Journal of Bodywork & Movement Therapies 30 (2022) 226–236

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

Prevention and Rehabilitation

Effect of Eutonia, Holistic Gymnastics, and Pilates on body posture for pre-adolescent girls: Randomized clinical trial

Fernanda dos Santos Lopes Niaradi [a, *], Maíra Fonseca dos Santos Lopes Niaradi [a], Maria Elisabete Rodrigues Freire Gasparetto [b]

[a] Graduate Program in Health, Interdisciplinarity and Rehabilitation from the Faculdade de Ciências Médicas da Universidade Estadual de Campinas, (UNICAMP), São Paulo, Brazil

[b] PhD in Medical Sciences from the State University of Campinas, Professor at the Department of Human Development and Rehabilitation of the Graduate Program in Interdisciplinary Health and Rehabilitation of the Faculdade de Ciências Médicas da Universidade Estadual de Campinas (UNICAMP), São Paulo, Brazil

ARTICLE INFO

Article history:
Received 9 May 2021
Received in revised form
2 November 2021
Accepted 4 February 2022

Keywords:
Posture
Exercise therapy
Physical therapy modalities
Primary prevention

ABSTRACT

Introduction: Postural changes frequently occur in pre-adolescent girls, with sedentary lifestyle with reduced physical activity level as one of the risk factors.
Objective: To investigate the effects of Eutonia, Holistic Gymnastics, and Pilates on body posture in pre-adolescent girls.
Methods: A randomized prospective quantitative clinical trial was conducted. The study included girls aged 10–13 years and compared the effects of Eutonia, Holistic Gymnastics, and Pilates on body posture. The sample comprised 80 girls divided into three intervention groups as follows: Eutonia group, 26 girls; Holistic Gymnastics group, 27 girls; and Pilates group, 27 girls. Ten sessions of 1 h each were conducted on a weekly basis. Static posture was analyzed using the Postural Analysis Software SAPO; dynamic posture, using the modified Layout for Assessing Dynamic Posture LADy; and lifestyle, using the Body Posture Evaluation Instrument Back PEI questionnaire. The data were statistically analyzed using the analysis of variance (ANOVA) by Kruskal-Wallis' averages test at 5% significance level ($p < 0,05$).
Results: The results showed that the three body movement practices improved the head inclination in the frontal plane (1,49°) and pelvic anteversion in the right (1,9°) and left profiles (2,09°). In addition, 25% of pre-teens started to carry their school bag correctly, improving their posture.
Conclusion: The body movement practices of Eutonia, Holistic Gymnastics, and Pilates improved head inclination, pelvic anteversion, and the correctness rate of carrying the schoolbag.

1. Introduction

Postural deviations have increased great interest in research and clinical practice (D'Amico et al., 2017). Some studies showed a prevalence of postural changes between 22% and 65% in children and adolescents (Ludwig et al., 2016; Ludwig 2017), of which 5% are severe deformities (Brzek et al., 2019). Body segment imbalance can lead to postural changes in nonadjacent segments. Anterior pelvic inclination is associated with lumbar spine hyperlordosis that can be compensated by increased thoracic kyphosis (Ludwig et al., 2016; Murta et al., 2020).

Anatomical, psychological, and environmental aspects interfere with body posture (D'Amico et al., 2017; Brzek et al., 2019; Ludwig et al., 2018) and the growth phase (D'Amico et al., 2017). Excessive sitting (Kwon et al., 2018), inadequate school furniture (Assiri et al., 2019), the manner of carrying backpacks and the weights of backpacks (Brzek et al., 2017; Chen and Mu, 2018; Noll et al., 2016; Candotti et al., 2012), the use of high heels (Pezzan et al., 2011), and sedentary lifestyle with reduced physical activity level represent risk factors of postural changes (Brzek et al., 2019; Ludwig et al., 2018; Walicka-Cuprys et al., 2019; Ciric et al., 2015).

The most frequent postural deviations in girls are lumbar hyperlordosis (González-Gálvez et al., 2020; Hezarikia et al., 2018; Araújo et al., 2019), pelvic anteversion (González-Gálvez et al., 2020), valgus knee (Ciric et al., 2015), head inclination (Penha et al., 2008), and high cervical hyperlordosis (Been et al., 2017). The literature shows that girls are more sedentary (Condessa et al., 2019; Cureau et al., 2016; Salvo et al., 2020) and present higher back

* Corresponding author. Pelágio Lobo, 142 sala 02 Jardim Brasil, Campinas, Cep 13073-013, Brazil.
E-mail address: fer.fisio2012@gmail.com (F.S.L. Niaradi).

https://doi.org/10.1016/j.jbmt.2022.02.021
1360-8592/

pain frequency (Noll et al., 2016; Kedra et al., 2019; Bazett-Jones et al., 2019) and intensity (Noll et al., 2016) than boys.

One way to prevent postural changes is through targeted physical activity (Brzek et al., 2019; Ludwig et al., 2018; Walicka-Cuprys et al., 2019). Previous studies have shown that Pilates (González-Gálvez et al., 2020), karate (Walicka-Cuprys et al., 2019), sensory motor training (Ludwig et al., 2016), strength exercises, stretching, and body awareness (Ludwig et al., 2018) improve pelvic tilt, and stabilization exercises and mobilization of the cervical spine improve head posture (Cho et al., 2017; Szczygiel et al., 2019).

The therapeutic resources that can be used in these cases include Somatic Education Eutonia, Holistic Gymnastics (Niaradi and Batista, 2016), and Pilates (González-Gálvez et al., 2020; Atilgan et al., 2017; Ahearn et al., 2018). The Eutonia and Holistic Gymnastics (Niaradi and Batista, 2016) methods have the goal of developing body awareness through relaxation, stretching movements, postural re-education, balance, and breathing, as well as the Pilates (González-Gálvez et al., 2020; Atilgan et al., 2017; Ahearn et al., 2018) method, which is a training that has the objective of strengthening and stretching the muscles. Studies have shown that Holistic Gymnastics (Niaradi and Batista, 2016, 2020) and Pilates (González-Gálvez et al., 2020; Atilgan et al., 2017; Ahearn et al., 2018) provide improvement in body posture, however, there are no studies on the effect of Eutonia on the posture of pre-adolescents.

Because growing girls have a sedentary lifestyle (Condessa et al., 2019; Cureau et al., 2016; Salvo et al., 2020), stimulating and making other forms of physical activity accessible, such as Eutonia, Holistic Gymnastics, and Pilates, are important. These body movement practices can prevent and correct postural deviations, pain, and discomfort; these practices also help avoid future pathologies and stimulate pleasure through movement by developing healthy lifestyle habits in pre-adolescents, thereby reducing the social and financial burdens of health systems. Thus, the objective of this study was to analyze the effects of Eutonia, Holistic Gymnastics, and Pilates on the dynamic and static postures of pre-adolescents, evaluate whether the ergonomic guidelines have been assimilated and encourage physical activity. The hypotheses of the study state that the three intervention programs will improve postural changes and raise awareness of the correct way to carry a school bag and sit in a chair - common problems in preadolescence.

2. Methods

2.1. Study characterization

The current study was a three-arm parallel-design randomized controlled trial. Due to the type of intervention, neither the pre-adolescents nor the therapists could be blinded, rendering this trial an open-labelled one.

A randomized and prospective quantitative clinical trial was conducted with approval by the ethics committee of the State University of Campinas, Campinas, Brazil, under approval No. 1869.831/CAEE 61623316.1.0000.5404, and registered in the Brazilian Registry of Clinical Trials ReBEC (RBR-25w6kk). The participants' parents and guardians signed an informed consent form (ICF), and the participants signed the consent form before the initiation of the study.

2.2. Participants

In this study, 103 female pre-adolescents aged 10–13 years who were enrolled in primary schools were evaluated and randomized into three intervention groups according to body movement practices, namely of Eutonia, Holistic Gymnastics, and Pilates. The inclusion criteria were age between 10 and 13 years, female sex, the absence of health problems, and signed ICF by family members. The exclusion criteria were pre-adolescents in special education; those with disabilities, sequelae of orthopedic, rheumatic, or neurological disease; those using limb prosthesis; those with pain during physical activities; and those with impediments regarding the use of swimming pool clothing. In this study, 18 pre-adolescents were excluded because they did not meet the age-related inclusion criteria. The final sample consisted of 80 pre-adolescents divided into the Eutonia (n = 26), Holistic Gymnastics (n = 27), and Pilates groups (n = 27), as shown in Fig. 1. The study protocol conformed to the CONSORT statement (2010). ('see Fig. 1').

2.3. Study site

The study was conducted in six public schools (three municipal and three state schools) in the city of Campinas, SP. In four schools, a lecture was held for parents and/or guardians to explain the research project in detail. In three schools, parents had little adherence, and in the fourth school, the principal included the lecture in a school meeting attended by approximately 60 parents. In the other two schools, the responsible researcher entered the classrooms during regular school hours and presented the project to the pre-adolescents, who took the ICF and consent form home. Data collection was conducted in the classrooms assigned to the project activities. Posture evaluations and practical classes were held in classrooms adapted for the activities (removal of desks), computer and faculty rooms, libraries, video rooms, material rooms, sports courts, and open areas of the school.

2.4. Evaluation and randomization

Pre-adolescents were considered enrolled in the study after the postural evaluation. The evaluations were scheduled by phone, with two girls scheduled per hour. While one answered the questionnaires, the other underwent the static and dynamic postural evaluations. To ensure credibility, the evaluations before and after the intervention were conducted by the responsible researcher, who had 25 years of experience (D'Amico et al., 2017), and the schools provided a room with adequate lighting and guaranteed privacy. The pre-adolescents wore bathing suits for the static postural evaluation and weight and height measurements for better posture visualization with identification of joints and muscles.

The photographic records were made in the anterior and posterior frontal and sagittal planes after locating and demarcating the anatomical points proposed by the Postural Analysis Software (SAPO—Software para Avaliação Postural, 2016). The anatomical landmarks were marked with Styrofoam balls (1 cm in diameter) wrapped with double-sided tape and placed in the specific anatomical landmarks suggested by the SAPO software, which is a reliable and accurate instrument for asymmetry and postural change analysis (Ferreira et al., 2010). A 30- × 30-cm white cardboard with a 6.5-cm width and 18.5-cm length and a 3.0-cm high plastic box placed in its center was used to standardize the position of the pre-adolescents in the photographs (PezzanJoão et al., 2011). The verbal command given was "your feet parallel to the edge of the cardboard and march with both feet, bringing the right foot closer to the left one until you touch the plastic box that is in the center of the cardboard, keeping your eyes on the horizon line." After the movement, the researcher drew the outline of the right and left feet with a pen and the outline of the cardboard on the ground with a piece of chalk for each pre-teen. Once the photograph was taken in the previous view, the pre-adolescent was asked to leave the cardboard and rotate it 90° inside the square marked on the ground

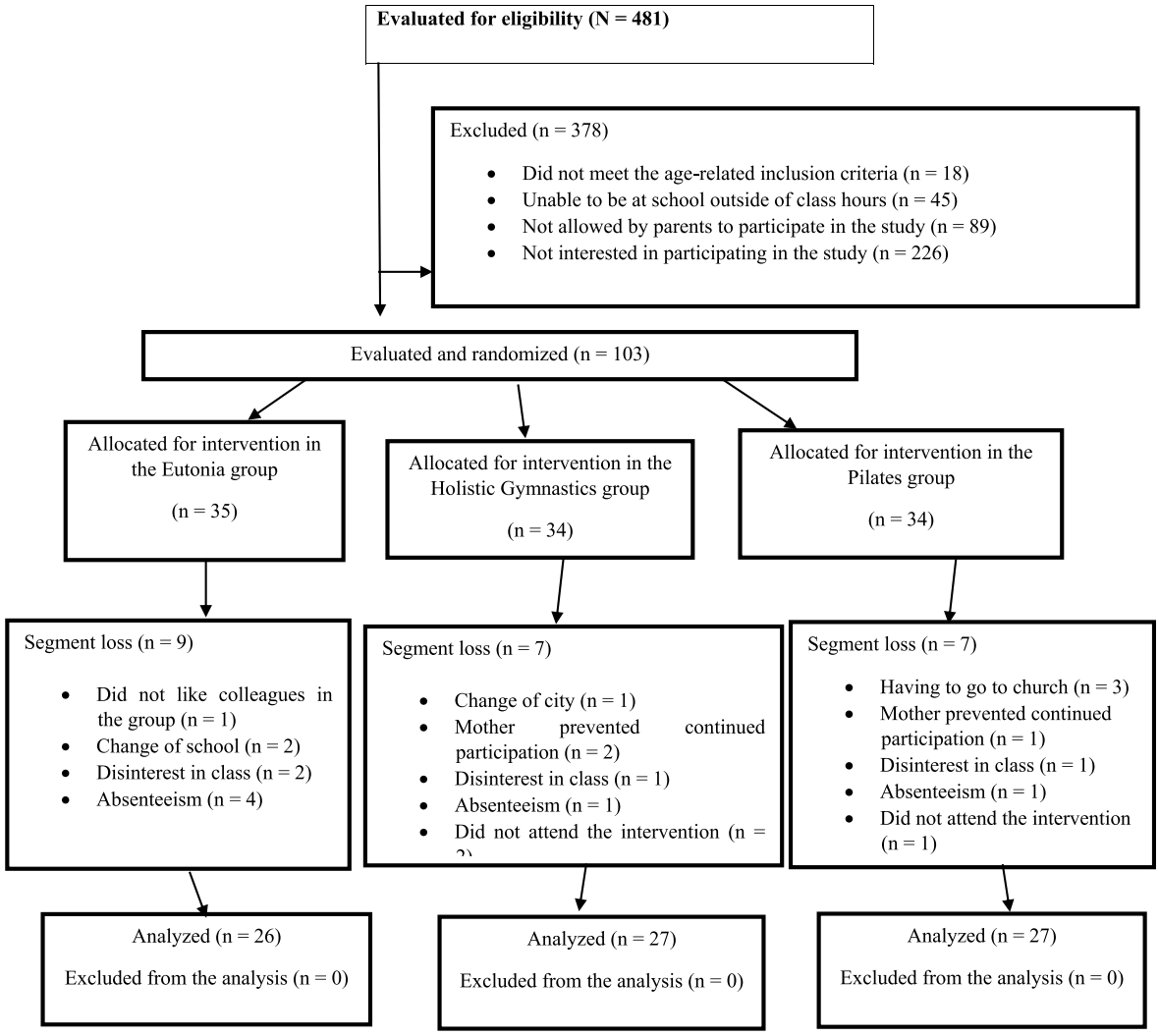

Fig. 1. Study flow diagram.

so that the pre-adolescent was positioned on top of the foot mark on the right-side view, left-side view, and back view.

A Nikon Coolpix S2900 digital camera on a 0.85-cm high tripod was used for photogrammetry at a distance of 3 m from the wall. A plumb line was placed 15 cm from the wall with two markers at 50 cm between them to allow the calibration of the photos.

Studies have highlighted the importance of evaluating and treating postural deviations in the sagittal plane as a form of spinal and pelvic balance (D'Amico et al., 2017) in adults. Because SAPO only presents a reference value for a variable, data analysis was performed to evaluate the cervical angle (angle formed by the intersection that joins the ear tragus to the spinous process of C7 and a line parallel to the ground) (Szczygiel et al., 2019) and the pelvic angle (free angle formed by the intersection that joins the anterior iliac spine, posterior superior iliac spine, and a line parallel to the ground) (Andrade et al., 2017).

In this study, the photographs were evaluated and analyzed by the responsible researcher specialized in body posture. For the photographic analysis, the researcher calibrated the reference of the photograph in 100% visualization and analyzed all the SAPO variables, generating a report with quantitative results and angles measured in degrees.

The layout for assessing dynamics posture (Noll et al., 2016), a validated instrument that evaluates the nine postures used in daily life through filming, was used to examine the dynamic body posture of the pre-adolescents (Noll et al., 2016). The present study included pictures of four postures used in daily life. The pre-adolescents were photographed in the following postures: sitting at a desk to write, sitting to type on the computer, picking up an object on the ground, and carrying the schoolbag. Dynamic posture was analyzed by the responsible researcher through the observation of the photograph. This instrument uses criteria to evaluate the postures in each filmed activity based on the final numerical score. Each posture was analyzed using several items; the higher the score, the more correctly the daily life activity was performed.

The parents or guardians answered a questionnaire with 15 questions to collect information on the personal and social aspects of the pre-adolescents. The pre-adolescents answered the Body Posture Evaluation Instrument Back PEI questionnaire (Noll et al., 2012), which is a valid and reproducible self-administered questionnaire with 21 closed questions, aimed at evaluating the body perception of school children in daily life activities. The female version of the questionnaire was used. The instrument addresses demographic, social, economic, behavioral, postural, and heredity

characteristics and evaluates the frequency of body posture behaviors and habits.

After the initial evaluations, the pre-adolescents were randomly assigned in simple randomization procedures to one of the three groups: the Eutonia group (n = 35), the Holistic Gymnastics group (n = 34), and the Pilates group (n = 34).

The randomization procedure was performed in each school, with the secretary drawing the names of the pre-adolescents from a paper bag to allocate them into the three body movement practices (Eutonia, Holistic Gymnastics, and Pilates). In general, all the pre-adolescents evaluated at each school were randomized into the three groups. The evaluation for the body movement practices were performed before or after school hours.

Thus, three groups of three to nine participants were formed to perform the body movement practice activities. Each group attended 1 h of class per week for 10 weeks, with a total of 10 h of intervention in each modality. After 10 h of intervention, the postures of the 80 girls were re-evaluated using a method similar to the initial evaluation. The pre-adolescents who missed some classes had the specific content given at another time, up to a maximum of three classes. The participants who exceeded this limit were automatically excluded from the project.

2.5. Intervention

The participants in all the intervention groups were instructed in the first three classes on the correct way to carry a backpack (first class), how to pick up an object correctly from the ground (second class), and how to sit at the school desk correctly (third class). Eutonia was practiced by another researcher, and in all classes, the pre-adolescents practiced a sequence called “control positions (CP),” which is presented in Table 1 e the content regarding the sequence of movements of the classes is presented in Table 2 (‘see Figs. 2,3 and 4’).

2.6. Statistical analyses

The data were statistically analyzed using the analysis of variance (ANOVA) by Kruskal-Wallis’ averages test at 5% significance level ($p < 0,05$).

3. Results

The characterization of the pre-adolescents is presented in Tables 3 and 4. In the pre-intervention moment, 64.47% of the pre-adolescents had sedentary leisure activities, 65% had a cell phone, 68.75% did not menstruate and 73.75% carried up to 10% of their body weight in their school backpacks. Table 5 shows the results of the static and dynamic postures. In the static posture, the results indicated that Eutonia, Holistic Gymnastics, and Pilates improved the inclination of the head in the frontal plane and pelvic anteversion in the right and left profiles. As for dynamic posture, the study suggests an improvement in the way the subjects carried their backpacks. It also verified that in the first position, sitting and writing, 80% of the pre-adolescents received 3,4,5 and 6 points, and 75% received 4, 5 and 6 points before and after the intervention. In the second position, sitting while typing on a computer, 75% of the pre-adolescents received 3, 4, 5, and 6 points, and 80% received 5, 6, and 7 points before and after the intervention. In the third position, picking up an object from the ground, 70% of the pre-adolescents received 2 points, and 80% received 2 and 3 points before and after the intervention. In the fourth position, how to carry the schoolbag, 99% of the pre-adolescents received 2 and 3 points, and 85% received 3 points before and after the intervention. Table 6 shows the analysis of variance for the body practices and their effect after intervention. The data shows that there was not a significant difference among the body practices ($p < 0,05$) on the results determined. However, after the intervention independently of the body practices adopted, there was a significant improvement on the horizontal alignment head *anterior view* ($p < 0,001$), angle of

Table 1
Description of Eutonia control positions (CP).

CP	Movement	Objective
First ankle and toe control	Toe flexion and extension.	To increase ankle and quadriceps flexibilities
Second waist, hip, thigh, and knee control. Sitting with crossed legs	Incline the trunk forward and backward.	To stretch the lumbar and gluteal regions
Third waist, hip, thigh, and knee control (Idem 2nd CP)	Trunk-over-thigh flexion.	To stretch the lumbar and gluteal regions
Fourth trunk and upper limb control (Idem second CP, flex the elbows at the waist with thumbs up)	Open the forearms to the side. Stretch the arms and incline the torso to the right and left.	To stretch the chest muscles and side of the torso
Fifth control of the posterior chain in the sitting position with the arms under the thighs	Stretch the legs without removing the arms from the thighs, and move the right leg away from the left, keeping the spine stretched and inclining the trunk forward.	To extend the posterior muscle chain
Sixth trunk control in the sitting position with one leg extended and the other flexed	Incline the torso over the stretched leg.	To stretch the lateral musculature of the torso
Seventh waist, hip, thigh, and knee control. Sitting with the arms extended to the ceiling with one leg flexed and the other extended	Incline the trunk forward with a rocking motion. Lower the arms in the chest to perform the same movement.	To stretch the lumbar, gluteal and ischiotibial regions
Eighth hip control in quadrupedal position	Flex one knee, and stretch the other leg in ventral decubitus position with the trunk on top of the flexed knee.	To stretch the muscles of the pelvis and gluteus
Nineth abdomen control. Sitting position, parallel legs, and feet on the ground	Lower the torso to the ground slowly, and return to the sitting position.	To strengthen the abdominal muscles
Tenth waist, hip, and thigh control in dorsal decubitus	Stretch one leg to the ceiling and rotate the ankle. Cross one leg over the other, and bring the knees to the ground. Open the arms at shoulder height, and drag one of the arms over the head drawing a half circle.	To stretch the gastrocnemius, ischiotibial, and lumbar muscles
Eleventh control of the posterior cervical and back muscles in dorsal decubitus position	Raise the stretched legs to the roof and back of the head, and return with an impulse to the squatting position.	To extend the posterior muscle chain
Twelfth control of the posterior cervical and back muscles in squatting position	From the squatting position, stretch your legs and raise your torso.	To extend the posterior muscle chain

Brieghel-Müller,1998. Source: the authors.

Table 2
Eutonia, Holistic Gymnastics, and Pilates class sequence.

Class	Eutonia	Holistic Gymnastics	Pilates
First	CPs 20 min (touch some part of the body with the hand) and CPs 10 min	Massaging the feet on bamboo. Bamboo on the paravertebral muscles. Twists on the cervical and pelvic regions. Sitting alignment of the spine with movements of the arms, legs, and trunk. Standing and balance movements with one limb	Pelvic clock, dead bug and femur arcs, bridging, assisted roll up, hundred, quadruped series, prone press up, dart, spine stretch, and standing roll down
Second	CPs, stimulation with cotton on arms and face and CPs	Standing in a circle with one foot on the ball. Lying on a seed bag and movements with arms and legs. Lying down, iliopsoas stretching, and movements with the arms and trunk. Lying down, legs extended to the ceiling and ball between the feet. Sitting with flexed legs and movements with legs and arms. Standing and bending the trunk	Arm arcs, dead bug and femur arcs, bridging, pelvic clock, hundred, roll up, single-leg circles, rolling like a ball, dart, spine stretch, and standing roll down
Third	CPs, sensitize the ischium with a rubber ball and CPs	Standing with a ball in the armpit and cervical stretching. Lateral decubitus, movements with the arms and legs. Lying with hands at the nape, raising the trunk, ventral decubitus pass to a sitting position. In pairs, flexing the trunk at 90°	Bridging, arm arcs, assisted roll up, bent knee opening, side to side, mermaid, side lying, prone press up, swan, and spine stretch
Fourth	CPs, bamboo on the back and foot and CPs	Standing and walking on a wooden stick. Lying down on a foam roll and movements with arms and legs. Roll of foam on the sacrum and twists. Lying down while stretching the leg. Sitting movement of the arms and legs. Standing with one leg in front of the other and bending the trunk	Pelvic clock, bridging, hundred, assisted roll up, single-leg circles, quadruped series, single-leg stretch, spine stretch, and standing roll down
Fifth	CPs, foam ball on the paravertebral muscles between the scapula and the spine and CPs	Standing on a wooden brick and movements with the leg. Lying down with a rubber ball on the trapezoids. Rubber ball on three points of the gluteus muscle. Side decubitus and movements with the arms and legs. Sitting and movements with the legs. Standing on one foot with the other on the knee with open arms crossed.	Bridging, arm arcs, assisted roll up, bent knee opening, side to side, mermaid, side lying, prone press up, swan, and spine stretch
Sixth	CPs, sand weights on the trapezium and sternum bone and CPs	Standing with a ball in hand and movements with the arm. Lateral decubitus position with ball between the knees and movements (arms and legs). Lying down with ball in the external malleolus and movement with the leg. Stretching of the ischiotibial and dorsal decubitus muscles, and bridging movement of the arms. Quadrupedal position (legs). Standing on one foot and stretch the other arm and leg while inclining the trunk	Quadruped series, dart, swan, mermaid, side lying, pelvic clock, bridging, assisted roll up, single leg stretch, rolling, and side-to-side spine stretch
Seventh	CPs, sand cushion on the sacrum, lumbar, and seventh vertebrae and CPs	Standing with one foot on rubber ball, in a lateral decubitus position, and a foam ball on the ribs, with movements of the arms and hip. Lying down with ball on the sacrum and trapezium, and movements of the pelvis and arms. Decubitus lateral position with movements of the arms and legs. Sitting alignment of the spine. Standing with both feet on rubber balls while stretching and bending the trunk	Pelvic clock, dead bug and femur arcs, bridging, assisted roll up, hundred, single-leg circles, double-leg stretch, prone press up, dart, spine stretch, and standing roll down
Eight	CPs, seeds on toes and CPs	Standing up and stretching arms to the ceiling. Lying down with bamboo on the paravertebral spine and movements of the arms and legs. Lying down with movements of the arm and legs, in the ventral decubitus position (arms). Kneeling leg movement. Sitting with bamboo, stretching the arms to the ceiling, and inclining and rotating the trunk. Standing with hands at the nape and inclining the trunk in front	Bridging, arm arcs, assisted roll up, bent knee opening, side to side, mermaid, side lying, prone press up, swan, and spine stretch
Ninth	CPs, massage of the feet with rubber ball and CPs	Standing to massage the foot with a small ball. Lying down with ball in hand, pushing the ball to the foot, and in a side decubitus position, twisting movements of the arms and legs. In pairs, sitting while backward stretching the arms and legs, with quadrupedal movements of the pelvis and spine, standing parallel to the wall and bending the trunk	Quadruped series, dart, swan, mermaid, side lying, pelvic clock, bridging assisted roll up, single leg stretch, rolling, side to side, and spine stretch
Tenth	CPs, bamboo between the vertebrae and the scapula, and bamboo in bones and CPs.	Standing with a sandbag on the head and massaging the foot with a baguette. Lying down, 2 balls on the buttocks, more on the knee, make circles with the legs. Decubitus lateral, arm on the diagonal and leg on the front make circles with the arm and leg. Sitting down, interlace with the fingers the toes and bending and extension movements, circles. Standing, hands entwined in the back and winding the trunk and lifting the arms away from the back.	Pelvic clock, dead bug and femur arcs, bent knee opening, bridging, assisted roll up, mermaid, hundred, single leg stretch, quadruped series, swan, spine stretch, and standing roll down

Siler (2008); Niaradi e Batista, 2016. Source: the authors.

the pelvis *right profile* ($p < 0,03$) *and left profile* ($p < 0,001$), how to carry the school bag ($p < 0,001$).

4. Discussion

This research shows that Eutonia, Holistic Gymnastics, and Pilates improved head inclination in the frontal plane, pelvic anteversion in the right and left sagittal planes, and the manner of carrying a school backpack.

As for the head posture in the frontal plane, photogrammetry presented excellent inter- and intra-examiner reliabilities for evaluation (Salahzadeh et al., 2014). In the present study, head posture was improved by 1.52°, 1.66°, and 1.29° after 10 intervention sessions with Eutonia, Holistic Gymnastics, and Pilates, respectively. Importantly, the cervical region is related to the input of proprioceptive senses. The proprioceptive sensing of the cervical region transmits information to correct misalignments and plays an important role in posture control. In addition, it sensitively reacts to

Fig. 2. Eutonia class.

fine head movement by acting in coordination with the vestibular system. Postural deviations in the head and neck result in erroneous information received by the visual and vestibular sensory system and lead to reduced balance increasing the risk of falls and musculoskeletal injuries in daily activities (Ha, Sung, 2020).

The results obtained in several studies on the effect of exercise for the improvement of head postural deviation are consistent with our results. Exercises to stabilize and stretch the cervical spine and shoulder movement in 20 sessions for healthy women aged between 30 and 60 years improved head inclination by 0.71° (Szczygiel et al., 2019). The practice of the Pilates method (10 sessions) by an 11-year-old girl with idiopathic scoliosis Moura et al. (2014) improved the head inclination by 0.4°. Strengthening neck and shoulder muscle exercises (40 sessions) indicated a 2.60° improvement in head inclination in 30 adolescents aged 17 years (Lee et al., 2013). Another study with the Pilates method Goulart et al. (2016) investigated the head position in 39 students aged between 9 and 14 years, of which 21 practiced the Pilates method, and 18 were sedentary. The results showed that the mean head inclination was 0.9° in the Pilates method practitioners and 8.4° in the sedentary participants.

In this study, the three body movement practices aligned the body deviation in a shorter time interval than those reported in the studies by (Lee et al., 2013; Szczygiel et al., 2019). One of the hypotheses for these results is the fact that the somatic education methods, besides the stretching and postural reeducation movements, include relaxation. Relaxation stimulates inner calm in preadolescents, which demands a certain effort for this age group; however, when they reach the state of relaxation, they will notice postural deviations attentively and modify them, becoming more

Fig. 3. Holistic Gymnastics class.

focused on the sensations coming from their body. Thus, the development of more effective body awareness would improve head alignment. Moreover, in somatic education practices, the teacher does not demonstrate the movements but describes them verbally, so the student has to be attentive to what is being asked, increasing the focus of attention and improving body awareness. In the Pilates method, the alignment of the head was encouraged in all movements.

Head inclination in the frontal plane is more prevalent in girls. In the present study, 71 (88.75%) of the participants had this postural deviation, of whom 53 (66.25%) had a right inclination. Penha et al. (2008) evaluated 191 children of both sexes aged between 7 and 10 years, of whom 79.16% presented a head inclination in the frontal plane. For Werner et al. (2018), head movements are associated with behavior, imitation, and communicating a certain emotion. An inclined head is associated with feelings of inferiority, such as submission, sadness, shame, shyness, regret, embarrassment, guilt, and respect. Because the pre-adolescence phase is a period of great bodily and psychological transformations, these feelings can be expressed in body posture by inclining the head.

In the sagittal plane, the appropriate position of the pelvis is determinant of vertical alignment (D'Amico et al., 2017). The

Fig. 4. Pilates class.

alignment of the pelvis depends on the balance between the erector of the spine, abdominals, hip flexors, and ischiotibial muscles (Shamsi et al., 2020). Anterior pelvic inclination is a result of neuromuscular imbalance due to weakness of the abdominal and gluteal muscles and hypertension of the hip flexor muscles, being a major cause of lumbar hyperlordosis (Ludwig et al., 2016; Shamsi et al., 2020) associated with lumbar back pain (Ludwig, 2017). In the present study, pre-adolescents presented anterior inclination in the right and left sagittal planes. In the right profile, this postural deviation was improved by a mean of 1.62°, 0.55°, and 3.55° with Eutonia, Holistic Gymnastics, and Pilates, respectively. In the left profile, pelvic anteversion improved by a mean of 2.43°, 1.20°, and 2.63° after 10 intervention sessions with Eutonia, Holistic Gymnastics, and Pilates, respectively.

Some studies showed that the Pilates method is effective for improving pelvic anteversion. In the present study, Pilates showed a better result for this postural deviation in the right and left profiles than the somatic education methods. Gonzalez-Gálvez et al. (2020) evaluated adolescents who underwent an intervention with the Pilates method for 9 months. The results indicated an improvement in anterior pelvic inclination of 2.26°; however, these results were obtained in a time interval longer than that in the present study. Atilgan et al. (2017) investigated the Pilates method in physiotherapy students, and the results showed that 21.4% and 7.1% of the students had anterior pelvic inclination before and after the intervention, respectively. Ahearn et al. (2018) evaluated the effect of Pilates on the pelvic postures of 20 dancers aged between 16 and 21 years, and the qualitative results indicated that 100% of

Table 3
Characterization of physical parameters of the pre-adolescents.

Characterization	Body Practices Groups	Pre-intervention Mean ± SD
Age (years)	Eutonia (n = 26)	11.15 ± 1.08[a]
	Holistic Gymnastics (n = 27)	10.96 ± 1.02[a]
	Pilates (n = 27)	10.89 ± 0.93[a]
Body mass (kg)	Eutonia (n = 26)	45.21 ± 13.22[a]
	Holistic Gymnastics (n = 27)	43.96 ± 13.59[a]
	Pilates (n = 27)	44.65 ± 14.55[a]
Height (cm)	Eutonia (n = 26)	1.52 ± 0.10[a]
	Holistic Gymnastics (n = 27)	1.51 ± 0.11[a]
	Pilates (n = 27)	1.49 ± 0.10[a]
BMI (kg/cm$^{2)}$	Eutonia (n = 26)	19.31 ± 4.75[a]
	Holistic Gymnastics (n = 27)	19.01 ± 4.04[a]
	Pilates (n = 27)	19.88 ± 4.82[a]

SD: standard deviation; n: number of pre-adolescents.
*Average followed by the same lowercase letters do not show significant difference among the groups at $p < 0.05$.

Table 4
Frequency of occurrence of the pre-adolescents' habits and menstruation in the group studied.

Characterization	Pre-intervention (n, %)
Menstruate (%)	
Yes	25 (31,25%)
No	55 (68.75%)
Type of leisure (%)	
Sedentary	49 (61,25%)
Physically active	27 (33,75%)
NA	4 (5%)
Cell phone (%)	
Yes	52 (65,0%)
No	28 (35,0%)
Weight of the bag	
10% of body weight	59 (73,75%)
More than 10% body weight	21 (26.25)

*n = number of pre-adolescents.

Table 5
Mean and p-value of static and dynamics postures, before and after intervention of Eutonia, Holistic Gymnastics and Pilates.

Variables	Body Practices	Pre-intervention	Post-intervention	p-value
Static posture		Mean ± SD	Mean ± SD	
Anterior view	Eutonia (n = 26)	3.22 ± 2.58[a]	1.70 ± 1.40[a]	0.081
Horizontal alignment head (°)	Holistic Gymnastics (n = 27)	3.42 ± 2.82[a]	1.76 ± 1.56[b]	0.037*
	Pilates (n = 27)	2.58 ± 2.82[a]	1.29 ± 1.34[a]	0.178
Right profile	Eutonia (n = 26)	14.18 ± 5.89[a]	12.56 ± 5.18[a]	0.807
Angle of the pelvis (°)	Holistic Gymnastics (n = 27)	12.46 ± 5.14[a]	11.91 ± 5.76[a]	0.997
	Pilates (n = 27)	14.18 ± 5.86[a]	10.63 ± 5.39[a]	0.066
Left profile Angle of the pelvis (°)	Eutonia (n = 26)	13.59 ± 6.51[a]	11.16 ± 5.41[a]	0.233
	Holistic Gymnastics (n = 27)	11.11 ± 5.21[a]	9.91 ± 5.36[a]	0.876
	Pilates (n = 27)	12.86 ± 4.35[a]	10.23 ± 3.80[a]	0.147
LADy dynamic posture				
1. Sitting and writing (9 points)	Eutonia (n = 26)	4.38 ± 1.47[a]	4.88 ± 1.56[a]	0.733
	Holistic Gymnastics (n = 27)	4.78 ± 1.76[a]	5.26 ± 1.61[a]	0.748
	Pilates (n = 27)	4.67 ± 1.59[a]	6.00 ± 1.27[b]	0.004*
2.Sitting at the computer (9 points)	Eutonia (n = 26)	5.33 ± 1.27a	6.15 ± 1.06[a]	0.244
	Holistic Gymnastics (n = 27)	5.33 ± 1.44[a]	5.74 ± 1.48[a]	0.769
	Pilates (n = 27)	5.08 ± 1.26[a]	5.77 ± 1.11[a]	0.097
3.Picking up object on the ground (9 points)	Eutonia (n = 26)	1.88 ± 0.64[a]	2.07 ± 0.61[a]	0.804
	Holistic Gymnastics (n = 27)	1.92 ± 0.60[a]	2.22 ± 0.78[a]	0.361
	Pilates (n = 27)	1.81 ± 0.72[a]	2.29 ± 0.80[b]	0.022*
4.Schoolbag (3 points)	Eutonia (n = 26)	1.88 ± 0.65[a]	2.08 ± 0.63[b]	0.002*
	Holistic Gymnastics (n = 27)	1.93 ± 0.62[a]	2.22 ± 0.80[a]	0.110
	Pilates (n = 27)	1.81 ± 0.74[a]	2.30 ± 0.82[a]	0.110

*Statistically significant at p < 0,05.
SD: standard deviation; n: number of participants, Layout for Assessing Dynamic Posture LADy.

Table 6
Analysis of variance (ANOVA) of static and dynamic postures between the body practices and pre and post-intervention.

Variables	Statistic	p.value
Horizontal alignment head *Anterior view*		
Body Practices	2.77	0.06
Time (pre and post-intervention)	12.17	<0.001*
Interaction: Body Practices & Time	0.15	0.86
Angle of the pelvis *Right profile*		
Body Practices	0.09	0.82
Time (pre and post-intervention)	4.51	0.03*
Interaction: Body Practices & Time	0.88	0.41
Angle of the pelvis *Left profile*		
Body Practices	0.76	0.46
Time (pre and post-intervention)	8.51	<0.001*
Interaction: Body Practices & Time	0.65	0.52
How to carry the school bag		
Body Practices	2.40	0.09
Time (pre and post-intervention)	26.82	<0.001*
Interaction: Body Practices & Time	0.42	0.65

*Significant at p < 0,05.

the participants noticed an improvement in pelvic alignment. One of the hypotheses for these results is that the Pilates method encompasses isotonic and isometric contractions Hernandez et al. (2020), strengthens the deep paravertebral muscles Atilgan et al. (2017), and focuses on the powerhouse composed of the abdominal transverse, multifidus, pelvic floor, and gluteus and lumbar paravertebral muscles, providing stability to the lumbar and pelvic regions Atilgan et al. (2017), Hernandez et al. (2020) and facilitating the movements of the limbs, thereby correcting the posterior anterior deviation of the pelvis.

Stretching, strengthening, and body awareness exercises improve pelvic anteversion. Ludwig et al. (2016) evaluated male adolescents divided into two intervention groups. One group performed strengthening and stretching exercises with improved pelvic anteversion of $-1.6° \pm 1.8°$. The other group additionally performed body awareness exercises, with better results ($-3.3° \pm 2.2°$). We emphasize that in the study by Ludwig et al. (2016), motor sensory exercises were added in one of the groups, whereas in the present study, the different forms of intervention were compared, which explains the contradictory results. Aali et al. (2018) concluded that adolescents with iliopsoas shortening present a greater inclination of the anterior pelvis than healthy adolescents. This result corroborates the findings of the present study on Eutonia, Holistic Gymnastics, and Pilates, which include iliopsoas stretching movements and improved this postural deviation. Barroqueiro and Morais (2014) conducted a case study of a male adolescent with isthmus spondylolisthesis treated with Global Postural Reeducation for 5 months once a week. The result of the study showed an improvement of 5.9° in pelvic anteversion. Contrary to the results of previous studies, those of the study of Shamsi et al. (2020), which investigated participants with back pain, compared the effects of static stretching and ischiotibial strengthening in the stretching position, indicated that the interventions did not improve the anterior inclination of the pelvis in adults with lumbar pain. The results presented show that the Pilates method and strengthening, stretching, and motor sensory exercises can efficiently improve pelvic anteversion. However, further studies with pre-adolescents should be conducted to confirm this hypothesis.

As for the correct way of carrying schoolbags, the backpack should be positioned at the T12 Chen and Mu (2018) height and have symmetrical straps carried on both shoulders to prevent postural changes Brzek et al. (2017) and spinal pain Noll et al. (2016). In the present study, before the intervention, 91.25% of the subjects used a backpack, and 52.5% carried it properly. After intervention, 98.75% used a backpack, and 80% carried it properly. These results indicate that pre-adolescents learned and developed the habit of carrying their backpacks correctly. Similar results were found in other studies, with 86.1% and 75% of schoolchildren who received guidance learning to carry their backpacks properly (Noll et al., 2016; Candotti et al., 2012).

In this study, 66.25% of the pre-adolescent girls did not practice physical activities outside of school, and 61.25% had sedentary leisure times, corroborating the results presented in the literature (Condessa et al., 2019; Cureau et al., 2016; Salvo et al., 2020). This phase of life represents an important period to guide and

encourage healthy habits, both in the postures used in daily life activities and the practice of physical activities, which can be carried over to adulthood.

The limitations of the study were the reduced number of participants during the study and the absence of facilities in some schools to conduct the practical classes, such as open spaces with circulation of people, dirty classrooms, and torn and deteriorated mats. Other limitations were not blinding, which could generate potential bias, a sequence of identical movements proposed to all participants without respecting the individual needs of each pre-adolescent, and not having a control group.

5. Conclusion

The body practices in Eutonia, Holistic Gymnastics, and Pilates improved head inclination in the frontal plane, pelvis anteversion in the right and left profiles, and the way the participants carried their school backpack over both shoulders.

Clinical Relevance

Because growing girls have a sedentary lifestyle stimulating and making other forms of physical activity accessible, such as Eutonia, Holistic Gymnastics, and Pilates, are important.

In this study, the body movement practices in Eutonia, Holistic Gymnastics, and Pilates improved head inclination, pelvic anteversion, and the correctness rate of carrying the schoolbag.

These body movement practices can prevent and correct postural deviations, pain, and discomfort; these practices also help avoid future pathologies and stimulate pleasure through movement by developing healthy lifestyle habits in pre-adolescents, thereby reducing the social and financial burdens of health systems.

Ethics committee

The State University of Campinas, Campinas, Brazil, under approval No. 1869.831/CAEE 61623316.1.0000.5404.

Registry of clinical trials

Brazilian Registry of Clinical Trials ReBEC (RBR-25w6kk).

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Fernanda dos Santos Lopes Niaradi: Conceptualization, Methodology, Project administration, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Supervision. **Maíra Fonseca dos Santos Lopes Niaradi:** Investigation, Resources, Writing – original draft, Writing – review & editing. **Maria Elisabete Rodrigues Freire Gasparetto:** Conceptualization, Methodology, Resources, Project administration, Supervision, Visualization, Drafting and revising the article.

Declaration of competing interest

The authors declare that they have no potential for conflict of interest in relation to this article.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior- Brasil (CAPES) – Finance Code 001.

References

Aali, S., Letafatkar, A., Ebrahimi, I., Barati, A.H., Hadadnejad, M., 2018. Effect of iliopsoas tightness on range of motion, muscular strength and alignment of lumbopelvic region in 11 to 14 years adolescents. Med. J. Tabriz Univ. Med. Sci. 40, 71–80.

Ahearn, E.L., Greene, A., Lasner, A., 2018. Some effects of supplemental Pilates training on the posture, strength, and flexibility of dancers 17 to 22 years of age. J. Dance Med. Sci. 22, 192–202. https://doi.org/10.12678/1089-313X.22.4.192.

Andrade, M.F., Chaves, E.C.L., Miguel, M.R.O., Simão, T.P., Nogueira, D.A., Iunes, D.H., 2017. Avaliação da postura corporal em estudantes de enfermagem. Rev. Esc. Enferm. USP 51, e03241. https://doi.org/10.1590/S1980-220X2016027303241.

Araújo, F.A., Simões, D., Silva, P., Alegrete, N., Lucas, R., 2019. Sagittal standing posture and relationships with anthropometrics and body composition during childhood. Gait Posture 73, 45–51. https://doi.org/10.1016/j.gaitpost.2019.07.130.

Assiri, A., Mahfouz, A.A., Awadalla, N.J., Abolyazid, A., Shalaby, M., Abogamal, A., Alsabaani, A., Riaz, F., 2019. Classroom furniture mismatch and back pain among adolescent school children in Abha city, southwestern Saudi Arabia. Int. J. Environ. Res. Publ. Health 16, E1395. https://doi.org/10.3390/ijerph16081395.

Atilgan, E., Tarakci, D., Mutluay, F., 2017. Examining the postural awareness and flexibility changes in physical therapy students who took clinica Pilates class. Pakistan J. Med. Sci. 33, 640–644. https://doi.org/10.12669/pjms.333.12808.

Barroqueiro, C., Morais, N.V., 2014. The effects of a global postural reeducation program on an adolescent handball player with isthmic spondylolisthesis. J. Bodyw. Mov. Ther. 18, 244–258. https://doi.org/10.1016/j.jbmt.2013.10.002.

Bazett-Jones, D.M., Rathleff, M.S., Holden, S., 2019. Associations between number of pain sites and sleep, sports participation, and quality of life: a cross-sectional survey of 1021 youth from the Midwestern United States. BMC Pediatr. 19, 201. https://doi.org/10.1186/s12887-019-1576-6.

Been, E., Shefi, S., Soudack, M., 2017. Cervical lordosis: the effect of age and gender. Spine J. 17, 880–888. https://doi.org/10.1016/j.spinee.2017.02.007.

Brieghel-Müller, G., 1998. Eutonia e Relaxamento. Editora Summus, São Paulo.

Brzek, A., Dworrak, T., Strauss, M., Sanchis-Gomar, F., 2017. The weight of pupils' schoolbags in early school age and its influence on body posture. BMC Musculoskel. Disord. 18, 117. https://doi.org/10.1186/s 12891-017-1462-z.

Brzek, A., Knapik, A., Soltys, J., Gallert-Kopyto, W., Famula-Waz, A., Plinta, R., 2019. Body posture and physical activity in children diagnosed with asthma and allergies symptoms. Medicine 98, e14449. https://doi.org/10.1097/MD.0000000000014449.

Candotti, C.T., Noll, M., Roth, E., 2012. Avaliação do peso e do modo de transporte do material escolar em alunos do ensino fundamental. Revista Paulista de Pediatria 30, 100–106. https://doi.org/10.1590/S0103-05822012000100015.

Chen, Y.L., Mu, Y.C., 2018. Effects of backpack load and position on body strains in male schoolchildren while walking. PLoS One 13, e0193648. https://doi.org/10.1371/journal.pone.0193648.

Cho, J., Lee, E., Lee, S., 2017. Upper thoracic spine mobilization and mobility exercise versus upper cervical spine mobilization and stabilization exercise in individuals with forward head posture: a randomized clinical trial. BMC Musculoskel. Disord. 18 (1), 525. https://doi.org/10.1186/s12891-017-1889-2.

Ciric, A., Causevic, D., Bejdic, A., 2015. Differences in posture status between boys and girls 6 to 9 years of age. Homosporticus 17 (1), 15–20.

Condessa, L.A., Chaves, O.C., Silva, F.M., Malta, D.C., Caiaffa, W.T., 2019. Fatores socioculturais associados à atividade física de meninos e meninas: PeNSE 2012. Rev. Saude Publica 53, 25. https://doi.org/10.11606/S1518-8787.2019053000516.

Cureau, F.V., Silva, T.L.N., Bloch, K.V., Fujimori, E., Belfort, D.R., Carvalho, K.M.B., Leon, E.B., Vasconcellos, M.T.L., Ekelund, U., Schaan, D., 2016. ERICA: inatividade física no lazer em adolescentes brasileiros. Rev. Saude Publica 50 (1), 4s. https://doi.org/10.1590/S01518-8787.2016050006683.

D'Amico, M., Kinel, E., Roncoletta, P., 2017. Normative 3D opto-electronic stereophotogrammetric posture and spine morphology data in young healthy adult population. PLoS One 12 (6), e0179619. https://doi.org/10.1371/journal.pone.0179619.

Ferreira, E.A.G., Duarte, M., Maldonado, E.P., Burke, T.N., Marques, A.P., 2010. Postural Assessment software (PAS/SAPO): validation and reliability. Clinics 65, 675–681. https://doi.org/10.1590/S1807-59322010000700005.

González-Gálvez, N., Marcos-Pardo, P.J., Trejo-Alfaro, H., Vaquero-Cristóbal, R., 2020. Effect of 9-month Pilates program on sagittal spinal curvatures and hamstring extensibility in adolescents: randomized controlled trial. Sci. Rep. 10, 9977. https://doi.org/10.1038/s41598-020-66641-2.

Goulart IP, Teixeira LP, Lara S. Análise postural da coluna cervical e cintura escapular de crianças praticantes e não praticantes do método pilates. Fisioterapia e Pesquisa 23(1):38–44. https://doi.org/10.1590/1809-2950/14546123012016.

Ha, S.Y., Sung, Y.H., 2020. A temporary forward head posture decreases function of cervical proprioception. J. Exerc. Rehabil. 16 (2), 168–174. https://doi.org/10.12965/jer.2040106.053.

Hernandez, M.S., Lara, S., Rodrigues, J.B., Balk, R.S., Graup, S., 2020. A influência do método Pilates no desenvolvimento motor de crianças: um estudo de intervenção. Revista Brasileira de Educação Física e Esporte. 34 (2), 249–258. https://doi.org/10.11606/1807-5509202000020249.

Hezarikia, H., Rahimnia, A., Emami Meybodi, M., 2018. Differences between male and female sagittal spinopelvic parameters and alignment in asymptomatic pediatric and young adults. Minerva Ortop. Traumatol. 69 (2), 44–48. https://doi.org/10.23736/S0394-3410.18.03867-5.

Kedra, A., Kolwicz-Ganco, A., Sitarski, D., Kedra, P., Czaprowski, D., 2019. Prevalence of back pain and the knowledge of preventive measures in a cohort of 11619 Polish school-age children and youth-an epidemiological study. Medicine 98 (22), e15729. https://doi.org/10.1097/MD.0000000000015729.

Kwon, Y., Kim, J.W., Heo, J.H., Jeon, H.M., Choi, E.B., Eom, G.M., 2018. The effect of sitting posture on the loads at cervico-thoracic and lumbosacral joints. Technol. Health Care: Off. J. Eur. Soc. Eng. Med. 26 (S1), 409–418. https://doi.org/10.3233/THC-174717.

Lee, M.H., Park, S.J., Kim, J.S., 2013. Effects of neck exercise on high-school students' neck-shoulder posture. J. Phys. Ther. Sci. 25 (5), 571–574. https://doi.org/10.1589/jpts.25.571.

Ludwig, O., 2017. Interrelationship between postural balance and body posture in children and adolescents. J. Phys. Ther. Sci. 29 (7), 1154–1158. https://doi.org/10.1589/jpts.291154.

Ludwig, O., Fröhlich, M., Schmitt, E., 2016. Therapy of poor posture in adolescents: sensorimotor training increases the effectiveness of strength training to reduce increased anterior pelvic tilt. Cogent Medicine 3 (1), 1262094. https://doi.org/10.1080/2331205X.2016.1262094.

Ludwig, O., Kelm, J., Hammes, A., Schmitt, E., Fröhlich, M., 2018. Targeted athletic training improves the neuromuscular performance in terms of body posture from adolescence to adulthood—long-term study over 6 years. Front. Physiol. 9, 1620. https://doi.org/10.3389/fphys.2018.01620.

Moura, P.M., Silva, M.L., Teixeira, L.P., Yamada, E.F., Lara, S., 2014. Efeito do método Pilates sobre a escoliose idiopática: estudo de caso. Sci. Med. 24 (4), 391–398. https://doi.org/10.15448/1980-6108.2014.4.18253.

Murta, B.A.J., Santos, T.R.T., Araújo, P.A., Resende, R.A., Ocarino, J.M., 2020. Influence of reducing anterior pelvic tilt on shoulder posture and the electromyographic activity of scapular upward rotators. Braz. J. Phys. Ther. 24 (2), 135–143. https://doi.org/10.1016/j.bjpt.2019.02.002.

Niaradi, F.S.L., Batista, C.G., 2016. Efeito da Ginástica Holística na postura de meninas de 10 a 12 anos. Conscientiae Saúde 15 (4), 575–583. https://doi.org/10.5585/ConsSaude.v15n4.6736.

Niaradi, F.S.L., Batista, C.G., 2020. Prática da Ginástica Holística na flexibilidade e postura de uma adolescente com alterações no desenvolvimento: estudo de caso. Revista Saúde e Meio Ambiente- RESMA 11 (2), 297–311.

Noll, M., Candotti, C.T., da Rosa, B.N., Sedrez, J.A., Vieira, A., Loss, J.F., 2016. Layout for assessing dynamic posture: development, validation, and reproducibility. Pediatr. Phys. Ther. 28 (4), 435–444. https://doi.org/10.1097/PEP.0000000000000292.

Noll, M., Candotti, C.T., Vieira, A., Loss, J.F., 2012. Back pain and body posture evaluation instrument (Back PEI): development, content validation and reproducibility. Int. J. Publ. Health 58 (4), 565–572. https://doi.org/10.1016/j.pmn.2017.10.005.

Noll, M., Fraga, R.A., Rosa, B.N., Candotti, C.T., 2016b. Fatores de risco associados à intensidade de dor nas costas em escolares do município de Teotônia (RS). Revista Brasileira de Ciências do Esporte 38 (2), 124–131. https://doi.org/10.1016/j.rbce.2015.12.014.

Penha, P.J., Casarotto, R.A., Sacco, I.C.N., Marques, A.P., João, S.M.A., 2008. Qualitative postural analysis among boys and girls of seven to ten years of age. Braz. J. Phys. Ther. 12 (5), 386–391. https://doi.org/10.1590/S1413-35552008000500008.

Pezzan, P.A.O., João, S.M.A., Ribeiro, A.P., Manfio, E.F., 2011. Postural assessment of lumbar lordosis and pelvic alignment angles in adolescent users and nonusers of high-heeled shoes. J. Manipulative Physiol. Therapeut. 34 (9), 614–621. https://doi.org/10.1016/j.jmpt.2011.09.006.

SAPO—Software para Avaliação Postural, 2016. BMClab-Laboratório de Biomecânica e Controle Motor [Internet] São Bernardo do Campo. http://demotu.org/sapo/. (Accessed 9 June 2016).

Salahzadeh, Z., Maroufi, N., Ahmadi, A., Behtash, H., Razmjoo, A., Gohari, M., Parnianpour, M., 2014. Assessment of forward head posture in females: observational and photogrammetry methods. J. Back Musculoskelet. Rehabil. 27 (2), 131–139. https://doi.org/10.3233/BMR-130426.

Salvo, D., Aguilar-Farias, N., Jauregui, A., Varela, A.R., 2020. Sex and age disparities in physical activity among Brazilian adolescents: nature or nurture? J. Pediatr. 96 (1), 4–7. https://doi.org/10.1016/j.jped.2018.12.006.

Siler, B., 2008. O Corpo Pilates. Editora Summus, São Paulo.

Szczygiel, E., Sieradzki, B., Maslon, A., Golec, J., Czechowska, D., Weglarz, K., Szczygiel, R., Golec, E., 2019. Assessing the impact of certain exercises on the spatial head posture. Int. J. Occup. Med. Environ. Health 32 (1), 43–51. https://doi.org/10.13075/ijomeh.1896.01293.

Shamsi, M.B., Shahsavari, S., Safari, A., Mirzaei, M., 2020. A randomized clinical trial for the effect of static stretching and strengthening exercise on pelvic tilt angle in LBP patients. J. Bodyw. Mov. Ther. 24 (3), 15–20. https://doi.org/10.1016/j.jbmt.2020.02.001.

Walicka-Cuprys, K., Szeliga, E., Guzik, A., Mrozkowiak, M., Niewczas, M., Ostrowski, P., Tabaczek-Beister, I., 2019. Evaluation of anterior-posterior spine curvatures and incidence of sagittal defects in children and adolescents practicing traditional karate BioMed Research International, 19. https://doi.org/10.1155/2019/9868473. ID 9868473:1–9.

Werner, P., Al-Hamadi, A., Limbrecht-Ecklundt, K., Walter, S., Traue, H.C., 2018. Head movements and postures as pain behavior. PLoS One 13 (2), e0192767. https://doi.org/10.1371/journal.pone.0192767.