children between test 1 and 2; y-axis: Differences of the total scores of the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children between test 1 and 2

________observed average agreement, __________95% limit of agreement

## Convergent validity

Convergent validity was examined using Spearman's rank correlation analysis between total score and age, where we found a weak but significant association (R=0.171, p<0.001) [60,83].

## Discriminant validity

Discriminant validity was tested among children who took part in a back school program or not among different age groups. The Kolmogorov-Smirnov test results showed non normally distributed scores of the questionnaire (p>0.05). We found significant differences in the back care knowledge between 6 and 7 years old (p<0.001), 7–8 years old (p<0.001), and also 9–10 years old groups (p<0.001). Table 12 summarizes the results of back care knowledge in the examined population. The highest total score was 17.115±0.909 points among 9–10 years old children in the back school program group. The second highest total score was 16.308±2.429 points among 6–7 years old children, who took part in a back school program. E-learning back school program seemed to be similarly effective among 9–10 years old children according to the total scores (15.926±3.037 points), than the back school program for 7–8 years old children (total score: 15.714±1.802 points) (Table 6) [60].

***Table 6 – The results of the back care knowledge and spine disease prevention in the examined population***

| | | 6-7 years, 1.grader | | 7-8 years, 2.grader | | 9-10 years, 4.grader | | | 6-10 years, 1-4.grader |
|---|---|---|---|---|---|---|---|---|---|
| | | **No partici-pation in BSP (n=204)** | **Partici-pation in BSP (n=26)** | **No partici-pation in BSP (n=91)** | **Partici-pation in BSP (n=28)** | **No partici-pation in BSP (n=61)** | **Partici-pation in BSP (n=26)** | **Partici-pation in e-learning BSP (n=27)** | **Total of partici-pants (n=463)** |
| **Q1 (point)** | **Mean** | 1.088 | 6.231 | 0.319 | 5.643 | 0.705 | 6.808 | 6.074 | 2.063 |
| | **SD** | 1.623 | 1.142 | 0.880 | 1.367 | 0.803 | 0.492 | 1.662 | 2.639 |
| **Q2 (point)** | **Mean** | 0.691 | 1.923 | 0.187 | 2.000 | 0.525 | 1.962 | 1.741 | 0.851 |
| | **SD** | 0.946 | 0.392 | 0.469 | 0.000 | 0.721 | 0.196 | 0.526 | 0.950 |
| **Q3 (point)** | **Mean** | 0.505 | 1.615 | 0.176 | 1.536 | 0.443 | 1.885 | 1.741 | 0.706 |
| | **SD** | 0.691 | 0.637 | 0.437 | 0.637 | 0.671 | 0.326 | 0.594 | 0.830 |
| **Q4 (point)** | **Mean** | 1.054 | 2.654 | 0.286 | 2.679 | 0.721 | 2.885 | 2.593 | 1.240 |
| | **SD** | 1.037 | 0.977 | 0.583 | 0.476 | 0.897 | 0.326 | 0.747 | 1.214 |
| **Q5 (point)** | **Mean** | 0.637 | 1.923 | 0.341 | 1.929 | 0.557 | 1.654 | 1.889 | 0.849 |
| | **SD** | 0.902 | 0.392 | 0.619 | 0.378 | 0.904 | 0.629 | 0.423 | 0.951 |
| **Q6 (point)** | **Mean** | 0.765 | 1.000 | 0.681 | 1.000 | 0.689 | 0.962 | 0.963 | 0.788 |
| | **SD** | 0.425 | 0.000 | 0.469 | 0.000 | 0.467 | 0.196 | 0.193 | 0.409 |
| **Q7 (point)** | **Mean** | 0.118 | 0.962 | 0.099 | 0.929 | 0.311 | 0.962 | 0.926 | 0.330 |
| | **SD** | 0.323 | 0.196 | 0.300 | 0.262 | 0.467 | 0.196 | 0.267 | 0.471 |
| **C1 (point)** | **Mean** | 2.534 | 11.038 | 0.945 | 10.500 | 2.098 | 11.385 | 10.630 | 4.093 |
| | **SD** | 2.432 | 1.280 | 1.508 | 1.427 | 1.630 | 0.898 | 2.041 | 4.256 |
| **C2 (point)** | **Mean** | 2.324 | 5.269 | 1.143 | 5.214 | 1.852 | 5.731 | 5.296 | 2.734 |
| | **SD** | 1.608 | 1.343 | 0.973 | 0.876 | 1.389 | 0.452 | 1.354 | 2.031 |
| **Total score (point)** | **Mean** | 4.858 | 16.308 | 2.088 | 15.714 | 3.951 | 17.115 | 15.926 | 6.827 |
| | **SD** | 3.500 | 2.429 | 2.053 | 1.802 | 2.156 | 0.909 | 3.037 | 5.979 |
| **p** | | •p<0.001 | | •p<0.001 | | ••p<0.001 | | | |

•Mann-Whitney test results, ••Kruskal-Wallis test results, BSP: back school program, Q: question, C1: category 1; C2: category 2; SD: standard deviation

## 5.2 Baseline measurement before the 1-school year back school program

102 children were examined at the baseline.

The mean point of Question 1 was 0.255±0.886 points, Question 2 was 0.186±0.540 points, Question 3 was 0.176±0.496 points, Question 4 was 0.431±0.725 points, Question 5 was 0.363±0.742 points, Question 6 was 0.706±0.458 points and Question 7 was 0.216±0.413 points. The mean point of the anatomical, biomechanical knowledge was 1.127±1.559 points, and the mean point of the spine use, ergonomic knowledge was 1.206±1.205 points. The mean point of the total score targeted to the knowledge of back care, spine prevention was 2.333±2.136 points, which we can say was categorized inadequate with a 12.963±11.865%.

The mean points at the habitual posture from the back view were the following: the head 5.830±2.342 points, the shoulders 5.441±2.734 points, the spine 4.510±1.928 points, the hip 5.196±1.980 points, the ankle 6.471±3.114 points; from the side view: the upper back 5.049±1.111 points, the trunk 5.000±0.704 points, the abdomen 5.343±1.270 points, the lower back 5.049±1.492 points, the neck 5.245±3.016 points. The mean points at the posture deemed correct from the back view were the following: the head 5.196±3.061 points, the shoulders 4.020±2.229 points, the spine 4.216±1.827 points, the hip 4.755±2.373 points, the ankle 6.618±2.915 points; from the side view: the upper back 3.235±2.956 points, the trunk 3.039±2.914 points, the abdomen 2.598±3.280 points, the lower back 2.794±3.343 points, and the neck 4.755±3.748 points. The mean point of the total score in habitual posture was 53.137±10.576 points, the mean point of the posture deemed correct was 41.225±14.631 points. The maximum point of both types of postures was close to 50 points, which is the half score of the maximally correct posture. We can say that these were low scores.

The mean second of the trunk flexor static muscle strength was 3.804±6.482 seconds, and of the trunk extensor static muscle strength was 8.029±6.180 seconds. None of the trunk static muscle strength tests reached the normal range (normal: x≥10 sec).

The frequency of the negative results of the hip flexor muscle flexibility in the right leg was 48.039 (38.343-57.735)%, in the left leg was 49.020 (39.318-58.721)%, and the frequency of the negative results of the knee flexor muscle flexibility in the right leg was 26.471 (17.909-35.032)%, in the left leg was 29.412 (20.569-38.254)%. The hip flexor flexibility test on both sides was positive at more than half of the children, and the knee flexor flexibility test on both sides was positive at more than 70% of the children. We can say that this is a high percentage.

The mean millimeter of the lumbar motor control ability was 8.353±5.055 millimeters. It was out of the normal range (normal: $x \leq 3$ millimeter) [60].

## 5.3 Back care knowledge and spine disease prevention in the intervention and control groups

In the intervention group, the total score ($p<0.001$), the anatomical, and biomechanical ($p<0.001$), and the spine use, ergonomics knowledge ($p<0.001$) significantly improved after the program. Regarding the questions one by one, Question 1 ($p<0.001$), Question 2 ($p<0.001$), Question 3 ($p<0.001$), Question 4 ($p<0.001$), Question 5 ($p<0.001$), Question 6 ($p=0.014$), Question 7 ($p<0.001$) also showed a significant improvement in the intervention group. According to the total score in the intervention group, the back care knowledge and spine disease prevention before the program was 18.162±18.563%, which was inappropriate, after the program it got into the appropriate category with 90.385±13.477%, the improvement in the percentages was significant ($p<0.001$).

The control group did not show any significant change for the end of the program, except Question 7 ($p=0.046$). The total score ($p=0.134$), the anatomical, and biomechanical ($p=0.308$), the spine use, ergonomics knowledge ($p=0.331$) and Question 1 ($p=0.902$), Question 2 ($p=0.380$), Question 3 ($p=0.564$), Question 4 ($p=0.516$), Question 5 ($p=0.335$), Question 6 ($p=0.366$) did not change significantly after the program in the control group. According to the total score in the control group, the back care knowledge and spine disease prevention was 12.374±7.654%, which was inappropriate, after the program it increased to 16.667±9.849%, which improvement was not significant ($p=0.149$), and stayed in the same inappropriate category.

Besides, there were significant differences between the intervention and control groups at the end of the program regarding the total score ($p<0.001$), the anatomical, and biomechanical ($p<0.001$), the spine use, ergonomics knowledge ($p<0.001$) and also Question 1 ($p<0.001$), Question 2 ($p<0.001$), Question 3 ($p<0.001$), Question 4 ($p<0.001$), Question 5 ($p<0.001$), Question 6 ($p=0.011$), Question 7 ($p<0.001$) (Table 7) [85].

*Table 7 - Results of the back care knowledge and spine prevention in the intervention and control groups*

| | | Intervention group (n=26) | | Control group (n=22) | | Differences between the intervention and control groups |
|---|---|---|---|---|---|---|
| | | Mean ± SD (point) | p-value | Mean ± SD (point) | p-value | p-value |
| **Total score** | pre | 3.269 ±3.341 | <0.001 | 2.227 ±1.378 | 0.134 | 0.217 |
| | post | 16.269 ±2.426 | | 3.000 ±1.773 | | <0.001 |
| **Anatomical, biomechanical** | pre | 2.423 ±2.101 | <0.001 | 0.955 ±0.950 | 0.308 | <0.001 |
| | post | 11.000 ±1.265 | | 1.409 ±1.593 | | <0.001 |
| **Spine use, ergonomics** | pre | 0.846 ±1.515 | <0.001 | 1.273 ±1.241 | 0.331 | 0.064 |
| | post | 5.269 ±1.343 | | 1.591 ±1.297 | | <0.001 |
| **1. Question** | pre | 0.269 ±1.373 | <0.001 | 0.591 ±0.854 | 0.902 | 0.003 |
| | post | 6.231 ±1.142 | | 0.591 ±0.854 | | <0.001 |
| **2. Question** | pre | 0.231 ±0.587 | <0.001 | 0.227 ±0.528 | 0.380 | 0.848 |
| | post | 1.885 ±0.431 | | 0.364 ±0.727 | | <0.001 |
| **3. Question** | pre | 0.154 ±0.464 | <0.001 | 0.227 ±0.528 | 0.564 | 0.532 |
| | post | 1.615 ±0.637 | | 0.318 ±0.568 | | <0.001 |
| **4. Question** | pre | 0.346 ±0.689 | <0.001 | 0.409 ±0.734 | 0.516 | 0.743 |
| | post | 2.654 ±0.977 | | 0.500 ±0.802 | | <0.001 |
| **5. Question** | pre | 0.462 ±0.859 | <0.001 | 0.136 ±0.351 | 0.335 | 0.273 |
| | post | 1.923 ±0.392 | | 0.273 ±0.703 | | <0.001 |
| **6. Question** | pre | 0.769 ±0.430 | 0.014 | 0.636 ±0.492 | 0.366 | 0.318 |
| | post | 1.000 ±0.000 | | 0.773 ±0.429 | | 0.011 |
| **7. Question** | pre | 0.038 ±0.196 | <0.001 | 0.000 ±0.000 | 0.046 | 0.358 |
| | post | 0.962 ±0.196 | | 0.182 ±0.395 | | <0.001 |

pre: baseline, before the program; post: after the program; SD: standard deviation

## 5.4 Habitual posture and posture deemed correct in the intervention and control groups

Regarding the habitual posture, in the intervention group, the lowest pre-scores were 4.808±0.981 points for the spine and 4.808±1.721 points for the lower back, the highest pre-score was 6.538±3.088 points for the ankles. The lowest post-score was 6.731±2.426 points for the trunk and the highest post-score was 9.231±1.840 points for the upper back. The improvement in the total scores was 29%.

The total score of the habitual posture ($p<0.001$), the head ($p<0.001$), the shoulders ($p<0.001$), the spine ($p<0.001$), the hips ($p=0.003$), the ankles ($p=0.033$), the neck ($p<0.001$), the upper back ($p=0.005$), the trunk ($p<0.001$), the abdomen ($p<0.001$), and the lower back ($p<0.001$) significantly improved in the intervention group regarding the results at the end of the program.

In regard to the habitual posture, in the control group, the lowest pre-score was 4.545±2.632 points for the spine, the highest pre-score was 6.136±3.427 points for the ankles. The lowest post-scores were 5.000±3.086 points for the spine, 5.000±2.182 points for the ankles, 5.000±2.182 points for the upper back, and 5.000±1.154 points for the trunk.

The total score of the habitual posture ($p=0.644$), the head ($p=0.317$), the shoulders ($p=1.000$), the spine ($p=0.317$), the hips ($p=0.157$), the ankles ($p=0.317$), the neck ($p=0.083$), the upper back ($p=0.317$), the trunk ($p=0.564$), the abdomen ($p=0.317$), and the lower back ($p=0.317$) did not improve significantly in the control group regarding the results at the end of the program.

In addition, there were significant differences between the intervention and control groups at the end of the program in the total score of the habitual posture ($p<0.001$), the head ($p<0.001$), the shoulders ($p=0.001$), the spine ($p=0.006$), the ankles ($p=0.004$), the neck ($p=0.004$), the upper back ($p<0.001$), the trunk ($p=0.007$), the abdomen ($p<0.001$), and the lower back ($p<0.001$).

Regarding the posture deemed correct, in the intervention group the lowest pre-score was 2.885±3.514 points for the lower back, the highest pre-score was 6.346±3.019 points for the ankles. The lowest post-score was 7.692±2.542 points for the hips, the highest post-scores were 9.808±0.981 points for the head, 9.808±0.981

points for the shoulders, and 9.808±0.981 points for the lower back. The improvement in the total scores was 50%.

The total score of the posture deemed correct (p<0.001), the head (p<0.001), the shoulders (p<0.001), the spine (p<0.001), the hips (p<0.001), the ankles (p=0.013), the neck (p<0.001), the upper back (p<0.001), the trunk (p<0.001), the abdomen (p<0.001), and the lower back (p<0.001) significantly improved in the intervention group for the end of the program.

In regard to the posture deemed correct, in the control group the lowest pre-score was 2.727±3.693 points for the lower back, the highest pre-score was 6.818±2.905 points for the ankles. The lowest post-score was 3.864±2.642 points for the head, the highest post-score was 5.682±2.801 points for the ankles.

The total score of the posture deemed correct (p=0.118), the shoulders (p=0.527), the spine (p=0.763), the hips (p=0.564), the neck (p=0.782), the upper back (p=0.083), the trunk (p=0.132), the abdomen (p=0.090), and the lower back (p=0.023) did not improve significantly in the control group for the end of the program. The lower back significantly (p=0.023) improved, but the head (p=0.038) and the ankles (p=0.025) significantly worsened for the end of the program.

Additionally, there were significant differences between the intervention and control groups at the end of the program in the total score of the posture deemed correct (p<0.001), the head (p<0.001), the shoulders (p<0.001), the spine (p<0.001), the hips (p=0.001), the ankles (p=0.004), the neck (p<0.001), the upper back (p<0.001), the trunk (p<0.001), the abdomen (p<0.001), and the lower back (p<0.001) (Table 8) [85].

*Table 8 - Results of the habitual posture and posture deemed correct in the intervention and control groups*

| Results of habitual posture | | Intervention group (n=26) | | Control group (n=22) | | Differences between the intervention and control groups |
|---|---|---|---|---|---|---|
| | | Mean ± SD (point) | p-value | Mean ± SD (point) | p-value | p-value |
| **Total score of habitual posture** | pre | 52.500 ±10.089 | <0.001 | 52.500 ±10.089 | 0.644 | 0.654 |
| | post | 81.154 ±9.829 | | 54.091 ±11.406 | | <0.001 |
| **Head** | pre | 5.962 ±2.457 | <0.001 | 5.682 ±1.756 | 0.317 | 0.608 |
| | post | 9.038 ±2.010 | | 6.136 ±2.642 | | <0.001 |
| **Shoulders** | pre | 5.385 ±2.418 | <0.001 | 5.455 ±2.632 | 1.000 | 0.913 |
| | post | 8.462 ±2.353 | | 5.455 ±3.051 | | 0.001 |
| **Spine** | pre | 4.808 ±0.981 | <0.001 | 4.545 ±2.632 | 0.317 | 0.589 |
| | post | 7.500 ±2.550 | | 5.000 ±3.086 | | 0.006 |
| **Hips** | pre | 5.192 ±1.721 | 0.003 | 5.227 ±1.875 | 0.157 | 0.943 |
| | post | 6.923 ±2.481 | | 5.682 ±2.338 | | 0.090 |
| **Ankles** | pre | 6.538 ±3.088 | 0.033 | 6.136 ±3.427 | 0.317 | 0.712 |
| | post | 8.077 ±2.481 | | 5.000 ±2.182 | | 0.004 |
| **Neck** | pre | 5.192 ±2.994 | <0.001 | 5.000 ±2.673 | 0.083 | 0.810 |
| | post | 8.269 ±2.426 | | 5.682 ±3.198 | | 0.004 |
| **Upper back** | pre | 5.385 ±1.359 | 0.005 | 4.773 ±1.875 | 0.317 | 0.198 |
| | post | 9.231 ±1.840 | | 5.000 ±2.182 | | <0.001 |
| **Trunk** | pre | 5.192 ±0.981 | <0.001 | 4.773 ±1.066 | 0.564 | 0.160 |
| | post | 6.731 ±2.426 | | 5.000 ±1.1543 | | 0.007 |
| **Abdomen** | pre | 5.385 ±1.359 | <0.001 | 5.455 ±1.471 | 0.317 | 0.863 |
| | post | 8.654 ±2.262 | | 5.227 ±1.066 | | <0.001 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Lower back** | pre | 4.808 ±1.721 | 0.001 | 5.455 ±1.471 | 0.317 | 0.172 |
| | post | 8.269 ±2.426 | | 5.227 ±1.066 | | <0.001 |

pre: baseline, before the program; post: after the program; SD: standard deviation

| **Results of posture deemed correct** | | **Intervention group (n=26)** | | **Control group (n=22)** | | **Differences between the intervention and control groups** |
|---|---|---|---|---|---|---|
| | | Mean ± SD (point) | p-value | Mean ± SD (point) | p-value | p-value |
| **Total score of posture deemed correct** | pre | 40.962 ±16.311 | <0.001 | 41.364 ±13.903 | 0.118 | 0.983 |
| | post | 91.346 ±6.566 | | 45.909 ±8.679 | | <0.001 |
| **Head** | pre | 5.000 ±3.162 | <0.001 | 5.909 ±2.942 | 0.038 | 0.313 |
| | post | 9.808 ±0.981 | | 3.864 ±2.642 | | <0.001 |
| **Shoulders** | pre | 3.846 ±2.148 | <0.001 | 3.864 ±2.642 | 0.527 | 0.957 |
| | post | 9.808 ±0.981 | | 4.318 ±2.338 | | <0.001 |
| **Spine** | pre | 4.423 ±1.629 | <0.001 | 4.091 ±1.974 | 0.763 | 0.520 |
| | post | 9.231 ±1.840 | | 4.318 ±2.801 | | <0.001 |
| **Hips** | pre | 4.808 ±2.227 | <0.001 | 4.773 ±2.429 | 0.564 | 0.953 |
| | post | 7.692 ±2.542 | | 5.000 ±2.182 | | 0.001 |
| **Ankles** | pre | 6.346 ±3.019 | 0.013 | 6.818 ±2.905 | 0.025 | 0.596 |
| | post | 8.077 ±2.481 | | 5.682 ±2.801 | | 0.004 |
| **Neck** | pre | 5.000 ±4.000 | <0.001 | 3.864 ±3.427 | 0.782 | 0.317 |
| | post | 9.423 ±1.629 | | 4.091 ±2.505 | | <0.001 |
| **Upper back** | pre | 3.077 ±3.187 | <0.001 | 3.182 ±2.905 | 0.083 | 0.834 |
| | post | 9.231 ±1.840 | | 4.545 ±1.471 | | <0.001 |
| **Trunk** | pre | 2.885 ±2.889 | <0.001 | 3.182 ±3.290 | 0.132 | 0.816 |
| | post | 8.654 ±2.262 | | 4.318 ±1.756 | | <0.001 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Abdomen** | pre | 2.692 ±3.530 | <0.001 | 2.955 ±3.671 | 0.090 | 0.807 |
| | post | 9.615 ±1.359 | | 4.545 ±1.471 | | <0.001 |
| **Lower back** | pre | 2.885 ±3.514 | <0.001 | 2.727 ±3.693 | 0.023 | 0.807 |
| | post | 9.808 ±0.981 | | 5.227 ±1.875 | | <0.001 |

pre: baseline, before the program; post: after the program; SD: standard deviation

## 5.5 Trunk static muscle strength in the intervention and control groups

The trunk flexor ($p<0.001$) and extensor ($p<0.001$) static muscle strength significantly improved in the intervention group for the end of the program.

The trunk flexor ($p=0.203$) and extensor ($p=0.649$) static muscle strength did not improve significantly in the control group for the end of the program.

There were significant differences in the results of the post-test of the trunk flexor ($p<0.001$) and extensor ($p<0.001$) static muscle strength between the intervention and control groups (Table 9) [85].

***Table 9 - Results of the trunk static muscle strength tests in the intervention and control groups***

| | **Intervention group (n=26)** | | **Control group (n=22)** | | **Differences between the intervention and control groups** |
|---|---|---|---|---|---|
| | Mean ± SD (sec) | p-value | Mean ± SD (sec) | p-value | p-value |
| **TFSM pre** | 3.615 ±7.910 | <0.001 | 3.818 ±8.404 | 0.203 | 0.950 |
| **TFSM post** | 56.885 ±113.748 | | 4.318 ±2.801 | | <0.001 |
| **TESM pre** | 8.962 ±5.963 | <0.001 | 8.045 ±4.603 | 0.649 | 0.917 |
| **TESM post** | 77.000 ±139.801 | | 8.682 ±4.714 | | <0.001 |

TFSM: trunk flexors' static muscle strength; TESM: trunk extensors' static muscle strength; pre: baseline, before the program; post: after the program; sec: second; SD: standard deviation

## 5.6 Lower limb muscle flexibility in the intervention and control groups

The flexibility of the right hip flexor (p=0.004), the left hip flexor (p=0.002), the right knee flexor (p<0.001), and the left knee flexor (p<0.001) significantly improved in the intervention group after the program.

The flexibility of the right hip flexor (p=1.000), the left hip flexor (p=1.000), the right knee flexor (p=1.000), and the left knee flexor (p=1.000) did not show significant improvement in the control group after the program.

Significant improvements were between the intervention and control groups regarding the post-test results of the right hip flexor (p=0.024), the left hip flexor (p=0.024), the right knee flexor (p=0.001), and the left knee flexor (p=0.002) (Table 10) [85].

***Table 10 - Results of the lower limb muscle flexibility tests in the intervention and control groups***

| | **Intervention group (n=26)** | | **Control group (n=22)** | | **Differences between the intervention and control groups** |
|---|---|---|---|---|---|
| | Frequency (%) CI (lower-upper) | p-value | Frequency (%) CI (lower-upper) | p-value | p-value |
| **Right HF pre** | 46.154 (27.991-65.316) | 0.004 | 50.000 (29.106-70.894) | 1.000 | 0.793 |
| **Right HF post** | 84.615 (70.747-98.484) | | 54.545 (33.738-75.353) | | 0.024 |
| **Left HF pre** | 46.154 (26.991-65.316) | 0.002 | 50.000 (29.106-70.894) | 1.000 | 0.793 |
| **Left HF post** | 84.615 (70.747-98.484) | | 54.545 (33.738-75.353) | | 0.024 |
| **Right KF pre** | 23.077 (6.882-39.272) | <0.001 | 27.272 (8.662-45.883) | 1.000 | 0.741 |
| **Right KF post** | 80.769 (65.620-895.918) | | 31.818 (12.355-51.281) | | 0.001 |
| **Left KF pre** | 26.923 (9.873-43.973) | <0.001 | 31.818 (12.355-51.281) | 1.000 | 0.713 |
| **Left KF post** | 80.769 (65.620-895.918) | | 36.363 (16.262-56.465) | | 0.002 |

HF: hip flexor; KF: knee flexor; pre: baseline, before the program; post: after the program; %: negative test percentage; CI: confidence interval

## 5.7 Lumbar motor control ability in the intervention and control groups

There were significant ($p<0.001$) differences between the pre- and post-test lumbar motor control ability results in the intervention group, and also between the intervention and control groups' post-test results ($p<0.001$). In the intervention group, we can say that the lumbar motor control ability of the children stayed in the normal range (0.154±0.368 mm), after the program.

There was no significant ($p=0.614$) difference between the pre- and post-test lumbar motor control ability results in the control group (Table 11) [85].

***Table 11 - Results of the lumbar motor control ability test in the intervention and control groups***

| | **Intervention group (n=26)** | | **Control group (n=22)** | | **Differences between the intervention and control groups** |
|---|---|---|---|---|---|
| | Mean ± SD (mm) | p-value | Mean ± SD (mm) | p-value | p-value |
| **LMC pre** | 8.269 ±5.474 | <0.001 | 8.682 ±4.970 | 0.614 | 0.489 |
| **LMC post** | 0.154 ±0.368 | | 8.136 ±4.144 | | <0.001 |

LMC: lumbar motor control ability; pre: baseline, before the program; post: after the program; mm: millimeter; SD: standard deviation

# 6 Discussion

## 6.1 Development and psychometric evaluation of the Health Questionnaire of Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children

The most important results of the study show that we have developed a valid and reliable questionnaire for assessing the back care and spine disease prevention knowledge for 6–10 years old children. The instrument was validated on the Hungarian population, but an English version is also available. The validation procedure was according to the Delphi method, involving experts and children from the target population, thus helping to make interpretable and professionally relevant questions [34,66].

According to the teachers' and children's opinions, filling out the questionnaire was neither too easy nor too difficult, thanks to the given answer options, which were pictures and symbols, which also makes it easier to fill out.

Psychometric properties support the reliability of the instrument. The validity and reliability results showed good stability of the total score (Cronbach 0.797). The test-retest reliability results showed a strong correlation, the ICC was strong in total scores and in case of all questions. The limit of agreement was relatively low and suggested a narrow error of measurement range (− 3.49–1.29) and the mean difference between the two measurements was − 1.10, which result showed a low systematic error and small difference between the test and retest measurements. Furthermore, the regression analysis showed that the differences of the total score values increased as the acquired scores increased ($p<0.001$). For those who reached a higher score on the first measurement, the results of the second measurement showed an even greater improvement, they got to know the questions when completing the questionnaire and were better suited to correct them. The total scores showed a significant correlation with age ($p<0.001$) and in every age group the difference was significant between the subgroups which proved the higher scores of back school groups ($p<0.001$).

Validated questionnaires existing in the literature measuring back care knowledge in other age groups. Miñana-Signes et al. validated the Health questionnaire about knowledge for health and back care related to the practice of physical activity and exercise for adolescents (HEBACAKNOW-PAE) for 13–18 years old (Cronbach 0.80) [6]. M. Monfort et al. validated the Health questionnaire on back care knowledge in daily life physical activities (HEBACAKNOW) for children aged between 14 and 17 years old (Cronbach 0.82) [34]. Akbari-Chehrehbargh et al. developed the Back-care Behavior Assessment Questionnaire (BABAQ) for schoolchildren (5th grade), which aimed to measure the theory-based content of back care programs (Cronbach 0.84 and 0.93) [62]. It is worth mentioning a validated questionnaire connected to postural habits, validated by M. Monfort and Miñana-Signes in 2020, the questionnaire of Back-health related postural habits in daily activities (BEHALVES) for 13–17-year old adolescents, that occupies in some terms with back care knowledge [66].

However, Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6–10 years old children is the first questionnaire validated by professionals for children at that early age to assess the back care and spine disease prevention knowledge. The study population consisted of children who took part in a back school program or not. The validity and reliability of the questionnaire were good, it is a suitable instrument for the assessment of back care knowledge of 6–10 years old children.

**Back care knowledge and spine disease prevention**

It is interesting to look at how low is the back care knowledge of children not participating in any back school or posture education program. In the study of Miñana-Signes et al., 5th-grade primary school children who had not yet received back educational program (control group, mean age: 11.13 ± 0.34 years) completed two validated questionnaires related to back care knowledge. At HEBACAKNOW-PAE 2.04 ± 0.90 points were obtained from the maximum 10 points (20.4%), at HEBACAKNOW-DL 2.43 ± 1.18 points were achieved out of the maximum 10 points (24.3%) [86]. In the recent study children who did not participate in BSP reached 4.86 ± 3.500 points (1st grader) (27.0%), 2.09 ± 2.05 points (2nd grader) (11.6%), and 3.951 ± 2.16 points (4th grader) (22.0%) compared to the maximum 18 points. If we look at the percentage of correct answers, it can be deduced that children’s back care knowledge and spine prevention is between 20 and 60%, most are closer to 20%, which is inadequate.

It is also interesting to observe the back care knowledge of children after a back school program. ***Table 18 (see pages 105-106)*** shows the results of back care knowledge during the 1-school year back school program and after the personal and e-learning back school programs, and the results of back care knowledge assessed by validated and not validated knowledge questionnaires, tests found in the literature.

Back care knowledge and spine disease prevention need to be developed in addition to posture habits for the improvement of more effective spine prevention.

Habybabady et al. examined 404 children (203 in the intervention group, 201 in the control group; aged 10-11) before and after a back care education program on the change of back care knowledge and behavior. A week after the intervention, knowledge promotion in the intervention group was significantly higher than the control group after adjusting for primary knowledge scores ($p<0.001$) [87].

Cardon et al. measured the change of back care knowledge and fear-avoidance beliefs among 555 children (mean age at baseline: 9.7 years±0.7 years). In the group combining back care with physical activity promotion were 190 pupils, in the back care group were 193 children and the control group consisted of 172 children. In both intervention groups, the scores for back care related knowledge and back care behavior were significantly ($p<0.05$) higher than the control group [88].

In the research of Tóthné and Tóth, they measured the back care knowledge of 111 children before and eight months after the „Porci Berci" back education program. 79.33% of the children gave correct answers to the questions about lexical knowledge acquired from the spine, 93% recognized correct posture, and 79.01% managed to acquire spine-friendly movements [4].

A previous study of the recent research contained a similar questionnaire about back care knowledge. After a 10-week child back school program the back care knowledge significantly ($p<0.001$) improved in the intervention group, and there was a significant ($p<0.001$) difference at the end of the program between the intervention and control groups [23].

In the recent study, in the intervention group, the total score, the anatomical-biomechanical, and the spine use-ergonomic knowledge were significantly ($p<0.001$) better for the end of the program and were significantly ($p<0.001$) better than the control group's results after the program.

In the control group only Question 7 improved significantly ($p=0.046$) for the end of the program, which can be the result of the learning process. Research has shown, that during the examination sessions, children have learned the tests, thus for the next examination they could perform it better, than the first time. In our case, during the questionnaire filling, children could learn the correct answer, so for the next time, a higher percentage could choose the correct answer. Another reason can be that children can look for the correct answer for the next time. It can also contribute to the fact that only Question 7 improved significantly, that only two possible answers were given to this question, so children had a 50-50% chance that they would mark the correct answer, and can learn the correct one of the two answers more easily.

## 6.2 Physical parameters during the 1-school year back school program

### Habitual posture and posture deemed correct

Kovácsné et al. examined the change of the habitual posture among 30 (mean age: 12.7±2.2 years) ballet dancers and 32 (13.7±2.9 years) hip-hop dancers, on the effect of a 3-month core stability training program. The habitual posture measured after the program improved by a high percentage, in both groups (ballet 52.17%, hip-hop 37.5%) [72].

Kayapinar et al. tested the efficacy of a back school program among 80 (40: intervention group, 40: control group) 5-7 years old children on the change of posture. They also used the New York State Posture evaluation. In the intervention group, 8 from the 13 measured parameters showed significant ($p<0.05$) improvement in the intervention group and 4 parameters measured after the program were significantly ($p<0.05$) better in the intervention group than in the control group [9].

In the previous study of the recent research after the 10-week child back school program, the habitual posture ($p<0.001$), the posture deemed correct ($p<0.001$) significantly improved in the intervention group, and significant differences were found in the habitual posture ($p<0.001$), and posture deemed correct ($p<0.001$) between the intervention and control groups [23].

In our research, the total score of the habitual posture ($p<0.001$) and posture deemed correct ($p<0.001$) significantly improved in the intervention group for the end of the program and were significantly ($p<0.001$) better than the control group's results after the program. The ankles at the habitual posture ($p=0.033$) and posture deemed correct ($p=0.013$) did not change as much significantly as the other parts at both postures. This can be because we did not make adequate strengthening exercises for the stabilizing muscles around the ankles, since our focus was on the trunk and spine.

In the control group, the lower back part at posture deemed correct improved significantly ($p=0.023$) for the end of the program, which can be the result of the previously mentioned learning process. Posture deemed correct is the posture that children can position voluntarily, so after the first examination, they may learn how to position well the lower back, which they think is the correct positioning, and more are able to position it well the second time. If we check the habitual posture this phenomenon does not appear, that is the posture where children stand as they usually stand in everyday life.

The position of the head (p=0.038) and the ankles (p=0.025) significantly worsened in the control group after the program. A higher risk of developing musculoskeletal problems due to a sedentary lifestyle begins with school life, children are exposed to a variety of intrinsic and extrinsic risk factors, that contribute to the development of spine deformities and damage. On the other hand, the study of Varga Csabáné Zakariás et al., who is a physical education teacher, showed that the content of the physical education classes may not be appropriate for the prevention of spine problems and the improvement of trunk state of music school students [89].

There was no significant (p=0.090) difference between the intervention and control groups for the end of the program regarding the hip part at the habitual posture. The hip part can be affected by the flexibility of the hip flexors, which have been examined during the program. We did not find enough the stretching exercise of the hip flexors, they improved significantly in the intervention group, but not as much as they could, there are still gaps in the flexibility, thus it could result in a not significant change between the intervention and control groups after the program.

**Trunk muscle strength and lower limb muscle flexibility**

As a result of the „Porci Berci” program, between 1998-2009, 1138 children were measured with the Matthias test (posture test). According to the results in 1998, although 249 between the ages of 8-10 years 30.52 % of the children could carry the test correctly, in 2004, 2005, and 2009, the repeated tests showed a constantly deteriorating tendency [4].

In the research of Somhegyi et al., during the school year of 2001/2002, 200 6-14 years old children took part in the primary prevention program of the Hungarian Spine Society and 213 in the control group. In the intervention group, all the 12 muscle tests (responsible for posture) significantly ($p<0.01$) improved. In the control group in some of the abdominal and back muscle tests significant ($p<0.01$) improvement came to be, though this result was significantly ($p<0.01$) lower than the improvement in the intervention group, 6 muscle tests have not been changed and 4 showed significant ($p<0.05$) decadence [4]. In the school year of 2009/2010, they measured 530, 7-12 years old children, who took part in the same program for 6 months. The static muscle strength and muscle flexibility showed significant ($p<0.001$) improvement at the end of the program [4].

The 10-week child back school program ended with a significant improvement in the intervention group regarding the trunk flexor ($p<0.001$), trunk extensor ($p<0.001$), the right hip flexor ($p<0.001$), the left hip flexor ($p<0.001$), the right knee flexor ($p<0.001$) and the left knee flexor ($p<0.001$). Significant improvements were between the intervention and control groups regarding the post-test results of the right hip flexor ($p<0.001$), the left hip flexor ($p<0.001$), the right knee flexor ($p<0.001$), and the left knee flexor ($p<0.001$) [24].

In the research, that we conducted the trunk flexor ($p<0.001$), trunk extensor ($p<0.001$) static muscle strength, and the lower limb muscle flexibility ($p<0.001$) tests significantly improved in the intervention group for the end of the program and were significantly better than the control group's results measured at the end of the program.

**Lumbar motor control ability**

We did not find any back school program research in the literature, that examined the lumbar motor control ability. We can compare our results to a 10-week interval child back school program. After 10 weeks the lumbar motor control ability of the children significantly ($p<0.001$) improved, but this interval was not enough to get in the normal range [24].

There was another research by Kovácsné et al., who examined 30 (mean age: 14.86±1.00 years) ballet dancer children's lumbar motor control ability after the implementation of a new core prevention training program for low back pain. At the end of the 3-month program, the lumbar motor control ability improved significantly ($p<0.001$) [74].

In the recent research, the lumbar motor control ability significantly ($p<0.001$) improved in the intervention group for the end of the program. There was a significant ($p<0.001$) difference between the intervention and control groups' post-test results.

The results of the measured parameters are summarized and compared in ***Table 19*** ***(see pages 107-109)***.

## 6.3 Interpretation of the new results

Nationally, Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6–10 years old children is the first questionnaire developed and validated by professionals for children to assess the back care and spine disease prevention knowledge, and proved to be a valid and reliable tool (Cronbach 0.797).

Internationally, Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6–10 years old children is the first questionnaire developed and validated by professionals for children at that early age to assess the back care and spine disease prevention knowledge, and proved to be a valid and reliable tool (Cronbach 0.797).

We developed the content of a child back school program, that was registered as a "voluntary scientific work" in the Hungarian Intellectual Property Office.

The content of the child back school program was published as a book, in Hungarian (96 pages, 7 chapters, 7 tales, 159 pictures, 39 figures, 51 playful tasks, practice) [76].

The content of the child back school program was published as a book, in English (100 pages, 7 chapters, 7 tales, 159 pictures, 39 figures, 51 playful tasks, practice) [25].

A website was developed and designed for the content of the child back school program, thus ensuring the availability of materials and providing an opportunity for 6-10 years old children to become familiar with the content of the back school program and practice (10 animation videos, 10 theoretical videos, 8 practical videos, 9 conversations) [75].

The efficacy examination of the 1-school year back school program among 6-7 years old children proved to be effective among children aged 6-7 years, based on our results (back care knowledge $p_{total\ score}<0.001$; habitual posture $p_{total\ score}<0.001$, posture deemed correct $p_{total\ score}<0.001$; trunk flexors' $p<0.001$ and extensors' $p<0.001$ static muscle strength; lower limb muscle flexibility $p<0.05$; lumbar motor control ability $p<0.001$).

## 6.4 Clinical implication

For children who cannot read or write yet, an elaborated theoretical curriculum, practical part, and didactic material for home are needed. The program can be adapted to preschool children (from the age of 4).

## 6.5 Strength and limitation

The research was conducted on a small size of the population, a more significant number of the population would allow more reliable conclusions, therefore the small samples recommend cautious interpretation of intervention effects. The study was not randomized, and there was a 2-year follow-up only for the back care knowledge and spine prevention, the results of which are not presented in the dissertation.

The instrument does not collect questions on physical exercise for back care. It would be useful to further adapt the questionnaire even more to age and to expand it with questions.

## 6.6 Possible directions for further investigation

It would be useful to expand to a larger size of population.

It is recommended to be tested on preschool children. It would be interesting to detect the back care knowledge and physical parameters of preschool children and to assess the effect of an educational program on the development of the measured parameters since the material covers the material of children 4–10 years.

It would be interesting to transfer the material of the child back school program with the help of e-learning for children in a lower grade.

It may be effective to monitor how knowledge changes after a back school program, and to examine how children's knowledge lasting in long term or maybe an update is required, if yes, when, besides to examine is there any direct impact on the prevention of the spine problems.

It would be advantageous to validate the English version of the developed questionnaire.

It would be useful to develop and validate a questionnaire measuring the back care and spine disease prevention knowledge for 11-18 years old children.

It would be conductive to organize training for pedagogues, teachers, and kindergarten teachers.

# 7 Conclusions

According to the results of the recent study, we can state that the Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6–10 Years Old Children proved to be a valid and reliable tool for the examination of back care and spine disease prevention knowledge of 6–10 years old children.

The evolved back school programs have a remarkable impact on back care knowledge, the level of knowledge increases with the development of back schools.

We used a complex (habitual posture and posture deemed correct, trunk flexor-extensor static muscle strength, flexibility of lower limb muscles, influencing the posture, lumbar motor control ability) test system to measure the effectiveness of the developed 1-school year back school program. The multi-sided survey provided an opportunity to measure the parameters developed during the back school program. According to the results of the survey, the 1-school year back school program proved to be effective, it improves the trunk state of children aged 6-7.

# 8 Acknowledgment

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# 10 List of publications

## 10.1 Related to the topic of the dissertation

### Original article:

Szilágyi B, Makai A, Tardi P, Kovácsné Bobály V, Simon-Ugron Á, Járomi M. Back School Program: Development of Back Care Knowledge and Spine Disease Prevention and Trunk State Among 6-7 Year-Old-Children. Studia Universitas Babes-Bolyai Educatio Artis Gymnasticae. 2021;LXVI(3):77-93.

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***The total impact factor value of the publications related to the topic of the dissertation: 11.926.***

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Szilágyi B, L Molnár E, Járomi M. Mesés gerinctúra. Pécs, Magyarország; Szilágyi Brigitta. 2019. ISBN: 9786150052946

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# 11 Appendicies

## Tables

*Table 12 - Summary of the national child back school, back care, back health, and postural education study programs (research)*

| Author | Population | Methods | Applied program |
|---|---|---|---|
| Tóth & Tóthné, 1998, 2000 [16,46] | • 6-10 years<br>• 111 students | • Matthias test<br>• Self-developed questionnaire (for children, parents, teachers) | Porci Berci is looking for friends (Porci Berci barátokat keres, egészségmegőrző oktatóprogram):<br>• 6+1 sessions<br>• Theoretical and practical material (anatomy, physiology of the spine, muscle training, description of spine-friendly movements, automation of correct movements) |
| Somhegyi et al., 2003 [43] | • 6-14 years<br>Intervention group:<br>• 200 children<br>Control group:<br>• 213 children | • 12 tests to examine muscle strength, and the flexibility of muscles responsible for the posture | Posture Correction (Tartáskorrekció):<br>• 10 sessions<br>• 12-13 minutes of practice/ occasion (2-3 minutes warm-up, 10 minutes special exercising)<br>• Special set of exercises (strengthening, stretching)<br>Control group – no intervention |
| Gangel & Járomi, 2009 [48] | • 7-9 (8.5) years<br>• 127 children with kypholordotic back | • Matthias test<br>• Thomas test<br>• Flexibility test of the rectus femoris muscle | Bouldering-climbing:<br>• 4 month<br>• 2x / week<br>• 5 minutes warm-up, 40 minutes climbing and trunk muscle strengthening, 10 minutes cool-down and stretching |
| Némethné et al., 2011 [49] | • 3-6 years<br>• 19 preschool children | • Wall-occiput distance<br>• Delmas index<br>• The distance of inferior angles of scapulas<br>• Inspection of the presence of calcaneal valgus/varus<br>• Self-developed questionnaire (for parents) | Preventive back school program:<br>• 3 months<br>• Correct sitting, standing, and relaxed lying positions<br>• Spine-friendly lifting techniques<br>• Correction of posture disorders<br>• Development of muscle condition, awareness |

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| | | | • Improvement of physical abilities<br>• Adjusting the position of the trunk-shoulder girdle-pelvis<br>• Improvement of coordination |
| **Szilágyi et al., 2020 [24]** | Intervention group:<br>• 6-7 (6.8) years<br>• 26 children<br>Control group:<br>• 6-7 (6.7) years<br>• 22 children | • Lehmann tests:<br>➢ Trunk flexor and extensor static muscle strength<br>➢ Flexibility test of the hip and knee flexor muscles<br>• Lumbar motor control ability test (Sitting Forward Lean test) | Back school program:<br>• 10 weeks<br>• 1x / week, 30 minutes of practice/occasion (exercises for the improvement of trunk muscle strength, lower limb flexibility and lumbar motor control ability)<br>• 4x / week, 10 minutes of practice on the physical education lessons<br>• 7x / week, 10 minutes of practice at home<br>Control group – no intervention |
| **Szilágyi et al., 2019 [23]** | Intervention group:<br>• 6-7 (6.8) years<br>• 26 children<br>Control group:<br>• 6-7 (6.7) years<br>• 22 children | • Health Questionnaire on Back care knowledge and spine disease prevention<br>• Habitual posture and posture deemed correct examination (Photogrammetry test) | Back school program:<br>• 10 weeks<br>• 1x / week, 15 minutes of theoretical curriculum/occasion<br>• 1x / week, 30 minutes of practice/occasion (exercises for the improvement of trunk muscle strength, lower limb flexibility, posture, and lumbar motor control ability)<br>• 4x / week, 10 minutes of practice on the physical education lessons<br>• 7x / week, 10 minutes of practice at home<br>Control group – no intervention |

*Table 13 - Summary of the national child back school, back care, back health, and postural education programs (books)*

| Author | Target population | Name of the program/book | Content of the program/book |
|---|---|---|---|
| Tóth & Tóthné, 1998 [16] | • Primary school children | • Matthias test<br>• Self-developed questionnaire (for children, parents, teachers) | Porci Berci is looking for friends (Porci Berci barátokat keres, egészségmegőrző oktatóprogram kisiskolásoknak):<br>• Theoretical and practical material (anatomy, physiology of the spine, muscle training, description of spine-friendly movements, automation of correct movements) |
| Somhegyi et al., 2003 [43] | • Primary school children | • 12 tests to examine muscle strength, and the flexibility of muscles responsible for the posture | Posture Correction (Tartáskorrekció):<br>• Special set of strengthening and stretching exercises<br>• Special set of muscle strength and flexibility tests |
| Tóth, 2000 [47] | • Preschool and primary school children | The protection of the musculoskeletal system in childhood (A mozgásszervek védelme gyermekkorban) | • Theoretical and practical advice for the spine protection, use, spine friendly lifestyle in the physical education, in school-age<br>• Teaching and automation correct postures, unloading postures, relaxation<br>• Ergonomics |
| Tóthné & Tóth, 2015 [4] | • Primary school children | Back School Program of Conscious Seating for primary school children (Tudatos ülés gerinciskolája általános iskolásoknak) | • Low Back Pain<br>• Posture and measurements for posture<br>• Ergonomics<br>• Introduction to back school program, theoretical material of back school programs<br>• Anatomy of the musculoskeletal system<br>• Strengthening, stretching exercises |
| Vass, 2015 [45] | • Primary school children | Classroom Posture Corrections: a collection of exercises (Osztálytermi Tartáskorrekció: Gyakorlatgyűjtemény) + a workbook | • Tests for posture, muscle strength, and flexibility<br>• Mobilizing, strengthening and stretching exercises adapted into classroom |

*Table 14 - Summary of the features of the international child back school, back care, back health, and postural education study programs (research)*

| Author | Population | Methods | Applied program |
|---|---|---|---|
| **Spence et al., 1984 [90]** | 41 third-grade children:<br>• 14 in the lecture demonstration group<br>• 14 in the guided discovery group<br>• 13 in the control group<br>35 fifth-grade children:<br>• 11 in the lecture demonstration group<br>• 12 in the guided discovery group<br>• 12 in the control group | • Written test to assess the knowledge<br>• Practical test (obstacle course in which lifting a 2.3 kg crate onto a 1.2 m high cart was graded)<br>• 1 and 8-week follow-up | Demonstration group:<br>• 5-minute demonstration through the use of videotape, then a 5-minute review of the major principles presented in the tape<br>Discovery group:<br>• 15-minute interactive teaching session<br>Control group:<br>• No instructions, the same manner |
| **Robertson & Lee, 1990 [91]** | • 10-12 years<br>• 280 children | • Observation of static and dynamic posture | Back care education:<br>• 3 sessions<br>• First session: collection of data, sitting position, posture in sitting position<br>• Second session: collection of data, safe lifting techniques, sports injury prevention, stretching<br>• Third session: collection of data, repetition and completion of the learned knowledge |
| **Sheldon, 1994 [26]** | Pre-test:<br>• 34 sixth-grade student<br>• 36 eighth-grade student<br>Post-test:<br>• 27 sixth-grade student<br>• 28 eighth-grade students | • Written test of back care<br>• Practical performance assessment of the lifting task<br>Post-test:<br>• After 2 days of the instruction<br>• After 6-7 weeks of the instruction | Educational back care program:<br>• 15-minute verbal presentation (back injuries, low back pain, prevention)<br>• Visual demonstration of a partial squat lift |
| **Cardon et al., 2000 [68]** | Intervention groups:<br>• 10.02 years<br>• 82 children after the program | • Questionnaire of back care, posture knowledge<br>• Videotaped practical tests of movement sessions (taking off shoes, sitting, handling a | Intervention group - Back care education:<br>• 6 sessions lead by physical therapist + teachers were involved<br>• 1 occasion/week |

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| | • 10.84 years<br>• 116 children 3 months after the program<br>Control group:<br>• 10.75 years<br>• 116 children | crate, picking up a pen, moving a crate, book bag use) | • 1 hour/occasion<br>• Anatomy, pathology of the back<br>• Using 10 guidelines for back care<br>• Principles of biomechanical favorable postural behavior<br>• Skills according to good body mechanics<br>• Class teacher tasks supported by PE teachers: integration and repetition of the learned back posture principles, postural dynamism, improvement of dynamic sitting, interruption of prolonged static sitting, activating approach<br>Control group – no intervention |
| **Cardon et al., 2002 [92]** | Intervention group:<br>• 9.8 years<br>• 198 children<br>Control group:<br>• 10.3 years<br>• 165 children | Before-after the program, 3 months, and 1-year follow-up:<br>• Videotaped practical tests of movement sessions (taking off shoes, sitting, handling a crate, picking up a pen, moving a crate, book bag use)<br>• Questionnaire about back and neck pain<br><br>1 year after the program:<br>• Candid camera evaluation (observation in the classroom during a regular lesson, observation of movement session) | Intervention group - Back care education:<br>• The same as in Cardon (2000)<br>• 6 sessions with a physical therapist<br>• Teachers continued by the integration of the program<br>• Information session for teachers and parents<br>Control group – no intervention |
| **Geldhof et al., 2006 [18]** | Intervention group:<br>• 11.3±0.8 years<br>• 193 children<br>Control group:<br>• 11.4±0.8 years<br>• 172 children | • Questionnaire of back care, posture knowledge<br>• Questionnaire about back and neck pain<br>• Questionnaire about fear-avoidance beliefs<br>• Supplemental questions for teachers and children (usefulness, preferred sitting position, guideline implementation)<br>• Observation of material handling (use of back posture principles)<br>• Portable Ergonomic Observation Method (PEO) with video take (body postures and | Intervention group - Back care education:<br>• The same as in Cardon (2000)<br>• 6 sessions with a physical therapist<br>• Teachers continued by the integration of the program<br>• Didactic material was provided for the class teachers<br>• Information session for teachers and parents<br>• 2-year intervention<br>Control group – no intervention |

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| | | activities in the classroom) | |
| **Geldhof et al., 2007 [93]** | • 9-13 years<br>Intervention group:<br>• 213 children<br>• 94 children at 2-year follow up<br>Control group:<br>• 185 children<br>• 101 children at 2-year follow up | • Questionnaire of back care, posture knowledge<br>• Questionnaire about fear-avoidance beliefs<br>• Questionnaire about back and neck pain<br><br>• 1-year follow up with supplemental questions (how they remember the education sessions, how often they used the back posture principles) | Intervention group - Back care education:<br>• The same as in Geldhof (2006)<br>• 2-year intervention<br>Control group – no intervention |
| **Geldhof et al., 2007 [30]** | • 9.7±0.8 years<br>Intervention group:<br>• 213 children<br>Control group:<br>• 185 children | • Questionnaire of back care, posture knowledge<br>• Questionnaire about fear-avoidance beliefs<br>• Questionnaire about back and neck pain<br><br>• 2-year follow up with supplemental questions (how they remember the education sessions, how often they used the back posture principles)<br>• 20 supplemental questions on children's postural behavior | Intervention group - Back care education:<br>• The same as in Geldhof (2006)<br>• 2-year intervention<br>Control group – no intervention |
| **Geldhof et al., 2007 [29]** | Intervention group:<br>• 11.2±0.9 years<br>• 41 children<br>Control group:<br>• 11.4±0.6 years<br>• 28 children | • Trunk flexor-extensor muscle endurance test-> test-retest reliability<br>• Static spinal curvature assessment (Zebris CMS70P, Isny, Germany)-> test-retest reliability<br>• Capacity of leg muscles (Biodex System 3 Pro, Biodex Corp., Shirley, NY, USA)<br>• Questionnaire (physical activity) | Intervention group - Back care education:<br>• The same as in Geldhof (2006)<br>• 2-year intervention<br>Control group – no intervention |
| **Cardon et al., 2007 [88]** | • 9.7±0.7 years<br>• Back care promoting program group (n=193)<br>• Back care promoting and physical activity promoting program group (n=190)<br>• Control group (n=172) | • Observation of learned back care principles<br>• Questionnaire of back care, posture knowledge; fear-avoidance beliefs back and neck pain<br>• Accelerometer (physical activity) | Back care group:<br>• The same as in Geldhof (2006)<br>• 6 sessions with a physical therapist<br>Back care and physical activity group:<br>• 6 sessions with a physical therapist and on the component of Sports, Play, and Active Recreation for Kids (SPARK)<br>Control group - no program |

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| **Groll et al., 2009 [94]** | • 205 children<br>• parents<br>• teachers | • Examination of back pain, postural abnormalities, knowledge of the spine and proper posture | Back care tour (RückenKul-Tour):<br>• 8 double hours<br>• Theoretical knowledge<br>• Practical exercises |
| **Candotti et al., 2011 [95]** | Intervention group:<br>• 7 children (10.5±0.8 years), 10 adolescents (13.2±1.0 years)<br>Control group:<br>• 7 children,10 adolescents | • Static posture (posture grid, plumb line)<br>• Dynamic posture (video, observation)<br>• 8-month follow-up | Intervention group - PEP back education program:<br>• 8 lessons<br>• 2 lessons/week<br>• 1 hour/ lesson<br>• Anatomy, biomechanics, structure and function of the spine, proper-improper positions, motions of the spine, proper spine use techniques<br>Control group - no intervention |
| **Foltran et al., 2012 [96]** | • 9-16 years<br>• 4th to 8th grade<br>• 392 students at the baseline<br>• 114 students at the follow-up | • Back care questionnaire<br>• 2-year follow-up | • 2 lessons (50 minutes)<br>• 1 practical lesson (50 minutes)<br>• Anatomy, physiology, structure, function, diseases of the spine, ergonomics, spine use techniques, proper positions, postures |
| **Dolphens et al., 2011 [97]** | • 9-11 years<br>Intervention group:<br>• 198 children<br>• at 8-year follow up 96<br>Control group:<br>• 165 children<br>• at 8-year follow-up 98 | • Questionnaire (back care knowledge, spinal care behavior, self-efficacy towards proper back care behavior, back and neck pain in the past week and fear-avoidance beliefs)<br>• 8-year follow-up | Intervention group - Back care education:<br>• The same as in Gedholf (2006)<br>• 2-year intervention<br>Control group – no intervention |
| **Kayapinar et al., 2012 [9]** | • 5-7 years (kindergarten)<br>Intervention group:<br>• 40 children<br>Control group:<br>• 40 children | • Posture measurement with New York State Posture evaluation | Intervention group - Movement education program:<br>• 12 weeks<br>• 60 minutes/ occasion<br>• Basic motor movements, posture exercise, games<br>Control group – no intervention |
| **Habybabady et al., 2012 [87]** | • 10-11 years<br>Intervention group:<br>• 203 students<br>Control group:<br>• 201 students | • Questionnaire of knowledge and behavior<br>• 3-month follow-up | Intervention group - Back care education program:<br>• 4 educational pamphlets in the classroom by a trained expert<br>• 60 minutes/ pamphlet<br>• Anatomy, structure of the spine, ergonomic about backpack, proper postures, spine use techniques |
| **M Jordá et al., 2014 [19]** | • 119 children<br>• 13.97±2.29 years | • Self-administered survey (back pain, postural habits, physical activity)<br>• For the children and parents | Juvenile Back School Program:<br>• 1-hour informational session by rehabilitation physician (anatomy, function, ergonomics, posture, spine use, back pain) |

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| | | • 3-month follow-up<br>• Supplemental questions (whether participants practiced the learned exercises, and how often) | • 2x1 hour practice session by a physical therapist (posture, strengthening, stretching exercises)<br>• Illustrated handout of the content for home practice |
| **Vieira et al., 2015 [20]** | Intervention group:<br>• 40 students<br>• 8-12 years | • Observation with LADy (Lay-out for Assessing the Dynamic Posture)<br>• Semi-structured interviews with the legal guardians and teachers | PEP (postural education program):<br>• 9 lessons with a week interval by a physical therapist<br>• 1.5 hour/ lesson<br>• Tasks to perform at home<br>• Anatomy, structure, function, disorders of the spine, correct spine use techniques, postures, games |
| **Ritter & Souza, 2015 [98]** | Intervention group:<br>• 14.00±0.93 years<br>• 32 children<br>Control group:<br>• 15.38±0.97 years<br>• 29 children | • Observation of Daily Life Chores through video<br>• Observation of the Seated Posture in the Classroom<br>• Questionnaire: Tool for Knowing How Students Perceive Posture in School Environment<br>• 1-year follow-up | Intervention group - Postural education program:<br>• 10 weeks<br>• 20 sessions<br>• 2 sessions/ week<br>• 50 minutes/ session<br>• Anatomy, role, structure, motions of the spine, spine use techniques, positions, postures, outdoor recreational activities<br>Control group – no intervention |
| **Fonseca et al., 2015 [99]** | • 14-18 years<br>• 495 female adolescents | • Self-administered questionnaire of knowledge of body posture and postural behavior | - |
| **Hill & Keating, 2015 [100]** | • 4-11 years<br>Intervention group:<br>• 469 children<br>Control group:<br>• 239 children | • MySpine survey (back pain, for the intervention group question about the MySpine exercises)<br>• LBP was reported during the previous week on trial days 7, 21, 49, 105, 161, and 270 | MySpine program:<br>• 7 times by a physiotherapist during the 270 days<br>• Intervention group – back awareness education, spine use habits, behaviors and 4 back exercises to practice every day (MySpine exercises)<br>Control group – back awareness education, spine use habits, behaviors |
| **Brzek & Plinta, 2016 [21]** | Intervention group:<br>• 7.6±0.64 years<br>• 144 pupils<br>Control group:<br>• 7.72±0.73 years<br>• 222 pupils | • Body posture measurement (plumb line, Pedi-Scoliometer, digital inclinometer)<br>• Questionnaire (everyday life ergonomic positions)<br>• Weight of the school bag was measured<br>• 1-year follow-up | „I take care of my spine" program:<br>• 2x10 months<br>• Children, teachers, parents were involved<br>• Theoretical, practical material<br>Control group – no intervention |
| **Santos et al., 2017 [101]** | • 8.8±1.1 years<br>• 44 children | • Questionnaire (knowledge of spine and posture) | PEP (posture education program):<br>• Theoretical, practical material |

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| | | • Observation with LADy (filmed circuit for dynamic posture during the activity of daily living)<br><br>• 5- month follow-up (after 3 months a review was conducted) | • 8 meetings<br>• 1 meeting/week<br>• 90 minutes/meeting<br>• Anatomy, structure, function of the spine, spine use habits, techniques, postures<br><br>• After 3-month a review was conducted<br>• 4 meetings in 15 days<br>• 90 minutes/meeting |
| **Miñana-S et al., 2019 [22]** | Intervention group:<br>• 11.19±0.4 years<br>• 16 students<br>Control group:<br>• 11.13±0.34 years<br>• 16 students | • Nordic questionnaire<br>• Health questionnaire on back care knowledge concerning practice physical activity and exercise for adolescents<br>• Health questionnaire on back care knowledge concerning physical activities in daily life for adolescents<br>• Health questionnaire on back care postural habits concerning physical activities in daily life for adolescents<br><br>• 1-month follow-up | Intervention group - Back-health education program:<br>• 7 sessions (1 theoretical, 6 practical)<br>• 45 minutes/session<br>• Anatomy, function, pathologies of the back, correct-incorrect postural habits, principles of the healthy back, spine use habits, techniques, postures, strengthening, stretching<br>Control group – no intervention |
| **Dullien et al., 2018 [102]** | Intervention group:<br>• 10.59±0.438 years<br>• 87 pupils<br>Control group:<br>• 10.52±0.426 years<br>• 85 pupils | • Clinical orthopedic examination (Body weight, Body height, Orthopaedic abnormalities of the spine, Posture Test: Matthiass-Test)<br>• Health questionnaire (Anamnestic questions, How often do you have back pain?)<br>• Motor test (Push-ups, Sit-ups, Balance test, Stand and Reach, Hanging on wall bars)<br>• Back-behaviour Trial (Back pack handling, Demonstrate sitting postures, Demonstrate strengthening exercises, Carrying a water crate)<br>• Knowledge Test (12 questions on healthy back knowledge) | Intervention group:<br>• 10-month<br>• 1. Knowledge improvement through five lessons on back care, which was held by a teacher with the provided material<br>• 2. Posture awareness training and improvement in the classroom with three posters<br>• 3. Reducing muscular imbalance of the core muscles through mandatory back and abdominal muscle exercises at the beginning of each lesson held by a physical education teacher |
| **Minghelli et al., 2021 [103]** | • 10-16 years<br>• 153 students<br>• 2 Intervention groups (GA, GB) | • Theoretical Test (back care knowledge)<br>• Practical Test (correct spine use)<br><br>• 1-year follow-up | • Spine anatomy; spinal joint physiology (spinal movements and intervertebral disc mechanics); postural changes and spinal pathologies; ergonomic |

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| | | | analysis of sitting posture (during the writing and watching a class); sleeping; getting out of bed; standing; lifting and transporting objects; transporting the backpack; the distribution of the material in the backpack; consequences of adopting an incorrect and/or prolonged posture; the importance of intervals after maintaining the static posture; and exercises<br>GA Intervention group:<br>• 6 sessions (3 theoretical 3 practical)<br>• 45 minutes/session<br>• 1 occasion/week<br>GB Intervention group:<br>• 1 theoretical session<br>• 90 minutes |
| **Toloza et al., 2021 [13]** | Intervention group:<br>• 5.66±0.75 years<br>• 50 children<br>Control group:<br>• 5.57±0.51 years<br>• 21 children | • Knowledge of Back Care Questionnaire (9 questions, distribution and lifting of loads, adoption of postures, and anatomy of the spine) | Intervention group - Back Care Education Program:<br>• 15 sessions<br>• 2 hours/ session<br>• distributed over 5 weeks (3 times/week)<br>• cognitive component: anatomy, physiology, alterations of the spine, adoption of appropriate postures and movements is school lofe; distribution and lifting of loads; apotion of sleeping postures, sitting and standing<br>• attitudinal component: practice of adopting postures, execution of appropriate movements<br>• passive and active methods: films, stories, games, exercises, relaxation)<br>Control group:<br>• 15 sessions<br>• 2 hours/ session<br>• distributed over 5 weeks (3 times/week)<br>• physical exercise activities, strengthening, stretching exercises for the back muscles |

*Table 15 - Summary of the features of the international child back school, back care, back health, and postural education programs (books)*

| Author | Target population | Name of the program/book | Content of the program/book |
|---|---|---|---|
| **Lehmann, 1998 [14]** | • 4-14 years old children | Rückenschule für kinder | • Theoretical and practical knowledge, exercises<br>• Tests for muscle strength and flexibility |
| **Kempf & Fischer, 1999 [1]** | • primary school children | Rückenschule für Kinder | • Plays<br>• Functional motions<br>• Posture training<br>• Informational group discussion<br>• Relaxation |
| **Kollumβ & Stotz, 2001 [15]** | • primary school children | Rückenschule für Kinder- ein Kinderspiel | • Theoretical and practical knowledge, exercises |

*Table 16 - The applied 1-school year back school program*

| Months | Theoretical curriculum | Exercise program | Repetition, duration of the exercises | Duration of the training, intensity |
|---|---|---|---|---|
| **1.** | bones | • exercises for sensation and formation of posture playfully, in group<br>• trunk muscle strengthening exercises | ➢ 6x<br>➢ 3-5x, 3 sec | ➢ 30 minutes<br>➢ max. strength 50-60% |
| **2.** | spinal column | • playful exercises to practice the correct posture<br>• sensation of the movements of the trunk, pelvis, and scapula in a playful form<br>• lumbar motor control exercises in lateral lying position and on hands and knees<br>• isometric trunk muscle strengthening exercises<br>• stretching exercises (hip and knee flexors) | ➢ 8-10x, 3 sec<br>➢ 8-10x<br>➢ 5-7x<br>➢ 3-5x, 3 sec<br>➢ 5-7x, 3 sec | ➢ 30 minutes<br>➢ max. strength 50-60% |
| **3.** | movements of the spinal column | • playful exercises to practice the correct posture on a stable surface<br>• sensation of the movements of the trunk and scapula in a playful form<br>• lumbar motor control exercises in lateral lying position and on hands and knees<br>• isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (wall-bar, jump box, small ball)<br>• stretching exercises (hip and knee flexors) | ➢ 8-10x, 5 sec<br>➢ 8-10x<br>➢ 5-7x<br>➢ 3-5x, 5 sec<br>➢ 5-7x, 5 sec | ➢ 30 minutes<br>➢ max. strength 50-60% |
| **4.** | movement segment, biomechanical features of the disc | • playful exercises to practice the correct posture on a stable surface<br>• sensation of the movements of the trunk and scapula in a playful form<br>• lumbar motor control exercises in lateral lying position and on hands and knees | ➢ 8-10x, 7 sec<br>➢ 8-10x<br>➢ 5-7x | ➢ 30 minutes<br>➢ max. strength 50-60% |

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| | | • isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (pillow, jump box)<br>• stretching exercises (hip and knee flexors) | ➢ 3-5x, 7 sec<br>➢ 5-7x, 7 sec | |
| **5.** | muscles | • playful exercises to practice the correct posture on a stable surface<br>• sensation of the movements of the trunk and scapula in a playful form<br>• lumbar motor control exercises in lateral lying position and on hands and knees<br>• isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (wall-bar, pillow, rolling board)<br>• stretching exercises (hip and knee flexors) | ➢ 8-10x, 10 sec<br>➢ 8-10x<br>➢ 5-7x<br>➢ 3-5x, 10 sec<br>➢ 5-7x, 10 sec | ➢ 30 minutes<br>➢ max. strength 50-60% |
| **6.** | trunk muscles | • pair exercises with and without equipment<br>• strengthening of trunk and pelvis stabilizer muscles<br>• lumbar motor control exercises on hands and knees and in kneeling position<br>• stretching exercises (hip and knee flexors) | ➢ 8-10x, 5-10 sec<br>➢ 3-5x, 5-10 sec<br>➢ 5-7x<br>➢ 5-7x, 10 sec | ➢ 30 minutes<br>➢ max. strength 50-60% |
| **7.** | correct posture in the standing position | • playful exercises to practice the correct posture on an unstable surface in the standing position<br>• lumbar motor control exercises on hands and knees and standing position<br>• isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (Dyn-air, balancing rope)<br>• stretching exercises (hip and knee flexors) | ➢ 8-10x, 10 sec<br>➢ 5-7x<br>➢ 3-5x, 10 sec<br>➢ 5-7x, 10 sec | ➢ 30 minutes<br>➢ max. strength 50-60% |
| **8.** | correct posture in sitting position | • playful exercises to practice the correct posture on an unstable surface in sitting position | ➢ 8-10x, 10 sec | ➢ 30 minutes |

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| | | • lumbar motor control exercises on hands and knees, in sitting and standing position<br>• trunk muscle strengthening exercises with equipment (Dyn-air, physioball)<br>• stretching exercises (hip and knee flexors) | ➢ 5-7x<br>➢ 3-5x, 10 sec<br>➢ 5-7x, 10 sec | ➢ max. strength 50-60% |
| **9.** | spine-friendly school | • strengthening, stretching, posture, corrective and lumbar motor control ability developer exercises adapted in the classroom | ➢ 10x, 5-10 sec | ➢ 30 minutes<br>➢ max. strength 50-60% |
| **10.** | spine-friendly free time | • sports games, spine-friendly sports to develop trunk muscle strength and lumbar motor control ability | ➢ 10x, 5-10 sec | ➢ 30 minutes<br>➢ max. strength 60-80% |

sec: second; x: multiplicity

*Table 17 - The didactic material for home during the 1-school year back school program*

| Months | Theoretical curriculum | Exercise program (in a playful form) | Repetition, duration of the exercises |
|---|---|---|---|
| **1.** | bones | • exercises for sensation and formation of posture<br>• trunk muscle strengthening exercises | ➢ 3-5x, 3 sec |
| **2.** | spinal column | • exercise to practice the correct posture<br>• sensation of the movements of the trunk, pelvis, and scapula<br>• lumbar motor control exercises in lateral lying position<br>• isometric trunk muscle strengthening exercises | ➢ 3-5x, 3 sec |
| **3.** | movements of the spinal column | • exercises to practice the correct posture on a stable surface<br>• sensation of the movements of the trunk and scapula<br>• lumbar motor control exercises in lateral lying position<br>• isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (balloon) | ➢ 3-5x, 5 sec |
| **4.** | movement segment, biomechani-cal features of the disc | • exercises to practice the correct posture on a stable surface<br>• sensation of the movements of the trunk and scapula in a playful form<br>• lumbar motor control exercises on hands and knees<br>• isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (small ball) | ➢ 3-5x, 5 sec |
| **5.** | muscles | • exercises to practice the correct posture on a stable surface<br>• sensation of the movements of the trunk and scapula in a playful form<br>• lumbar motor control exercises on hands and knees<br>• isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (pillow) | ➢ 5-7x, 3 sec |
| **6.** | trunk muscles | • strengthening of the trunk and pelvis stabilizer muscles<br>• lumbar motor control exercises in kneeling position | ➢ 5-7x, 3 sec |
| **7.** | correct posture in the standing position | • exercises to practice the correct posture on an unstable surface in the standing position<br>• lumbar motor control exercises in standing position | ➢ 5-7x, 5 sec |

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| | | • isometric trunk muscle strengthening exercises, trunk muscle strengthening exercises with equipment (pillow) | |
| **8.** | correct posture in sitting position | • exercises to practice the correct posture on an unstable surface in sitting position<br>• lumbar motor control exercises in sitting position<br>• trunk muscle strengthening exercises with equipment (physioball) | ➢ 5-7x, 5 sec |
| **9.** | spine-friendly school | • exercises to practice the correct posture on an unstable surface in standing position<br>• lumbar motor control exercises in sitting and standing position<br>• trunk muscle strengthening exercises with equipment (chair) | ➢ 7-10x, 3-5 sec |
| **10.** | spine-friendly free time | • indoor and outdoor muscle strengthening exercises and lumbar motor control developer exercises with and without equipment (ball) | ➢ 7-10x, 3-5 sec |

sec: second; x: multiplicity

*Table 18 – Comparison of the back care knowledge results with international research*

| Author (year) | Examined population/ Intervention group | Questionnaire/ Test | Total scores of back care knowledge for the intervention group (points) | |
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| | | | Pre-intervention | Post-intervention |
| Miñana-S et al., 2019 [22] | • 11.19±0.4 years<br>• 16 students<br>• 7 sessions (1 theoretical, 6 practical) of education | HEBACAKNOW-PAE (validated)<br>HEBACAKNOW-DL (validated) | 2.36±0.72<br>3.32±1.24 | 6.56±1.28<br>6.32±1.57 |
| Dullien et al., 2018 [102] | • 10.59±0.438 years<br>• 87 pupils<br>• 10-month education | Knowledge test (not validated) | 14.42±3.03 | 17.17±2.84 |
| Santos et al., 2017 [101] | • 8.8±1.1 years<br>• 44 children<br>• 8-week education | Questionnaire to evaluate the theoretical knowledge of the spine and body posture (not validated) | - | 9.0±1.8 |
| Habybabady et al., 2012 [87] | • 203 students<br>• 10-11 years<br>• 4 educational pamphlets | Questionnaire of knowledge and behavior (locally validated) | Knowledge: 43.4±12.93<br>Behavior: 53.3±16.34 | Knowledge: 60.5±24.32<br>Behavior: 65.5±20.34 |
| Foltran et al., 2011 [96] | • 9-16 years<br>• 4th to 8th grade<br>• 392 students at the baseline<br>• 2 lessons and 1 practical lesson for education | Back care questionnaire (not validated) | 3.6±2.9 | 7.5±2.2 |
| Cardon et al., 2000 [68] | • 10.02 years<br>• 82 children<br>• 6-week education | Knowledge test (not validated) | -0.9 | 3.38 |
| Toloza et al., 2021 [13] | • 5.66±0.75 years<br>• 50 children<br>• 5-week education | Knowledge of Back Care Questionnaire (not validated) | - | 7.73±1.03 |
| The recent study Szilágyi et al., 2021 [85] | • 6-7 years<br>• 26 children<br>• back school program | Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children | 3.269±3.341 | 16.269±2.426 |

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| The recent study Szilágyi et al., 2021 [60] | • 7-8 years<br>• 28 children<br>• back school program | Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children | - | 15.714±1.802 |
| The recent study Szilágyi et al., 2021 [60] | • 9-10 years<br>• 26 children<br>• back school program | Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children | - | 17.115±0.909 |
| The recent study Szilágyi et al., 2021 [60] | • 9-10 years<br>• 27 children<br>• e-learning back school program | Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children | - | 15.926±3.037 |

*Table 19 – Summary and comparison of the results of the 1-school year back school program with national and international research*

| Author | Applied program/ Methods | Results of the research (Improvements) | Results of the present research (Improvements) |
|---|---|---|---|
| **Back care knowledge and spine disease prevention** | | | |
| **Tóth & Tóthné 1998, 2000 [16,46]** | • Porci Berci is looking for friends program<br>➢ Self-developed knowledge questionnaire for children | • 8 months after the program children gave correct answers in 79.33% for the questions related to the spine, 93% in recognition of correct and incorrect posture, 79.01% received good evaluation for evaluating the automation of spine-friendly motions | |
| **Cardon et al. 2007 [88]** | • Back care group, back + physical activity group, control group<br>➢ Questionnaire of back care knowledge, back care behavior; fear-avoidance beliefs back | Post results between the intervention (both) and control groups:<br>• Back care knowledge, back care behavior ($p<0.001$), fear-avoidance beliefs ($p<0.01$) | Pre and post results in the intervention group:<br>• Total score ($p<0.001$)<br>• Anatomical, biomechanical knowledge ($p<0.001$)<br>• Spine use, ergonomics knowledge ($p<0.001$) |
| **Habybabady et al., 2012 [87]** | • Back care education program<br>• 3-month follow-up<br>➢ Questionnaire of knowledge and behavior | Post results of knowledge and behavior between the intervention and control groups:<br>• After 1 week ($p<0.001$)<br>• After 3 months ($p<0.001$) | Post results between the intervention and control groups:<br>• Total score ($p<0.001$)<br>• Anatomical, biomechanical knowledge ($p<0.001$)<br>• Spine use, ergonomics knowledge ($p<0.001$) |
| **Szilágyi et al., 2019 [24]** | • Child back school program<br>➢ Knowledge of spinal function (back care knowledge) | Pre and post results in the intervention group and post results between the intervention and control groups:<br>• Total score ($p<0.001$)<br>• Anatomical, biomechanical knowledge ($p<0.001$) | |

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| | | • Spine utilization, ergonomics knowledge (p<0.001) | |
| **Toloza et al., 2021 [13]** | • Back Care Education Program<br>➢ Back care questionnaire | Pre and post results in the intervention group:<br>• Knowledge of Back Care improved | |
| **Habitual posture and posture deemed correct** | | | |
| **Kayapinar et al., 2012 [9]** | • Movement education program<br>➢ Posture measurement with New York State Posture evaluation | Pre and post results in the intervention group:<br>• 8 from 10 parameters of the posture (p<0.05)<br><br>Post results between the intervention and control groups:<br>• 4 from 10 parameters of the posture (p<0.05) | Pre and post results in the intervention group:<br>• Total score of habitual posture (p<0.001)<br>• Total score of posture deemed correct (p<0.001)<br><br>Post results between the intervention and control groups:<br>• Total score of habitual posture (p<0.001)<br>• Total score of posture deemed correct (p<0.001) |
| **Kovácsné et al., 2016 [72]** | • Spine prevention program<br>➢ Habitual posture with postural analysis grig chart | Pre and post results in the intervention groups:<br>• ballet 52,17%<br>• hip-hop 37,5% | |
| **Szilágyi et al., 2019 [24]** | • Child back school program<br>➢ Habitual posture, posture deemed correct with photogrammetry evaluation | Pre and post results in the intervention group and post results between the intervention and control groups:<br>• Total score of habitual posture (p=0.001)<br>• Total score of posture deemed correct (p<0.001) | |
| **Trunk muscle strength and lower limb muscle flexibility** | | | |
| **Geldhof et al., 2007 [18]** | • Multi-factorial back posture education program<br>➢ Trunk flexor, extensor endurance muscle testing | Pre and post results in the intervention group:<br>• trunk flexor endurance<br>• trunk extensor endurance | Pre and post results in the intervention group:<br>• Trunk flexor (p<0.001), extensor static muscle strength (p<0.001)<br>• Hip flexor, knee flexor muscle flexibility (p<0.05) |
| **Szilágyi et al., 2020** | • Child back school program | Pre and post results in the intervention group | |

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| **[24]** | ➢ Trunk flexor, extensor static muscle strength<br>➢ Hip flexor, knee flexor muscle flexibility | and post results between the intervention and control groups:<br>• Trunk flexor ($p<0.001$), extensor static muscle strength ($p<0.001$)<br>• Hip flexor, knee flexor muscle flexibility | Post results between the intervention and control groups:<br>• Trunk flexor ($p<0.001$), extensor static muscle strength ($p<0.001$)<br>• Hip flexor, knee flexor muscle flexibility ($p<0.05$) |
| **Lumbar motor control ability** | | | |
| **Kovácsné et al., 2016 [72]** | • Core prevention training program<br>➢ Leg lowering test for lumbar motor control ability | • Lumbar motor control ability of the dancers (ballet $p\leq0.001$, hip-hop $p<0.001$) | Pre and post results in the intervention group:<br>• Lumbar motor control ability ($p<0.001$) |
| **Szilágyi et al., 2020 [24]** | • Child back school program<br>➢ Sitting Forward Lean Test for lumbar motor control ability | Pre and post results in the intervention group and post results between the intervention and control groups:<br>• Lumbar motor control ability ($p<0.001$) | Post results between the intervention and control groups:<br>• Lumbar motor control ability ($p<0.001$) |

**Appendix 1: Trial registration, permission for the development and psychometric evaluation of the Health Questionnaire of Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children**

PÉCSI TUDOMÁNYEGYETEM
Klinikai Központ
Regionális és Intézményi Kutatás-Etikai Bizottsága

**Tóth Botond**
**III. évfolyamos gyógytornász hallgató**
**PTE ETK**
**Fizioterápiás és Sporttudományi Intézet**
**7623 Pécs, Rákóczi út 2.**
**Vizsgálatvezető**

**Pécs, 2020. június 02.**

Tisztelt Vizsgálatvezető!

A PTE-KK Regionális és Intézményi Kutatás – Etikai Bizottság alúlírott meghatalmazott személyei a **2020. június 2.-ai** rendkivüli ülésükön megtárgyalták az Ön által benyújtott dokumentumokat.

**Témavezetők: Szilágyi Brigitta MSc, szakoktató gyógytornász**
**postai cím:, 7632 Pécs, Uitz Béla utca 17.**

**dr. Járomi Melinda egyetemi adjunktus**
**PTE ETK Fizioterápiás és Sporttudományi Intézet 7623 Pécs, Rákóczi út 2.**

**Cím:** 6 – 7 éves gyermekekre adaptált gerincprevenciós tudásteszt validálása

**Sponzor:** saját kezdeményezésű vizsgálat

**Mellékletek:** (1.) probléma felvetés; (2.) tudományos és irodalmi háttér; (3.) a vizsgálat célja; (4.) protokoll: vizsgálati személyek és alkalmazott módszerek: a gerinctúra tudásteszt; (5.) gerinchasználattal kapcsolatos ismeretek kérdőíves felmérése; az eredeti angol nyelvű kérdőív - The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) Manual - és magyar nyelven összeállított fizikai aktivitás kérdőív (általános iskolások számára) mellékelve van; (6.) szülői, (7.) pedagógusi tájékoztató és beleegyező nyilatkozat; (8.) befogadó és támogató nyilatkozat az intézet igazgatójától;

**Döntés:** a PTE KK Regionalis Kutatás Etikai Bizottság alúlírott meghatalmazott személyei a **2020. június 2.-ai** rendkivüli ülésükön az ortopéd szakrovos bíráló javaslatára alakitották ki **szakmai és etikai véleményüket**, amelynek alapján **tudomásul vették** a klinikai vizsgálat protokoll szerinti kivitelezését. Egyúttal felkérjük a tisztelt vizsgálat vezetőt, hogy a vizsgálatok befejezése után **összefoglaló jelentést** legyen szíves Bizottságunknak küldeni.

**Ügyiratszám: 8342 – PTE 2020.**

Szívélyes üdvözlettel

Dr. Komoly Sámuel
egyetemi tanár, a Bizottság elnöke

Dr. Kocsis Béla
egyetemi docens, a Bizottság titkára

H-7623 Pécs • Rákóczi út 2.
Telefon: +36(72) 536-100 • Fax: +36(72) 536-101 • E-mail: foigazgatoi.hivatal@kk.pte.hu

**Appendix 2: Trial registration, permission for the implementation and examination of the 1-school year back school program**

PÉCSI TUDOMÁNYEGYETEM

Klinikai Központ
Regionális és Intézményi Kutatás–Etikai Bizottsága

**Szilágyi Brigitta**
**szakoktató**
**PTE ETK**
**Fizioterápiás és Sporttudományi Intézet**
**7623 Pécs, Rét u. 4.**
**Vizsgálatvezető**

**Pécs, 2016. április 02.**

Tisztelt Vizsgálatvezető!

A PTE-KK Regionális és Intézményi Kutatás – Etikai Bizottsága **2016.04.01.-ei** ülésén megtárgyalta az **Ön** által benyújtott dokumentumokat:

**Cím:** Gerinciskola programok alkalmazása általános iskolások körében
**Konzulens:** dr. Járomi Melinda adjunktus, gyógytornász, humán kineziológus, PTE ETK Fizioterápiás és Sporttudományi Intézet

**Mellékletek:**
(1.) tudományos és (2.) irodalmi háttér;
(3.) Kutatási terv: problémafelvetés, vizsgálati célok, kérdések, vizsgálati alanyok; módszer,
(4.) várható eredmények;
(5.) szülői tájékoztató (6.) pedagógus – tanító tájékoztató (7.) szülői beleegyező nyilatkozat
(8.) intézet igazgatói támogató nyilatkozat;
(9.) befogadó nyilatkozat a pécsi Apáczai Cere János álatlános iskola és gimnáziumi kollégium részéről

**Döntés:** A PTE KK RIKEB 2016. április 01.-ei ülésén **engedélyezte** a vizsgálatok protokoll szerinti kivitelezését és egyben felkéri a vizsgálatvezetőt a vizsgálatok lezárulásakor **összefoglaló jelentést** legyen szíves Bizottságunknak küldeni.

**Ügyiratszám: 6125.**

Szívélyes üdvözlettel

Dr. Kosztolányi György
egyetemi tanár, a Bizottság elnöke

Dr. Kocsis Béla
egyetemi docens, a Bizottság titkára

H-7623 Pécs · Rákóczi út 2.
Telefon: +36(72) 536-100 · Fax: +36(72) 536-101 · E-mail: foigazgatoi.hivatal@kk.pte.hu

**Appendix 3: Declaration of Support from the head of the schools**

**Támogató nyilatkozat**

Engedélyezem, hogy

Szilágyi Brigitta szakoktató és Dr. Járomi Melinda gyógytornász, humánkineziológus, adjunktus (PTE ETK)

a(z)

Pécsi Apáczai Csere János Általános Iskola, Gimnázium, Kollégium, Alapfokú Művészeti Iskola
1. sz. Általános Iskola OM: 027399
7632 Pécs, Apáczai Csere János körtér 1 C ép.

..................................................................................................

intézetben

**„Gerinciskola program alkalmazása általános iskolások körében"**

témában felmérést végezzen.

..................................................................................................

intézetvezető

***Tisztelt Igazgató Asszony!***

Tisztelettel kérem, hogy engedélyezni szíveskedjék munkánkat, amely során felmérést szeretnénk végezni a következő témában:

*„Gerinciskola program alkalmazása általános iskolások körében"*

Mellékelten csatolunk egy kisebb összefoglalót, egy szülői tájékoztatót és egy szülői beleegyező nyilatkozat mintát.

Köszönettel:

Szilágyi Brigitta (MSc, szakoktató) és Járomi Melinda (Ph.D, adjunktus, intézetvezető-helyettes)

PTE ETK Fizioterápiás és Sporttudományi Intézet

Pécs, 2017.09.13.

........................................................................

Bartos Erika

Igazgató

Pécsi Református Kollégium Gimnáziuma, Szakgimnáziuma, Szakközépiskolája, Általános Iskolája és Óvodája • Pécs, Engel János József u. 15. • 1691 • Máté 10.16

**ENGEDÉLY**

Alulírott……Dr. Litter Adrienn…… ( Intézetvezető )
engedélyezem, hogy Romhányi Fanny (Pécsi Tudományegyetem Egészségtudományi Kar, Fizioterápiás és Sporttudományi Intézet, Fizioterápiás Tanszék, Gyógytornász szakirány, IV. éves hallgató) a(z)
……PTE Gyakorló Ált. Isk. Gimn. és Szakgimn. Deák F. Gimnáziuma és Általános Iskolája…… intézetben
**„6 hetes gerinciskola program első osztályos, általános iskolás tanulók körében”** témában gyakorlatot végezzen.

……[signature]……

Intézetvezető

PTE Gyakorló Általános Iskola, Gimnázium és Szakgimnázium Deák Ferenc Gimnáziuma és Általános Iskolája

Pécs, 2018. január 8.

**Appendix 4: Parent's consent form of the children involved in the study**

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**BELEEGYEZŐ NYILATKOZAT**
**(Szülői nyilatkozat)**

„Gerinciskola program alkalmazása és hatékonyságának felmérése 6-7 éves gyermekek körében"

---

**<u>Vizsgálóhely neve:</u>**

Pécsi Apáczai Csere János Általános Iskola, Gimnázium, Kollégium, Alapfokú Művészeti Iskola, 1. Számú Általános Iskola

**<u>Vizsgálatot végző neve és beosztása</u>:**

Szilágyi Brigitta, szakoktató

Dr. Járomi Melinda, PhD, adjunktus, intézetigazgató-helyettes

Én …………………………………………………….. beleegyezem, hogy ……………………………………………….nevű gyermekem, Szilágyi Brigitta PhD disszertációjának vizsgálati alanyául szolgáljon, a gerinciskola programon és a hozzá tartozó törzs állapotfelmérési vizsgálatokon részt vegyen.

Hozzájárulok továbbá, hogy a vizsgálatok során:

- a vizsgálatot végző szakember amennyiben szükséges, gyermekemmel közvetlen kontaktusba kerüljön,
- a vizsgálat adatait, eredményeit (NÉV NÉLKÜL, az adatvédelmi törvénykönyv rendelkezése szerint) tudományos fórumokon szóban, tudományos közleményekben írásban szabadon felhasználhatja.
- A foglalkozások során videó felvételt és (szem kitakarásával/anélkül) fotót készíthet, melyeket disszertációjához, tudományos publikációban és konferencián felhasználhat.

Kelt:………………….. Aláírás

**BELEEGYEZŐ NYILATKOZAT**
**(Szülői nyilatkozat)**

„Gerinciskola program alkalmazása és hatékonyságának felmérése 6-7 éves gyermekek körében"

**<u>Vizsgálóhely neve:</u>**

PTE Gyakorló Általános Iskola, Gimnázium és Szakközépiskola Deák Ferenc Gimnáziuma és Általános Iskolája

**<u>Vizsgálatot végző neve és beosztása</u>:**

Szilágyi Brigitta, szakoktató

Dr. Járomi Melinda, PhD, adjunktus, intézetigazgató-helyettes

Én ………………………………………………….. beleegyezem, hogy ……………………………………………….nevű gyermekem, Szilágyi Brigitta PhD disszertációjának vizsgálati alanyául szolgáljon, a gerinciskola programon és a hozzá tartozó törzs állapotfelmérési vizsgálatokon részt vegyen.

Hozzájárulok továbbá, hogy a vizsgálatok során:

- a vizsgálatot végző szakember amennyiben szükséges, gyermekemmel közvetlen kontaktusba kerüljön,
- a vizsgálat adatait, eredményeit (NÉV NÉLKÜL, az adatvédelmi törvénykönyv rendelkezése szerint) tudományos fórumokon szóban, tudományos közleményekben írásban szabadon felhasználhatja.
- A foglalkozások során videó felvételt és (szem kitakarásával/anélkül) fotót készíthet, melyeket disszertációjához, tudományos publikációban és konferencián felhasználhat.

Kelt:………………….. Aláírás

**BELEEGYEZŐ NYILATKOZAT**
**(Szülői nyilatkozat)**

„Gerincprevenciós tudás és törzs állapotfelmérés általános iskolás gyerekek körében”

---

**Vizsgálóhely neve:**

Pécsi Református Kollégium Gimnáziuma, Általános Iskolája és Óvodája

**Vizsgálatot végző neve és beosztása:**

Szilágyi Brigitta, szakoktató

Dr. Járomi Melinda, PhD, adjunktus, intézetigazgató-helyettes

Én ………………………………………………….. beleegyezem, hogy …………………………………………….nevű gyermekem, Szilágyi Brigitta PhD disszertációjának vizsgálati alanyául szolgáljon, a gerincprevenciós kérdőívet kitöltse és a törzs állapotfelmérési vizsgálatokon részt vegyen.

Hozzájárulok továbbá, hogy a vizsgálatok során:

- a vizsgálatot végző szakember amennyiben szükséges, gyermekemmel közvetlen kontaktusba kerüljön,
- a vizsgálat adatait, eredményeit (NÉV NÉLKÜL, az adatvédelmi törvénykönyv rendelkezése szerint) tudományos fórumokon szóban, tudományos közleményekben írásban szabadon felhasználhatja.
- A vizsgálat során (szem kitakarásával/anélkül) fotót készíthet, melyeket disszertációjához, tudományos publikációban és konferencián felhasználhat.

Kelt:………………….. Aláírás

**BELEEGYEZŐ NYILATKOZAT**
**(Szülői nyilatkozat)**

„E-learning gerinciskola program alkalmazása általános iskolás gyerekek körében”

---

**Vizsgálóhely neve:**

Köztársaság Téri Általános Iskola

**Vizsgálatot végző neve és beosztása:**

Szilágyi Brigitta, szakoktató

Dr. Járomi Melinda, PhD, adjunktus, intézetigazgató-helyettes

Én ……………………………………………………….. beleegyezem, hogy ………………………………………………….nevű gyermekem, Szilágyi Brigitta PhD disszertációjának vizsgálati alanyául szolgáljon, az e-learning gerinciskola programon részt vegyen és a gerincprevenciós tudást felmérő kérdőívet kitöltse.

Hozzájárulok továbbá, hogy a vizsgálatok során:

- a vizsgálat adatait, eredményeit (NÉV NÉLKÜL, az adatvédelmi törvénykönyv rendelkezése szerint) tudományos fórumokon szóban, tudományos közleményekben írásban szabadon felhasználhatja.

Kelt:………………….. Aláírás

**Appendix 5: Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children**

***Gerinchasználattal és -prevencióval kapcsolatos tudást felmérő kérdőív 6-10 éves gyerekek számára***

Kód:.........................................................................................

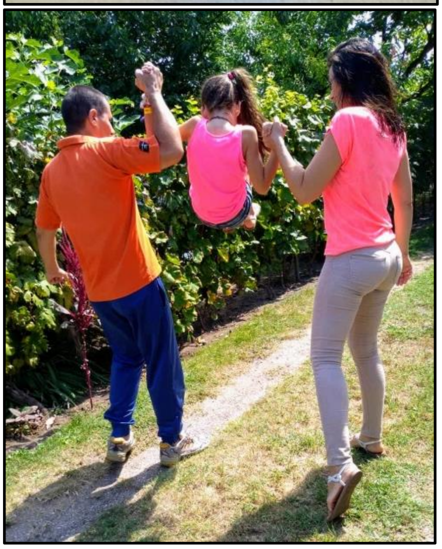
Nem: .......................................................................................

Életkor: ....................................................................................

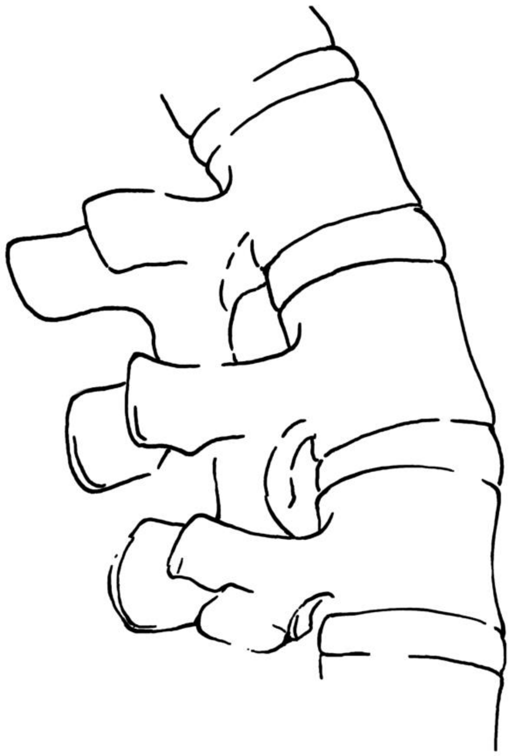
Iskola, osztály:.........................................................................

Dátum: ....................................................................................

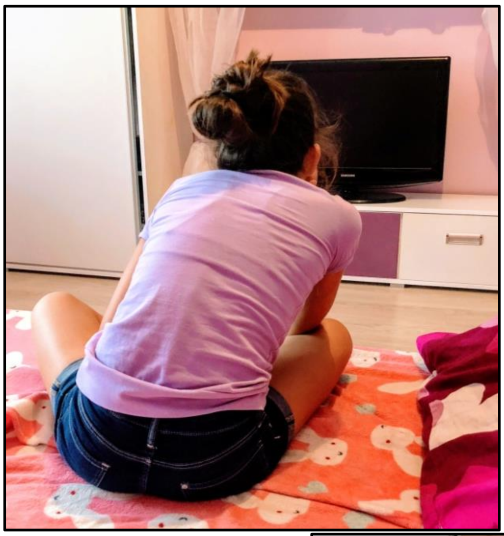
1. Az összes gerincoszlopot rajzold be a képeken!



2. Színezz ki egy csigolyát kékre, és egy porckorongot pirosra!

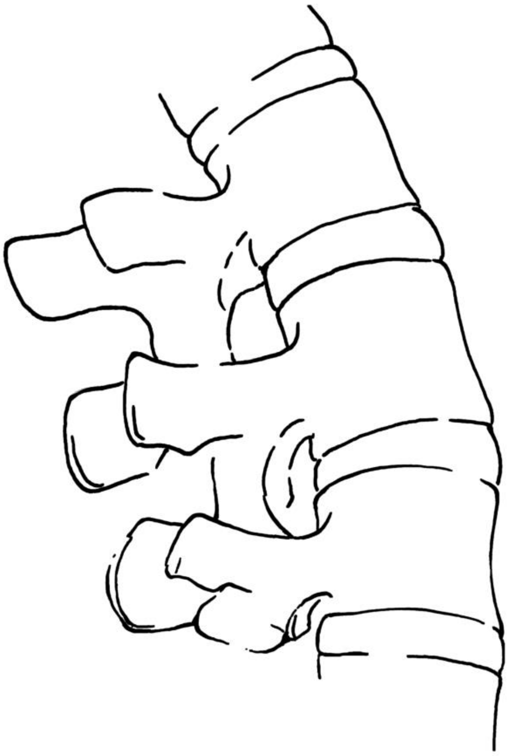


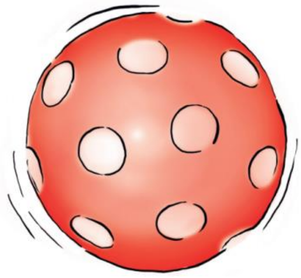
3. Jelölj be 2 helyes testhelyzetet TV nézés közben!

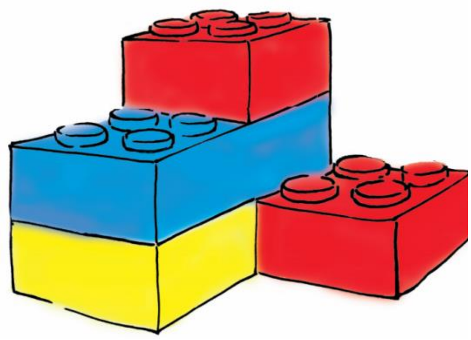


4. Jelölj be 3 helyes testhelyzetet!

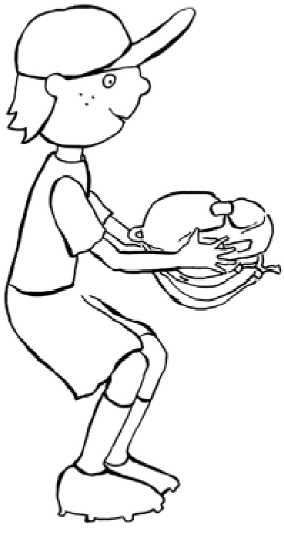
5. Kösd össze a hasonló keménységűeket!



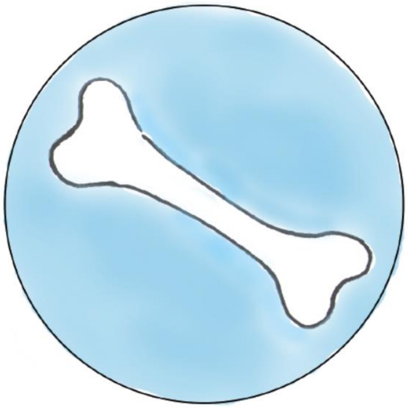


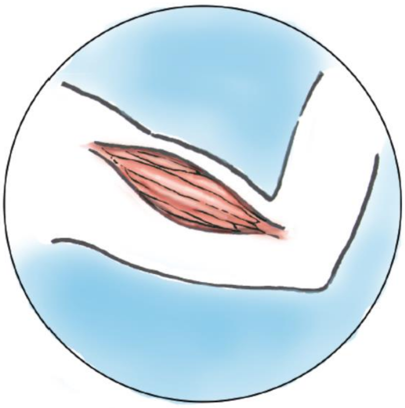


6. Jelöld be, hol emeli fel helyesen a fiú a táskát!



7. Jelöld be, mi tartja és mozgatja a gerincoszlopot?





*Health Questionnaire on Back Care Knowledge and Spine Disease Prevention for 6-10 Years Old Children*

Code:.........................................................................................

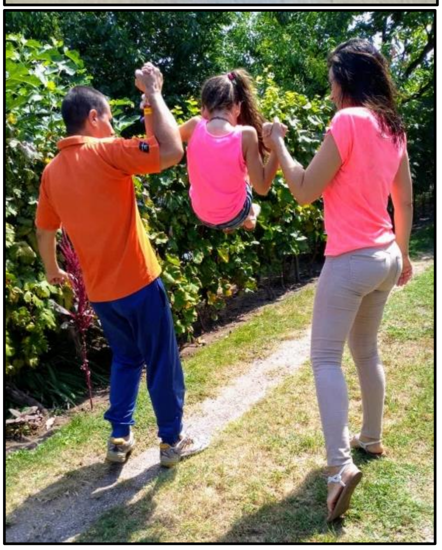
Sex:.........................................................................................

Age: .........................................................................................

School, class:.........................................................................................

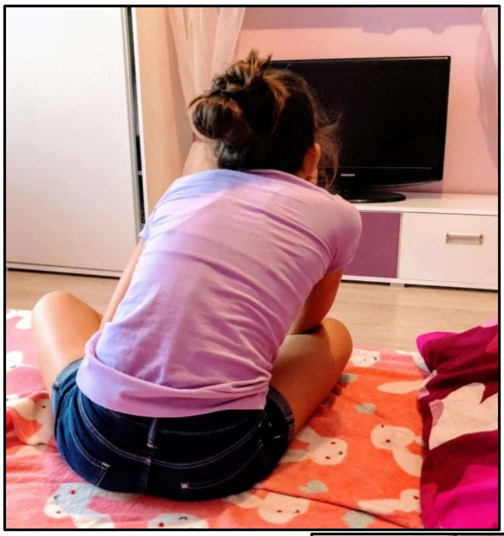
Date: .........................................................................................

1. Draw all the spinal columns on the pictures!



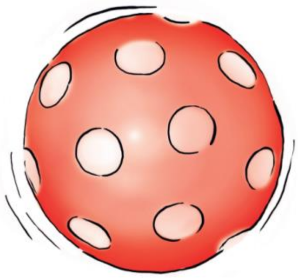
2. Color one vertebra to blue and one disc to red!

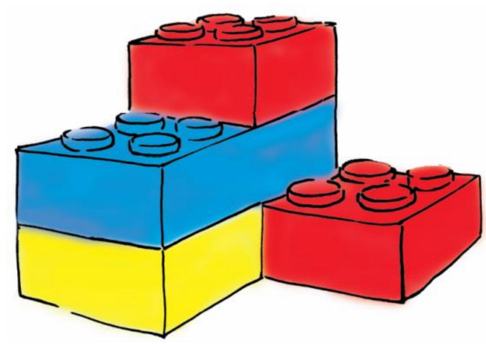
3. Mark 2 correct postures during watching TV!



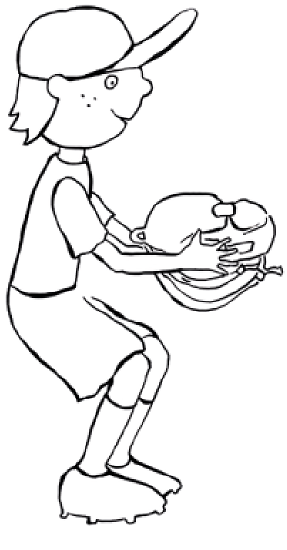
4. Mark 3 correct postures!

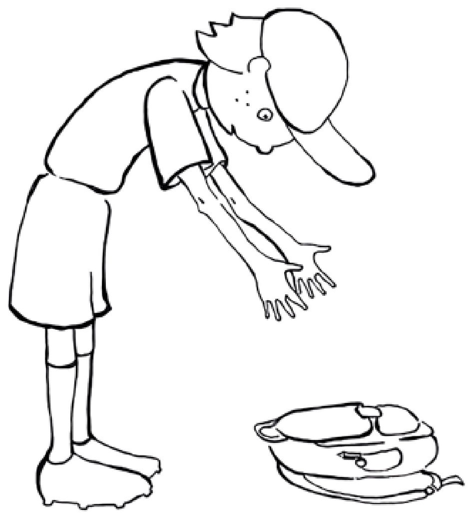
5. Connect those with similar hardness!



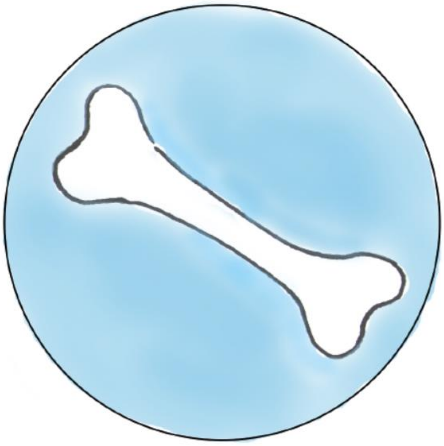


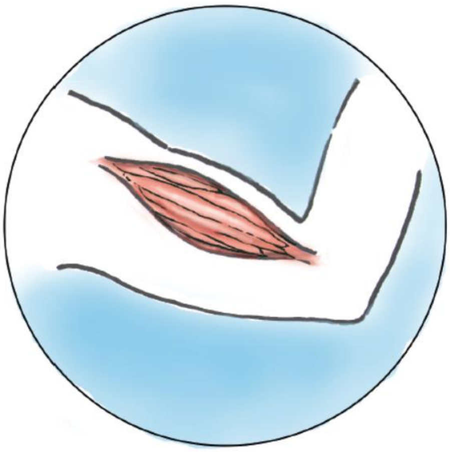
6. Mark, where the boy is correctly lifting the bag!





7. What holds and moves the spinal column?





## Appendix 6: Registration by the Hungarian Intellectual Property Office

# ÖNKÉNTES MŰNYILVÁNTARTÁS
# MŰPÉLDÁNY

NYILVÁNTARTÁSI SZÁM: 007597

A tanúsítvány és a hozzáfűzött műpéldány sem szerzői jogi, sem a szellemi alkotásra vonatkozó más jogi védelmet nem keletkeztet, csupán bizonyítási eszközként szolgál annak igazolására, hogy a szerző által a sajátjaként nyilvántartásba vett alkotás a tanúsítvány kiállításának napján a tanúsítványhoz hozzáfűzött műpéldány szerinti tartalommal létezett.

**Figyelmeztetés!**
*A tanúsítvány és a hozzáfűzött műpéldány sértetlen állapotban bizonyító erejű.*

SZTNH - 2012.054

## Certification

SZELLEMI TULAJDON NEMZETI HIVATALA
1081 Budapest, II. János Pál pápa tér 7. • 1438 Budapest, Pf. 415.
Telefon: 312 4400 • Telefax: 474 5534
Adószám: 15311746242 SZJ 15 Közigazgatás

*Ügyiratszám:*
**Y1900164 /3**
*Ügyintéző:*
**Dávid Károly**
*Nyilvántartási szám:* **007597**

*Tárgy:* Tanúsítvány önkéntes műnyilvántartásba vételéről

**T A N Ú S Í T V Á N Y**

Igazolom, hogy

Szilágyi Brigitta, 7632 Pécs, Uitz Béla u. 17. 5/17
L Molnár Edit, 7636 Pécs, Csipke u. 9. IV/13
Dr Járomi Melinda, 7636 Pécs, Polgárszőlő u. 30. fsz. 3.

mint kérelmező(k) a mellékelt 'MESÉS GERINCTÚRA' című dokumentumot saját tudományos művé(ük)ként vetette(ék) nyilvántartásba.

E tanúsítványt a Szellemi Tulajdon Nemzeti Hivatala által vezetett önkéntes műnyilvántartás részletes szabályairól szóló 26/2010. (XII. 28.) KIM rendelet alapján állítottam ki.

Budapest, 2019. március 8.

SZELLEMI TULAJDON NEMZETI HIVATALA Önkéntes Műnyilvántartás 1.

Dávid Károly
*ügyintéző*

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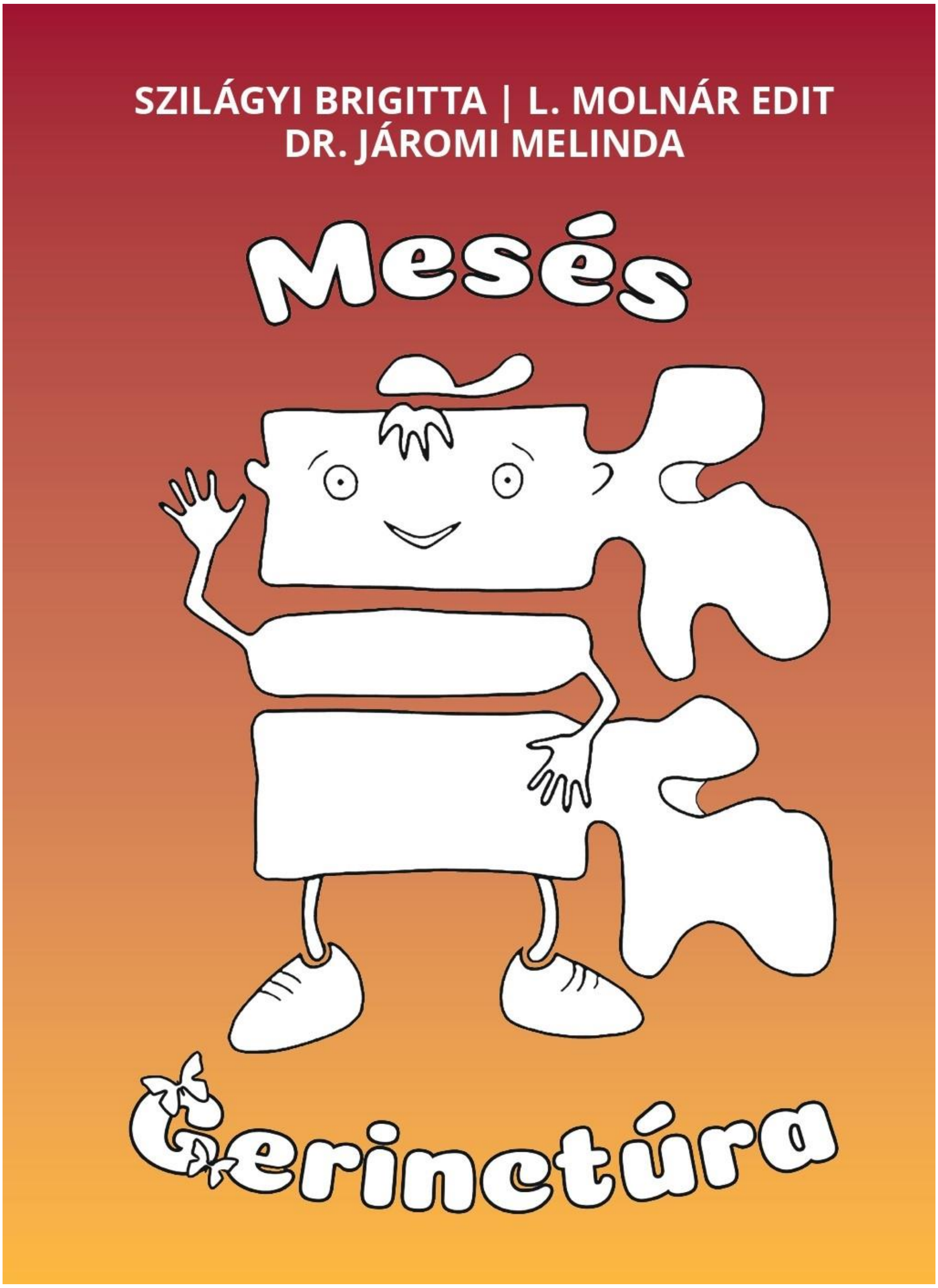
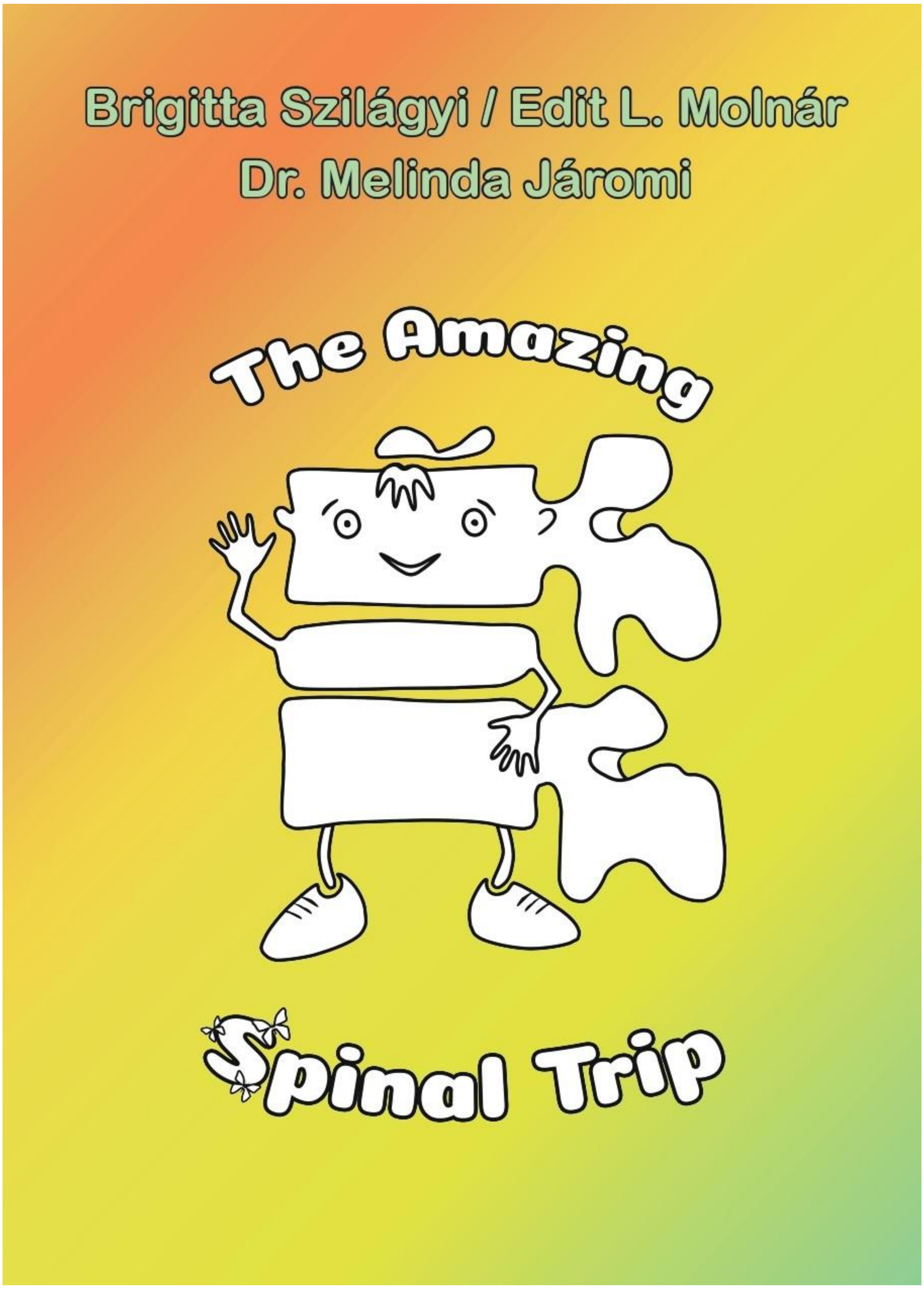
**Appendix 7: The applied back school program**

**The cover of the Hungarian book**

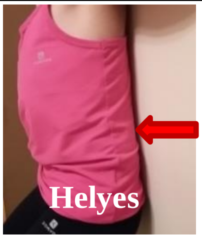


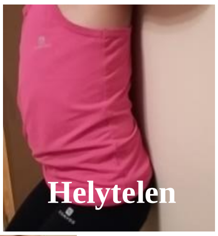
**The cover of the English book**



## Appendix 8: An exercise pattern of the didactic material for home

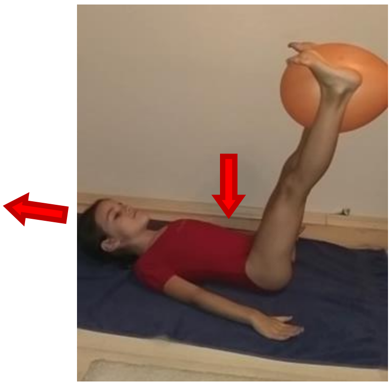
### GERINCISKOLA PROGRAM – OTTHONI FELADATOK




HELYES TESTTARTÁS MEGÉREZTETŐ, KIALAKÍTÓ GYAKORLAT

- Állj háttal a falhoz
- Lépj előre egy kis lépést
- Hajlítsd a térded
- Fújd ki a levegőt és hasizommal szorítsd a derekad a falhoz
- Könyököt is szorítsd a falhoz
- Maradj ebbe a helyzetben, amíg 3-ig számolsz
- Figyelj rá, hogy a derekad és könyököd is szorítsd a falhoz végig



IZOMERŐSÍTŐ, IZOMNYÚJTÓ GYAKORLAT

- Bokád között fogd a lufit!
- Feküdj a hátadra!
- Szorítsd le a derekad a talajba!
- Nyújts a lábadat a plafon felé!
- Lábfejedet feszíts hátra (pipál a lábfej)!
- Sarokkal nyújtózz a plafon felé!
- Ha jól csinálod a gyakorlatot, most érzed, hogy húzódik a lábadon az izom. Ez kicsit kellemetlen lehet, de annak a jele, hogy jól csináltad a gyakorlatot. Tarts meg ezt a helyzetet 3 számolásig (másodpercig)! Ismételd 5-ször!

NYÚJTÓZÁS A FALNÁL

- Ülj sarokra a fallal szemben, legyen a fal és a térdeid között egy kis távolság.
- Tedd a karjaidat fül mellé nyújtva, a tenyereket a falra.
- A hasadat enyhén feszítsd meg, a gerinced maradjon egyenes végig! A fejed ne lógjon!
- A lapockáidat tartsd végig összezárva!

- Végezd ezt a gyakorlatot 10 másodpercig, 5-ször egymás után!

**Jelöld be melyik napokon tornáztál otthon!**

| | Hétfő | Kedd | Szerda | Csütörtök | Péntek | Szombat | Vasárnap |
|---|---|---|---|---|---|---|---|
| Időtartam/ ismétlésszám | | | | | | | |

**7. sz. melléklet**

**DOKTORI ÉRTEKEZÉS BENYÚJTÁSA ÉS NYILATKOZAT A DOLGOZAT EREDETISÉGÉRŐL**

Alulírott

név: Szilágyi Brigitta
születési név: Szilágyi Brigitta
anyja neve: Földényi Klára Viktória
születési hely, idő: 1991.09.07
Examination and development of back care knowledge and spine disease prevention among 6-10 years old children című doktori értekezésemet a mai napon benyújtom a(z) Egészségtudományi Doktori Iskola (PR-7) Sport- és Egészségtudomány Programjához/ (S-4) A rendszeres testedzés preventív, terápiás és rehabilitációs szerepe témacsoportjához.

Témavezető(k) neve: dr. habil Járomi Melinda

Egyúttal nyilatkozom, hogy jelen eljárás során benyújtott doktori értekezésemet
- korábban más doktori iskolába (sem hazai, sem külföldi egyetemen) nem nyújtottam be,
- fokozatszerzési eljárásra jelentkezésemet két éven belül nem utasították el,
- az elmúlt két esztendőben nem volt sikertelen doktori eljárásom,
- öt éven belül doktori fokozatom visszavonására nem került sor,
- értekezésem önálló munka, más szellemi alkotását sajátomként nem mutattam be, az irodalmi hivatkozások egyértelműek és teljesek, az értekezés elkészítésénél hamis vagy hamisított adatokat nem használtam.

Dátum: Pécs, 2022.03.22

Szilágyi Brigitta
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doktorjelölt aláírása

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témavezető aláírása

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társtémavezető aláírása