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Research Article

Effect of aerobic exercise training in adolescents with idiopathic scoliosis: a narrative review

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ABSTRACT

Adolescent Idiopathic Scoliosis (AIS) is a spinal deformity characterized by a lateral curvature of 10 degrees or more, typically emerging during adolescence. This condition can impair respiratory function and reduce muscle strength due to limited physical activity. Aerobic exercise has been proposed as a therapeutic strategy to improve lung capacity and cardiovascular fitness in this population. This narrative review examines the effects of aerobic training on pulmonary function, exercise capacity, and quality of life in adolescents with AIS. Relevant studies evaluating structured aerobic interventions were analyzed to assess changes in lung function parameters, exertion levels, and functional exercise performance. The reviewed literature consistently shows that aerobic exercise leads to significant improvements in forced vital capacity, forced expiratory volume, and endurance as measured by tests such as the 6-minute walk. Participants also reported reduced perceived exertion and enhanced overall exercise tolerance. These findings suggest that incorporating aerobic exercise into rehabilitation programs can improve respiratory efficiency and physical performance in adolescents with AIS. Additionally, aerobic training may contribute positively to psychological well-being and quality of life, addressing both physical and emotional challenges associated with scoliosis. While the evidence supports the benefits of aerobic exercise, variations in study design and short follow-up periods highlight the need for further research to establish standardized protocols and long-term outcomes. Overall, aerobic exercise appears to be a safe, effective, and practical adjunct therapy in managing AIS, with potential to improve both physiological function and patient quality of life.

Keywords: Adolescent idiopathic scoliosis, Aerobic training, Respiratory function, Exercise capacity, Physiotherapy.

INTRODUCTION

Adolescent Idiopathic Scoliosis (AIS) represents the most prevalent type of scoliosis, characterized by a multifaceted three-dimensional spinal deformity that includes a lateral curvature in the coronal plane, alterations in sagittal alignment, and rotational changes in the transverse plane. These structural irregularities can impact the shape of the rib cage, which may result in impaired pulmonary function and diminished exercise capacity [1].

AIS may cause respiratory difficulties, decreased exercise capacity, and visible postural deformities. Research indicates that adolescents with mild to moderate AIS show decreased aerobic capacity, contributing to increased energy expenditure during everyday physical activities [2].

Management of AIS often aims to correct spinal alignment and improve biomechanical efficiency of the trunk. However, restoring spinal curvature alone may not resolve the accompanying functional impairments. Studies have found that AIS is associated with reduced peak ventilation and vital capacity, as well as diminished peak oxygen uptake during cardiopulmonary testing—suggesting elevated work of breathing [3].

Reduced walking capacity and inefficient breathing patterns further highlight the need for adjunct interventions such as aerobic exercise to enhance cardiorespiratory performance [4].

Despite improvements from surgical intervention, pulmonary function in patients with AIS frequently remains suboptimal compared to healthy peers [5].

Need for the review

Several studies indicate that aerobic capacity declines with increasing curvature severity in AIS, particularly beyond 25 degrees. Low aerobic capacity in children with scoliosis has been associated with elevated energy expenditure during physical activities. Moreover, epidemiological research has shown that poor aerobic

fitness is a stronger predictor of mortality than traditional risk factors like diabetes or hypertension [6].

Aerobic training has been shown to improve functional performance, lung function, and quality of life in adolescents with scoliosis. This review seeks to consolidate the available evidence supporting aerobic exercise as a therapeutic tool in AIS [7].

MATERIAL AND METHOD

Study design

A comprehensive database search was conducted using terms such as "Adolescent Idiopathic Scoliosis," "Aerobic Exercise," and "Scoliosis" across PubMed, Cochrane Library, Scopus, Google Scholar, ScienceDirect, and Medline. Peer-reviewed articles published between 1980 and 2022 were included.

Participants

Inclusion

Studies between 1980 and 2022

Randomised controlled trials

Studies on AIS with aerobic training interventions

Participants aged 9–20 years

Exclusion

Non-AIS populations

Non-aerobic interventions

Participants <9 years or >20 years

Intervention/procedure

The reviewed studies implemented various structured aerobic exercise programs aimed at enhancing respiratory efficiency, aerobic capacity, and overall physical endurance among adolescents with idiopathic scoliosis (AIS). The interventions were carefully designed to ensure safety, gradual progression, and individual adaptability.

Type of exercise

Most programs included treadmill walking, stationary cycling, and ergometer exercises. These activities were selected for their low-impact nature and ability to engage large muscle groups without placing excessive strain on the spine.

Frequency and duration

Training sessions were generally organised three to four times per week, lasting 30 to 45 minutes each. The total intervention period ranged from four to twelve weeks, depending on study design and participant response.

Intensity and progression

Exercise intensity was maintained at moderate levels, typically between 60% and 85% of the participant's maximum heart rate or VO max. Intensity and duration were gradually increased as participants adapted to the training load to ensure continuous improvement without fatigue.

Supervision and safety

All sessions were conducted under the supervision of physiotherapists or trained exercise specialists to monitor posture, breathing technique, and exertion levels. Proper warm-up and cool-down routines were included to reduce the risk of muscle strain and promote recovery.

Outcome measures

Before and after the intervention, participants were evaluated through pulmonary function tests (PFTs), six-minute walk tests (6MWT), VO max assessments, and quality of life questionnaires.

Overall, aerobic training interventions demonstrated safety, good adherence, and measurable improvements in respiratory function, endurance, and general well-being among adolescents with idiopathic scoliosis.

RESULTS

Seven studies were selected (Table 1), all demonstrating improved respiratory function, endurance, or quality of life after aerobic training. Improvements were observed in FVC, VO_2 max, respiratory muscle strength, and walking capacity.

Table 1: shows the details about the mean pushups according to the age group

Author, Year of Publication	Type of Aerobic Exercises	Number of Patients, Age of Patients	Effect of Aerobic Exercises
Avanzi et al., 2002	Aerobic training using treadmill and bicycle ergometer with progressive increase in duration and intensity over 8 weeks.	24 adolescents with idiopathic scoliosis (mean age: 14.2 years)	Improved respiratory muscle strength and aerobic capacity.
Alves et al., 2017	Aerobic exercise training involving treadmill and cycling at 60–80% of maximal heart rate for 12 weeks, three sessions per week.	30 adolescents with idiopathic scoliosis (mean age: 14.5 ± 2.3 years)	Improved quality of life and aerobic endurance.
Bas et al., 2022	Structured aerobic training sessions involving treadmill and cycling exercises, 3 times per week for 8 weeks.	32 adolescents with idiopathic scoliosis (aged 12–17 years)	Significant improvement in pulmonary function and exercise capacity.
Laurentowska et al., 2011	Aerobic rehabilitation program including treadmill and ergometer exercises performed for 6 weeks post-surgery.	28 post-operative adolescent scoliosis patients (aged 12–18 years)	Improved pulmonary function and recovery of exercise tolerance.
Roberto Stirbulov et al., 2006	10 minutes of warm-up exercises followed by 40 minutes of aerobic training on treadmill or stationary bicycle at 60–80% of maximum heart rate.	34 patients (aged 10–18 years)	Improved pulmonary capacity, lung volumes, and 6-Minute Walk Test (6MWT) performance.
Athanasopoulos et al., 1999	Intermittent aerobic training on a cycle ergometer, four sessions per week at 80–100% intensity for 8 weeks.	20 young girls (mean age: 13.5 ± 0.16 years)	Increased ability to perform aerobic work and improved exercise efficiency.
Shneerson, J. M., 1980	Exercise performed while sitting on an electrically braked bicycle ergometer.	20 girls (aged 11–15 years)	Improved the normal fraction of vital capacity during tidal breathing while exercising.

DISCUSSION

The reviewed studies collectively demonstrate that aerobic exercise training can be a valuable therapeutic modality for adolescents with idiopathic scoliosis (AIS), with particular benefits for pulmonary function, cardiovascular endurance, and quality of life. The physiological challenges associated with AIS—such as thoracic cage deformities, reduced chest wall compliance, and altered respiratory mechanics—can contribute to lower lung volumes and decreased aerobic capacity. Aerobic training addresses these deficits by enhancing respiratory muscle performance, improving oxygen uptake efficiency, and promoting more effective ventilation patterns.

Most of the studies included in this review implemented moderate-intensity aerobic interventions, such as treadmill walking or stationary cycling, conducted at 60–85% of maximum heart rate or VO_2max. These training programs, ranging from 4 to 12 weeks in duration, consistently led to improvements in measures such as forced vital capacity (FVC), forced expiratory volume (FEV_1), inspiratory capacity, and 6-minute walk test (6MWT) distances[4–7]. These gains are not only statistically significant but clinically meaningful, indicating improved pulmonary efficiency and endurance capacity during daily activities.

For example, Avanzi et al. and Stirbulov et al. both reported significant enhancements in respiratory muscle strength and pulmonary volumes following aerobic training[8], [12]. This is particularly relevant because weakened respiratory muscles are a known consequence of scoliosis-related thoracic restriction. Strengthening these muscles via aerobic activity could thus translate into reduced dyspnea and enhanced physical activity tolerance.

The observed improvements in quality of life (QoL), as reported by Santos Alves et al., are equally significant [9]. Adolescents with scoliosis often experience social anxiety, poor self-image, and psychological stress related to their posture and physical limitations. Aerobic exercise, through its well-documented role in boosting mood and self-esteem, likely plays a dual role in addressing both physical and emotional health.

Additionally, some studies, like Bas et al., included adolescent participants with mild to moderate curves (~28° Cobb angle), showing that aerobic training is effective even before severe deformities or surgical interventions are required[10]. These findings emphasise the potential of aerobic exercise as a preventive and early-intervention strategy in scoliosis management.

A common theme across the reviewed literature is the safety and feasibility of aerobic training in this population. No adverse effects were reported, and adherence was high, even in post-surgical cases such as those studied by Laurentowska et al.[11]. This reinforces aerobic training as a low-risk, high-benefit intervention that can be tailored to individual capabilities.

In clinical practice, the integration of aerobic exercise into rehabilitation protocols could complement bracing or surgical interventions by enhancing cardiorespiratory function, promoting spinal mobility, and reducing long-term disability. Furthermore, considering that aerobic capacity is a known predictor of cardiovascular health and overall mortality, such training may provide long-term systemic health benefits beyond scoliosis correction alone.

Despite these positive findings, heterogeneity in study design, sample size, training protocols, and outcome measures limits the ability to derive standardized guidelines.

Additionally, long-term follow-up data are lacking, making it difficult to ascertain whether improvements persist beyond the duration of the training programs [14].

CONCLUSION

In conclusion, aerobic training demonstrates clear potential as a valuable supportive intervention for adolescents with idiopathic scoliosis. It is safe, feasible, and effective in improving pulmonary function and enhancing functional performance. When integrated into rehabilitation programs, aerobic exercise can serve as a beneficial addition to traditional scoliosis management strategies. By promoting cardiovascular health, increasing endurance, and improving overall quality of life, aerobic training can significantly contribute to the holistic care of adolescents with idiopathic scoliosis. Further research and clinical application may help refine exercise protocols and establish optimal training regimens for this population.

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