Impact of Physical Exercise on the Treatment of Adolescent Idiopathic Scoliosis: A Systematic Review

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ABSTRACT

One of the most prevalent types of scoliosis is adolescent idiopathic scoliosis (AIS). Syndromic scoliosis is linked to a neuromuscular, skeletal, or connective tissue problem, neurofibromatosis, or another serious medical condition. Exercise is almost usually included in the therapy plan, especially to improve the patient's functional abilities. The purpose of this study is to conduct a comprehensive and systematic assessment of the literature to determine the efficacy of physical activity in the treatment of adolescent idiopathic scoliosis. We conducted a database search using the keywords adolescent, scoliosis, and exercise in the NCBI Pubmed, PedRo, and Research Gate databases. For the selection of articles to be reviewed, we apply inclusion criteria. Articles published between 2011 and 2021, randomized control trials, quasi experiments, and cohort studies examining the effect of exercise on people with AIS were also included. A systematic search was carried out in accordance with the criteria in the recommended reporting items for systematic reviews and meta-analysis (PRISMA) checklist. The impact of physical activity in adolescent idiopathic scoliosis was demonstrated in all 18 articles that met the inclusion and exclusion criteria. We were able to demonstrate through a study of the literature that physical exercise in the treatment of AIS has an effect on decreasing the curvature of the spine curve, as well as a favorable influence on other characteristics such as respiratory function, strength, and posture balance in AIS. This study provides recommendations based on scientific evidence that exercises such as posture correction, core stabilization, spinal stabilization, and SCROTH exercise have a positive impact on vertebral curve progression and functional aspects of AIS patients.

Keywords: *Customize Scoliosis; Physical Exercise; Physiotherapy; Systematic Review*

1. INTRODUCTION

Scoliosis is a type of spine deformity in which a person's spine bends laterally, either with or without vertebral rotation. The most common abnormality of the spine is idiopathic scoliosis. Idiopathic scoliosis is defined as a lateral bend in the spine that arises in otherwise healthy children for unknown reasons [1]. The three varieties of idiopathic scoliosis are infantile idiopathic scoliosis, juvenile idiopathic scoliosis, and adolescent idiopathic scoliosis, which are defined by the age at which the problem was first detected [2], [3].

One of the most typically treated types of scoliosis is adolescent idiopathic scoliosis (AIS). Syndromic scoliosis is linked to a neurological, skeletal, or connective tissue problem, neurofibromatosis, or another serious medical condition [3], [4]. There isn't much research that provide useful information on the prevalence of AIS. Several studies that do provide such information have substantial faults, such as different scoliosis classifications, study methodology, and age groupings, missing criteria for comparison, and inclusion of curves greater than 10°, despite universal agreement that scoliosis is a deformity greater than 10° [5].

Treatment for AIS differs according on how severe the curves are. Exercise, on the other hand, is virtually always a part of the therapeutic regimen [6]. The workout's main purpose is to keep the curvature from getting worse and to reduce the severity of scoliosis. Despite the difficulty of explaining how exercise therapy can correct a complex three-dimensional structural deformity such as that seen in AIS, it has been recommended as a beneficial treatment. To minimize unavoidable reviewer bias, an impartial examination of existing evidence on this topic is clearly required. The current study's goal was to conduct an unbiased literature

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evaluation on the utility of exercise therapy in the treatment of AIS.

2. METHOD

A thorough literature review was used in this investigation. Previous research on adolescent idiopathic scoliosis and exercise were systematically reviewed. Following the study procedures, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) approach was used. The information was gathered by searching the NCBI Pubmed, Research Gate, and PedRo databases on the internet. The keywords "exercise," "adolescent idiopathic scoliosis," and "physical therapy" were used to conduct a systematic search for journals in the database.

The inclusion criteria were: (1) Article with study design experimental such as: pretest posttest design, randomized control trial or cohort study, (2) Respondent diagnosed with adolescent idiopathic scoliosis based on clinical assessment, (3) Respondent with adolescent idiopathic scoliosis aged 10-17 years old, (4) investigate any form of exercise such as aerobic exercise, resistance or strengthening exercise, scoliosis-specific exercise, stabilization exercise and physical activity as an intervention for AIS, (5) Articles published in 2011-2021 in English with full-text available. Research that is not published in full text, dissertations, book chapters and conference abstracts were excluded.

3. RESULT AND DISCUSSION

A keyword search of internet databases yielded 248 articles: Pubmed (232), Research Gate (11) and PedRo (11). (6). A full text review was performed on 37 papers after duplicate elimination (10 articles) and initial screening by title and abstract. The 18 articles that were analyzed were those that did not match the inclusion criteria. Figure 1 shows a diagram of the systematic review process from the PRISMA flow chart.

3.1. Results

Each study's characteristics were extracted using a standardized data extraction form. Authors, year of publication, method, sample size of all included trials, and research result are all included in this systematic review, as indicated in Table 1.

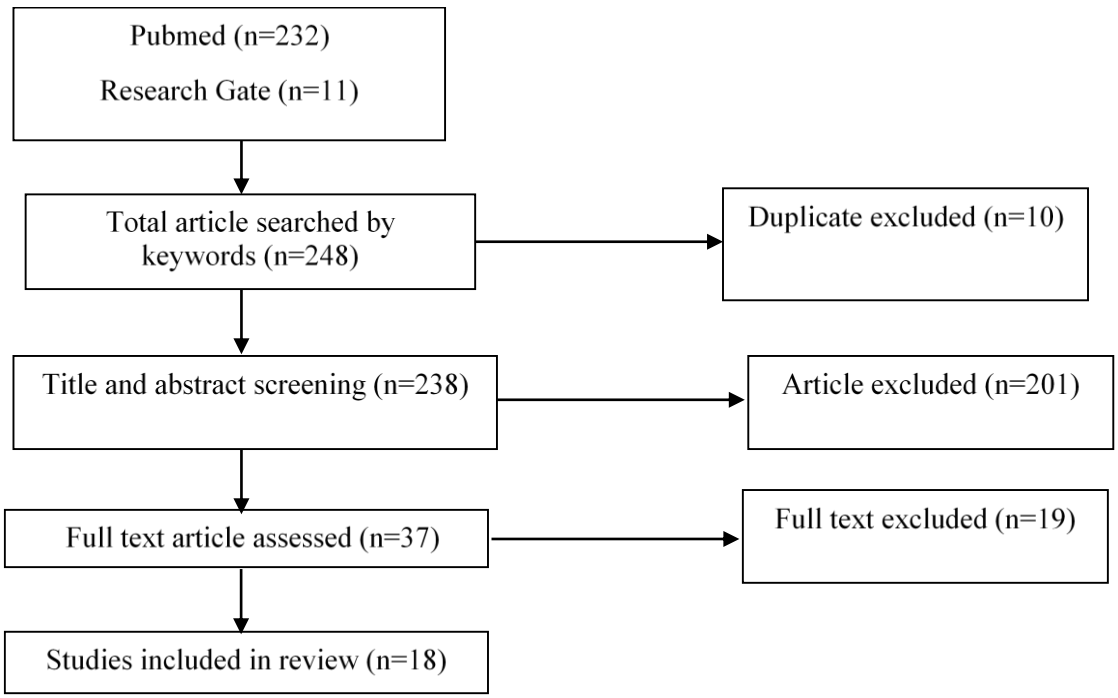

Figure 1 PRISMA diagram of the systematic review process

Table 1 Characteristics of the included systematic reviews.

Author	Year	Purpose of Study	Method	Subject	Result
Monticone *et al.,* [7]	2014	To see how active self-correction and task-oriented exercise affect mild AIS patients' spine abnormalities and health-related quality of life	Randomized controlled study	55 subjects with mild AIS in both control and experimental group	Decreased in Cobb Angle of >5° in experimental group
Bas *et al.,*[8]	2011	To see how aerobic training affects anthropometric and cardiopulmonary measurements	Randomized controlled trial	6 females with mild AIS in both control and experimental group	Decreased in body fat in experimental group and greater increase in VO2max in the treatment group than the control group
Yagci *et al.,*[9]	2019	To see how beneficial a combination of core stabilization and scoliosis-specific exercise is in patients with intermediate AIS	Randomized controlled trial	30 females with moderate AIS	Thoracic and lumbar Cobb angles and trunk rotation angles decreased and body symmetry improved in both group
Xavier *et al*., [10]	2020	To see how resistance training and mixed aerobic and resistance training affect respiratory function, perceived exertion, and functional capacity	Randomized controlled trial	20 adolescents with AIS in both control and experimental group	Increased in FEV1 and peak expiratory flow, also lower perceived exertion on aerobic-resistance training group
Liu *et al*., [11]	2020	To see how exercise treatment affects idiopathic scoliosis	Prospective controlled cohort study	99 AIS patient with Cobb Angle 10° - 25°	Exercise protocol can effectively control or improve curve progression
Zapata *et al.,* [12]	2015	To see if spinal stability exercise can help AIS patients with low back discomfort	Randomized controlled trial	24 subjects with AIS divided into control and experimental group	Spinal stabilization exercise significantly reduce back pain
Gur *et al,,*[13]	2017	To evaluate the effectiveness of core stabilization training in AIS patients	Randomized controlled trial	25 subjects with AIS divided into control and experimental group	In the experimental group, there was an improvement in the degree of lumbar apical vertebral rotation and discomfort
Won *et al.,*[14]	2021	To investigate the effect of neuromuscular stabilization technique on Cobb's Angle in AIS patients	Randomized controlled trial	20 females with AIS divided into control and experimental group	Cobb's Angle improved more in the experimental group than in the control group
Kocaman *et al.,* [15]	2021	To evaluate the efficacy of Schroth exercise and core stabilization exercise in AIS patients	Randomized controlled trial	28 subjects with AIS divided into 2 group	Cobb angle, thoracic rotation angle, cosmetic trunk deformity, and spinal mobility improved more in the Schroth group
Yagci *et al.,*[16]	2017	To evaluate the influence of exercise training on AIS patients' subjective visual, postural, and haptic experience of verticality	Randomized controlled trial	32 females with AIS divided into three group	In the stability exercise and basic body awareness group, visual, postural, and haptic perception improved
Kuru *et al.,*[17]	2015	To assess the effectiveness of three-dimensional Schorth exercise in AIS patients	Randomized controlled trial	45 AIS patients	Cobb angle and rotation angle significantly decreased in exercise group
Gao *et al*.,[18]	2019	To compare the efficacy of orthotic treatments with scoliosis-specific exercise in AIS patients	Prospective randomized controlled study	25 AIS patients	Better Cobb angle correction, improved respiratory parameters, and back muscle endurance were achieved when orthotic intervention was paired with scoliosis-specific training
Hedayati *et al.,* [19]	2017	The purpose of this study was to see how group exercise with brace adjustment affected AIS patients	Quasi-experimental study	30 subjects divided into control and experimental group	The experimental group had a larger improvement in Cobb angle and self-image satisfaction

3.2. Discussion

Several studies have found muscular imbalance in the lumbar multifidus and deep paraspinal muscles in AIS patients. Muscle atrophy and alterations in muscular fiber composition have both been linked to muscle imbalance [20]. In scoliosis, electromyography (EMG) activity demonstrated muscular imbalance, with muscle volume anomalies on both sides of the spine [13].

A core stability exercise aimed at improving postural balance and decreasing compensatory movement is controlling the position of the trunk in static postures and functional tasks. Deep trunk muscles are used for this [21], [22]. The core stabilization exercise program included core physical strength training, local muscle stability training, global muscle stability training, and global muscle mobility training, as well as diaphragmatic breathing technique during exercise [13]. Core

stabilization has been shown to be more useful than general fitness exercises like aerobic activity for improving spinal stabilization. Cobb angles, trunk rotation angles, body symmetry, cosmetic trunk deformity, and discomfort have all been shown to improve in AIS patients who do core stabilization exercises [9], [13],[12].

Scoliosis specific exercise is an intervention that is widely used in the treatment of scoliosis. This exercise consists of a variety of spinal self-correction strategies adapted to specific exercises [23]. The Schroth method is one of various types of exercise treatments for scoliosis. The Schroth method helps prevent progression of curvature, restores abnormal vertebral curves, reduces pain, improves posture, reduces lumbar lordosis, increases vital capacity and prevents surgery [17], [23]–[26]. The results of a study by Monticone et al. [7] demonstrated that active self-correction and task-oriented exercise helped AIS patients improve their quality of life by decreasing Cobb angle, reducing the level of spine deformity, and enhancing their quality of life. The combination of the two workouts is thought to be more effective than traditional exercise alone.

Unlike typical workouts, task-oriented exercises have unique goals and characteristics. Task-oriented exercises are performed using selective motions to accomplish maximum deformity correction through neuromuscular control of the spine and limbs. Exercise paired with education can help patients modify their behavior, resulting in increased exercise compliance and a longer intervention time. Increased knowledge of the disease and patient self-management skills, as well as desire and self-awareness to exercise, are all benefits of education [7]. To preserve spinal health and prevent abnormalities, it is critical to provide accurate information, gradually expose patients to exercise, and educate adaptive behavior.

Individuals with AIS may experience dyspnea and decreased respiratory function. AIS can cause respiratory muscle weakness, limitation of exercise and daily activities [27]. In conditions where the spinal curvature reaches 45° causing a decrease in chest compliance which can affect the decrease in vital capacity and minute ventilation [28].

The effects of a combination of aerobic and resistance training on respiratory function, perceived effort, and functional exercise capacity were compared by Xavier et al. [10]. 10 minutes of stretching and low-intensity aerobics, 40 minutes of aerobic activity on a treadmill, and 10 minutes of cooling down and relaxation make up the aerobic exercise regimen (slow walking and relaxation techniques in supine lying position). The combined workout program includes 10 minutes of stretching and low-intensity aerobics, 30 minutes of treadmill aerobics, 10 minutes of weight training, and 10 minutes of cooling down and relaxation (slow walking and relaxation techniques in the supine lying position). The researchers discovered that combining aerobic and resistance training improved peak expiratory flow and functional exercise capacity, which was characterized by a decrease in perceived exertion and lower respiratory rate. The results of another study [8] showed that a cycling exercise program with a duration of 1 hour 3 times per week for 6 weeks could reduce body fat percentage, increase V02max and increase metabolic equivalent in METS. Resistance exercise that increases exercise capacity in AIS patients may be explained by whole-body fitness mechanisms or interactions between the limb and thoracic muscles. Strengthening exercises can indirectly increase the strength of the trunk and shoulder girdle muscles (through a stabilizing role)[10], [29].

The use of many therapies in the treatment of AIS is becoming more popular. Patients who underwent a combination of exercise and orthotic intervention had a significantly lower Cobb angle, improved back muscle endurance, and improved pulmonary function than those who got orthotic intervention alone, according to Gao et al., [18]. The findings of this study support those of Hedayati et al., [19], who found that combining group exercise with bracing improved Cobb angle and quality of life in the self-image satisfaction category. Later review papers included in this overview began to do subgroup analysis in terms of other outcome measures as additional studies focused on various elements of AIS.

The goal of this study is to gather data on the effects of specific activities on adolescent idiopathic scoliosis. Notable limitations of the study include the fact that we only reviewed literature written in English, which limits our review scope.

4. CONCLUSION

According to current evidence from systematic reviews, exercise therapy such as core stabilization, self-correction exercise, scoliosis-specific exercise, aerobic exercise, and resistance training may have an effect on Cobb angle, trunk rotation angle, respiratory function, and health-related quality of life in adolescent idiopathic scoliosis patients.

REFERENCES

[1] X. Guo, W. W. Chau, Y. L. Chan, and J. C. Y. Cheng, “Relative anterior spinal overgrowth in adolescent idiopathic scoliosis,” *Journal of Bone and Joint Surgery - Series B*, vol. 85, no. 7, pp. 1026–1031, 2003, doi: 10.1302/0301-620X.85B7.14046.

[2] F. Altaf, A. Gibson, Z. Dannawi, and H. Noordeen, “Adolescent idiopathic scoliosis.,” *BMJ (Clinical research ed.)*, vol. 346, p. f2508, Apr. 2013, doi: 10.1136/bmj.f2508.

[3] J. C. Cheng *et al.*, "Adolescent idiopathic scoliosis.," *Nature reviews. Disease primers*, vol. 1, p. 15030, Sep. 2015, doi: 10.1038/nrdp.2015.30.

[4] S. L. Weinstein, "The Natural History of Adolescent Idiopathic Scoliosis.," *Journal of pediatric orthopedics*, vol. 39, no. Issue 6, Supplement 1 Suppl 1, pp. S44–S46, Jul. 2019, doi: 10.1097/BPO.0000000000001350.

[5] M. R. Konieczny, H. Senyurt, and R. Krauspe, "Epidemiology of adolescent idiopathic scoliosis," *Journal of Children's Orthopaedics*, vol. 7, no. 1, pp. 3–9, 2013, doi: 10.1007/s11832-012-0457-4.

[6] S. C. Mordecai and H. V. Dabke, "Efficacy of exercise therapy for the treatment of adolescent idiopathic scoliosis: A review of the literature," *European Spine Journal*, vol. 21, no. 3, pp. 382–389, 2012, doi: 10.1007/s00586-011-2063-4.

[7] M. Monticone, E. Ambrosini, D. Cazzaniga, B. Rocca, and S. Ferrante, "Active self-correction and task-oriented exercises reduce spinal deformity and improve quality of life in subjects with mild adolescent idiopathic scoliosis. Results of a randomised controlled trial," *European Spine Journal*, vol. 23, no. 6, pp. 1204–1214, 2014, doi: 10.1007/s00586-014-3241-y.

[8] P. Bas *et al.*, "Beneficial effects of aerobic training in adolescent patients with moderate idiopathic scoliosis.," *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society*, vol. 20 Suppl 3, pp. 415–419, 2011, doi: 10.1007/s00586-011-1902-7.

[9] G. Yagci and Y. Yakut, "Core stabilization exercises versus scoliosis-specific exercises in moderate idiopathic scoliosis treatment," *Prosthetics and Orthotics International*, vol. 43, no. 3, pp. 301–308, 2019, doi: 10.1177/0309364618820144.

[10] V. B. Xavier, O. Avanzi, B. D. M. C. de Carvalho, and V. L. dos S. Alves, "Combined aerobic and resistance training improves respiratory and exercise outcomes more than aerobic training in adolescents with idiopathic scoliosis: a randomised trial," *Journal of Physiotherapy*, vol. 66, no. 1, pp. 33–38, 2020, doi: 10.1016/j.jphys.2019.11.012.

[11] D. Liu *et al.*, "Effects of Specific Exercise Therapy on Adolescent Patients with Idiopathic Scoliosis: A Prospective Controlled Cohort Study," *Spine*, vol. 45, no. 15, pp. 1039–1046, 2020, doi: 10.1097/BRS.0000000000003451.

[12] K. A. Zapata, S. S. Wang-Price, D. J. Sucato, M. Thompson, E. Trudelle-Jackson, and V. Lovelace-Chandler, "Spinal Stabilization Exercise Effectiveness for Low Back Pain in Adolescent Idiopathic Scoliosis: A Randomized Trial," *Pediatric Physical Therapy*, vol. 27, no. 4, pp. 396–402, 2015, doi: 10.1097/PEP.0000000000000174.

[13] G. Gür, C. Ayhan, and Y. Yakut, "The effectiveness of core stabilization exercise in adolescent idiopathic scoliosis: A randomized controlled trial," *Prosthetics and Orthotics International*, vol. 41, no. 3, pp. 303–310, 2017, doi: 10.1177/0309364616664151.

[14] S. H. Won, D. W. Oh, and M. Shen, "An 18-month follow-up study on the effect of a neuromuscular stabilization technique on Cobb's angle in adolescent idiopathic scoliosis: A single-blind, age-matched controlled trial," *Journal of Back and Musculoskeletal Rehabilitation*, vol. 34, no. 1, pp. 87–93, 2021, doi: 10.3233/BMR-191559.

[15] H. Kocaman, N. Bek, M. H. Kaya, B. Buyukturan, M. Yetis, and O. Z. Buyukturan, "The effectiveness of two different exercise approaches in adolescent idiopathic scoliosis: A single-blind, randomized-controlled trial," *PLoS ONE*, vol. 16, no. 4 April, pp. 1–15, 2021, doi: 10.1371/journal.pone.0249492.

[16] G. Yagci, Y. Yakut, and E. Simsek, "The effects of exercise on perception of verticality in adolescent idiopathic scoliosis," *Physiotherapy Theory and Practice*, vol. 34, no. 8, pp. 579–588, 2018, doi: 10.1080/09593985.2017.1423429.

[17] T. Kuru, Ï. Yeldan, E. E. Dereli, A. R. Özdinçler, F. A. T. I. H. Dikici, and Ï. Çolak, "The efficacy of three-dimensional Schroth exercises in adolescent idiopathic scoliosis: A randomised controlled clinical trial," *Clinical Rehabilitation*, vol. 30, no. 2, pp. 181–190, 2016, doi: 10.1177/0269215515575745.

[18] C. Gao, Y. Zheng, C. Fan, Y. Yang, C. He, and M. Wong, "Could the Clinical Effectiveness Be Improved under the Integration of Orthotic Intervention and Scoliosis-Specific Exercise in Managing Adolescent Idiopathic Scoliosis?: A Randomized Controlled Trial Study," *American Journal of Physical Medicine and Rehabilitation*, vol. 98, no. 8, pp. 642–648, 2019, doi: 10.1097/PHM.0000000000001160.

[19] Z. Hedayati, A. Ahmadi, M. Kamyab, T. Babaee, and M. S. Ganjavian, "Effect of Group Exercising and Adjusting the Brace at Shorter Intervals on Cobb Angle and Quality of Life of Patients With Idiopathic Scoliosis," *American Journal of Physical Medicine and Rehabilitation*, vol. 97, no. 2, pp. 104–109, 2018, doi: 10.1097/PHM.0000000000000812.

[20] H. Kim *et al.*, "Asymmetry of the cross-sectional area of paravertebral and psoas muscle in patients with degenerative scoliosis," *European Spine Journal*, vol. 22, no. 6, pp. 1332–1338, 2013, doi:

10.1007/s00586-013-2740-6.

[21] R. Muthukrishnan, S. D. Shenoy, S. S. Jaspal, S. Nellikunja, and S. Fernandes, "The differential effects of core stabilization exercise regime and conventional physiotherapy regime on postural control parameters during perturbation in patients with movement and control impairment chronic low back pain," *Sports Medicine, Arthroscopy, Rehabilitation, Therapy and Technology*, vol. 2, no. 1, 2010, doi: 10.1186/1758-2555-2-13.

[22] C. Ayhan, E. Unal, and Y. Yakut, "Core stabilisation reduces compensatory movement patterns in patients with injury to the arm: A randomized controlled trial," *Clinical Rehabilitation*, vol. 28, no. 1, pp. 36–47, 2014, doi: 10.1177/0269215513492443.

[23] C. Fusco, F. Zaina, S. Atanasio, M. Romano, A. Negrini, and S. Negrini, "Physical exercises in the treatment of adolescent idiopathic scoliosis: An updated systematic review," *Physiotherapy Theory and Practice*, vol. 27, no. 1, pp. 80–114, 2011, doi: 10.3109/09593985.2010.533342.

[24] J. Y. Park, S. H. Kim, J. C. Lee, and S. B. Ju, "Effect of schroth rehabilitation exercise program on scoliome-ter readings, lumbar lordosis and calcaneal valgus angle in patients with idiopathic scoliosis," *Iranian Journal of Public Health*, vol. 49, no. 4, pp. 808–809, 2020, doi: 10.18502/ijph.v49i4.3191.

[25] H.-J. Lee and S.-M. Lee, "Effects of Schroth exercise therapy on curvature and body appearance of patients with lumbar idiopathic scoliosis," *Physical Therapy Rehabilitation Science*, vol. 9, no. 4, pp. 230–237, 2020, doi: 10.14474/ptrs.2020.9.4.230.

[26] S. Schreiber *et al.*, "The effect of Schroth exercises added to the standard of care on the quality of life and muscle endurance in adolescents with idiopathic scoliosis-an assessor and statistician blinded randomized controlled trial: 'SOSORT 2015 Award Winner,'" *Scoliosis*, vol. 10, no. 1, pp. 1–12, 2015, doi: 10.1186/s13013-015-0048-5.

[27] J. Martínez-Llorens *et al.*, "Muscle dysfunction and exercise limitation in adolescent idiopathic scoliosis," *European Respiratory Journal*, vol. 36, no. 2, pp. 393–400, 2010, doi: 10.1183/09031936.00025509.

[28] T. Tsiligiannis and T. Grivas, "Pulmonary function in children with idiopathic scoliosis," *Scoliosis*, vol. 7, no. 1, p. 7, 2012, doi: 10.1186/1748-7161-7-7.

[29] D. G. Behm, A. D. Faigenbaum, B. Falk, and P. Klentrou, "Canadian Society for Exercise Physiology position paper: Resistance training in children and adolescents," *Applied Physiology, Nutrition and Metabolism*, vol. 33, no. 3, pp. 547–561, 2008, doi: 10.1139/H08-020.

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