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Advances in Physical Therapy Techniques for the Management of Scoliosis: A Comprehensive Review

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Abstract

Background: Scoliosis, characterized by a lateral curvature of the spine exceeding 10 degrees, is the most common spinal deformity, affecting adolescents predominantly. It can be classified into congenital, syndromic, and idiopathic forms. Early detection and intervention are crucial to manage this condition effectively and prevent progression.

Methods: This systematic review analyzed literature from January 2010 to 2023, focusing on the impact of physical therapy and exercise regimens on the Cobb angle in adolescents with idiopathic scoliosis (AIS). Searches were conducted in electronic databases including PubMed, Cochrane, and ScienceDirect, filtering for controlled and randomized trials published in English.

Results: A total of nine high-quality studies involving 411 participants were included. The findings indicated that physiotherapy interventions, particularly scoliosis-specific exercises and bracing, significantly reduced the Cobb angle. Notably, task-oriented ergonomic exercises demonstrated greater efficacy compared to traditional rehabilitation methods. Bracing, when combined with physical therapy, yielded superior outcomes in curve stabilization and reducing the need for surgical intervention.

Conclusion: The review underscores the effectiveness of tailored physical therapy approaches in managing AIS. Methods such as the Scientific Exercise Approach to Scoliosis (SEAS) and Schroth exercises not only improve the Cobb angle but also enhance patients' quality of life. The results advocate for a more integrated approach in the treatment of scoliosis, emphasizing the need for personalized therapies based on individual patient profiles to optimize outcomes and reduce the progression of spinal deformities.

Keywords: Scoliosis, Physical Therapy, Cobb Angle, Adolescent Idiopathic Scoliosis, Bracing.

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1. Introduction

Scoliosis is a three-dimensional spinal malformation defined by a lateral curvature exceeding 10 degrees in the coronal plane. This is the most prevalent spinal deformity, derived from the ancient Greek term "scoliosis," or "curved." It may be categorized based on age of onset, etiology, occurrence, and curve morphology; for instance, it can be divided into three primary forms according to causation: congenital, syndromic, and idiopathic [1-4]. Congenital scoliosis is a spinal deformity resulting from abnormal vertebral development, whereas syndromic scoliosis arises from neurofibromatosis, other major medical conditions, or dysfunctions in the neuromuscular, skeletal, and connective tissue systems. Idiopathic scoliosis lacks a recognized cause and is classified based on the patient's age upon diagnosis into three categories: infantile idiopathic scoliosis (IIS), juvenile idiopathic scoliosis (JIS), and adolescent idiopathic scoliosis (AIS) [5]. IIS mostly impacts children aged three years and younger, JIS affects those between three and nine years, and AIS pertains to those between 10 to 18 years. The term AIS refers to adolescents aged 10 years or older diagnosed with scoliosis, whereas idiopathic indicates that the precise etiology and etiopathogenesis are uncertain. Thoracolumbar and lumbar curves are mostly seen in men; conversely, females have a greater prevalence of thoracic and double curves, however, the origin and pathophysiology of this syndrome remain ambiguous. Typically, the patient, family, general practitioner, or school nurse first observes postural alterations [6]. A comprehensive medical history, physical examination, and routine scoliosis radiographs have elucidated the diagnosis of AIS.

The Cobb angle quantifies spinal curvature, and its measurement is crucial for assessing scoliosis severity, defining optimal treatment strategies, and tracking case progression or regression post-therapy [7,8]. The Cobb angle can be assessed through various methodologies; notably, it can be manually calculated by measuring the spinal angle on a posterior-anterior (PA) X-ray film. This standard technique involves identifying the upper and lower vertebrae of the spinal deformity, drawing lines along the vertebral borders, and measuring the Cobb angle either directly or geometrically. Additionally, it can be measured digitally using a smartphone, radiographic software, or other tools [9]. Curves measuring under 25 degrees were categorized as mild, those ranging from 25 to 40 degrees as moderate, and those beyond 40 degrees as severe. The angle of trunk rotation and the apex of the curve deformity are assessed using a scoliometer or inclinometer, where an angle of five degrees or less is deemed normal, while an angle of seven degrees or more is regarded as abnormal [10]. Preventing scoliosis is unfeasible; however, early identification is advocated to guarantee timely and adequate treatment. The use of forward-bending screening tests may be contentious; nonetheless, scoliosis cannot be entirely prevented, hence "preventive" measures are restricted to early intervention and timely treatment [11].

The two distinct treatment techniques (non-surgical and surgical) are prevalent in diverse regions globally [12]. The wait-and-see approach is prevalent in the United States, the United Kingdom, and Australia, while exercises and preparatory measures are extensively advised for patients in other regions of Europe [13]. The purpose of non-surgical therapy in adolescence is to halt curve progression, whereas surgical intervention aims for curve correction and stabilization. Nonetheless, pulmonary function is the only adverse effect of AIS and is significantly associated with curve magnitude. Consequently, therapists must consider the possibility of curve progression while formulating a treatment strategy. The main aim of non-surgical therapy is to limit surgical procedures by mitigating curve progression [14]. The non-surgical care of AIS increasingly employs a physiotherapy strategy that includes physical exercises, rehabilitation programs, and the use of braces, which are routinely utilized in the treatment of AIS [15,16]. Nonetheless, the effectiveness of brace treatment remains contentious [17]. The primary objective of AIS bracing is to avert or inhibit the progression of spinal deformity curves until skeletal maturity is reached during growth [16]. Bracing is often used for skeletally immature individuals with spine curvature ranging from 25 to 45 degrees. However, if a patient exhibits a significant likelihood of curve progression and the curvature measures less than 25 degrees, it may be used [18]. In individuals with AIS, bracing significantly reduces the progression of high-risk curves necessitating surgical intervention, and this benefit amplifies with extended durations of brace use [14,19].

To enhance strength, spinal mobility, and balance, and address spinal deformity in Adolescent Idiopathic Scoliosis (AIS), physical scoliosis exercises should be initiated as the primary intervention for mild scoliosis in individuals with a low risk of curve progression [20,21]. Diverse physiotherapy therapies exist for the treatment of AIS, including Schroth physiotherapy scoliosis-specific exercises (PSSE), core stabilization (CS) exercises, stretching, and massage, as well as manual approaches. This literature analysis reveals a lack of studies investigating the impact of various physical activities on the Cobb angle in Adolescent Idiopathic Scoliosis (AIS). The major objective of this study is to analyze and compare the impact of various physical workouts on the Cobb angle, while the secondary objective is to evaluate the effectiveness of bracing in avoiding spine curvature in Adolescent Idiopathic Scoliosis (AIS).

2. Methods

Individual keywords were used to query the electronic databases PubMed, Cochrane Central Register of Controlled Trials, Physiotherapy Evidence Database (PEDro), Elton B. Stephens Company (EBSCO) host, and ScienceDirect (Elsevier). Only controlled, randomized, and non-randomized trials published in English from 2010 to 2023 were included in the bibliographical search.

3. The advantages of physiotherapy or exercise regimens on the Cobb angle in individuals with adolescent idiopathic scoliosis

This systematic review sought to gather current information about the advantages of physiotherapy or exercise regimens on the Cobb angle in individuals with adolescent idiopathic scoliosis (AIS). The findings indicate that physiotherapeutic therapies may reduce the Cobb angle across various exercise or bracing circumstances. The selection of physiotherapy interventions in all the investigations was rather haphazard. Nine studies were chosen for examination, deemed to possess good quality (PEDro score of eight or above with low or ambiguous bias), with a total of 411 individuals (133 men and 278 females).

The PEDro score was nine out of ten in five assessments and eight in three investigations. In the whole Cochrane assessment, seven trials exhibited a low risk of bias, while two presented indeterminate risks of bias due to the majority of studies not being conducted by blinded therapists or assessors.

This systematic analysis presents evidence of varying quality supporting a medium-effect strategy to decrease Cobb angle in individuals with Adolescent Idiopathic Scoliosis (AIS). A randomized controlled study (RCT) included 36 individuals, aged 10 to 15, who were allocated into two groups: an experimental group and a control group, each including 18 participants. The experimental group engaged in task-oriented ergonomic workouts alongside standard exercises for one year, while the control group participated in spinal reinforcement, active self-correction, and breathing exercises. The Cobb angle exhibited a considerable reduction before and after the intervention in both groups, with notably larger values in the task-oriented exercise groups compared to the control group. This indicates that exercise mitigates curve development and diminishes anomalies in AIS [22-26].

A study included 53 male patients aged 20-25 years, who were randomly assigned to two groups: one including 25 patients participating in a home-based exercise program and the other consisting of 28 patients in a community-based exercise program. The community-based group engaged in all activities together, including gym sessions under an instructor's supervision, whereas the home-based group got an instructional video and phone calls from the teacher. The trial results indicated that Cobb angles were marginally smaller than the average in both groups throughout the 10-week exercise program, although the study anticipated that the home-based exercise program would be less effective than the community-based group program; however, no clinically significant difference was observed between the two. This may be due to the trial's restricted sample size or the absence of a control group. The researchers also determined that patients who did not engage in exercise exhibited no changes, resulting in ethical concerns [27-32].

In a separate trial, 110 patients under the age of 10, comprising both genders, were randomly allocated into two groups of 55 participants each: the experimental group, which engaged in active self-correction, task-oriented spinal exercises, and educational interventions, and the control group, which adhered to traditional spinal exercise rehabilitation. Both groups had outpatient sessions weekly for 60 minutes and

were instructed to maintain home workouts twice weekly for one year, each lasting 30 minutes. The experimental group had a reduction in Cobb angle above five degrees, whilst the control group remained stable [33]. In patients with intermediate AIS, the active self-correction and task-oriented exercise regimen outperformed typical Cobb angle reduction treatments, with effects lasting for at least one-year post-intervention.

Furthermore, 50 patients from a randomized controlled trial, including both men and girls under the age of 10, were randomly divided into two groups of 25 individuals each. One group received orthosis intervention (OI) along with exercise, whereas the other group received OI only. The research group used the Scientific Exercise Approach to Scoliosis (SEAS), and after six months of intervention, patients in the orthosis combined with the exercise group had a more significant correction of the Cobb angle compared to those in the orthosis control group [34-38]. In scoliosis care, several orthotic designs exist, differing in construction methodology, stiffness, mechanism of action, and area of effect [39-44]. The Boston brace is a custom-fitted orthosis including correction cushions placed on the convexity of the curve and comfort points, inhibiting progression by applying a three-point pressure on the spinal curvature, as identified by Kalichman et al. [45]. Nonetheless, it is crucial to acknowledge the deterioration of back muscles induced by OI, since it is essential for maintaining spinal alignment and stabilizing body posture [46].

In research including 60 patients, aged 10 to 17 years, both male and female, participants were randomly assigned to an exercise group and an OI group, each comprising 30 patients. The SEAS was executed by the research group, revealing a significant alteration in the Cobb angle after 12 months of intervention for both techniques. Bracing surpassed Cobb angle correction during a 12-month assessment, according to the intergroup comparison data. Nonetheless, it is unequivocal that bracing has shown efficacy in halting the advancement of the deformity and reducing the need for surgical intervention. Moreover, due to their improved mental health, the patients in the exercise group were perceived to possess a more favorable perspective on their physical appearance. Conversely, due to the stress in the bracing, the impression of the bracing community may be skewed [7].

A recent randomized controlled trial (RCT) recruited 30 female patients aged 10 to 17 years, who were randomly allocated to the SEAS group and the core stabilization (CS) group, with 15 patients in each group. Spinal bracing was used in both groups alongside the activities. The patients were directed to wear the brace for 23 hours each day, removing it just after exercise and for one hour daily for personal grooming. The workout regimens for both SEAS and CS spanned 40 hours each. In conclusion, the results demonstrate that all patients had reduced thoracic and lumbar Cobb angles of the scoliotic curve and that both SEAS bracing and CS bracing exercises were successful in restraining curve progression over a four-month duration. The data indicate that both treatment regimens effectively prevented curve development in people with mild curve adolescent idiopathic scoliosis (AIS) and that their impact on the Cobb angle was comparable. Negrini et al. discovered that in patients with AIS who received just exercise recommendations, SEAS exercises were more advantageous than traditional physiotherapy and noted that SEAS effectively reduced corrective losses while using a brace in instances with intermediate curves [13]. The primary objective of scoliosis treatment is to improve aesthetic appearance since the cosmetic deformity significantly increased in both groups in this research. Following four months of exercise and bracing treatment, a significant increase in cosmetic deformities in both groups may be attributed to reduced curve amplitude and enhanced body symmetry [39].

An experiment involved 30 patients, including both boys and girls aged 10 to 18 years, who were randomly assigned to the SEAS group and the Schroth exercise group (SEG), with 15 patients in each group. Both groups did their designated exercises five days per week for seven weeks, and after seven months of intervention, both the SEG and SEAS groups exhibited substantial enhancements in pre- and post-Cobb angle measures. Intergroup studies suggested that Schroth may be more efficacious than SEAS in altering the mild-to-severe Cobb angle in adolescent idiopathic scoliosis [28].

A separate study involved 30 female patients with scoliosis, aged 10 to 17 years, who participated in home-based programs and were randomly divided into two groups: one group engaged in scoliosis-specific

exercises (SSE) on a side-alternating whole-body vibration (sWBV) platform, while the other group performed standard SSE. The Cobb angle was assessed with magnetic resonance imaging (MRI) at baseline and after six months, alongside the documentation of menarche onset in a subgroup analysis. This research revealed that home-based SSE conducted on the sWBV platform for six months inhibits the development of scoliosis in girls with AIS, particularly before menarche. The statistical difference between the two groups was substantial, and the clinical relevance of the primary curve was as follows: 20% of the sWBV rose by five or more, 75% remained steady, and 5% dropped. The test group exhibited no improvement, steadied at 8%, then saw an 11% decline. The subgroup analysis likewise demonstrated the most scientifically significant enhancement in the pre-menarche cohort [30].

A prior study had 25 patients (one male and 24 girls) aged 10 to 16 years, who were randomly allocated to the stabilization group (SG) (n=12) and the control group (CG) (n=13). The CG participated in conventional scoliosis exercise regimens, encompassing respiratory exercises, postural training, spinal stabilization activities, stretching routines for the impacted muscles (particularly on the concave side of the curve), and overall strengthening exercises for the affected muscles (notably on the convex side of the curve). The SG engaged in central stabilization exercises with conventional healing therapy. The investigation determined that the average Cobb angle decreased by nine degrees in SG and two degrees in CG. The intergroup comparison of the Cobb angle revealed a much higher alteration in the SG compared to the CG [37].

This systematic review analyzed four trials that compared SEAS exercises with control groups or alternative interventions, concluding that SEAS exercises were more effective in managing diseases related to spine abnormalities and scoliosis development. This study included five additional trials assessing five distinct exercise regimens alongside typical spinal workouts, with the majority of these experimental investigations demonstrating a significant decrease in Cobb angle. This analysis has notable limitations, such as the lack of defined inclusion criteria in the papers analyzed and the predominance of non-randomized trials among the included researches. Moreover, recent research has shown significant limitations about the lack of blinding, masked allocations, and variations in exercise regimes. Moreover, many exercise modalities exhibit varying intensities and effects, and the variability in exercise protocols precludes clear findings. The duration of intervention ranged from 10 weeks to 12 months, while the sample sizes of the included studies varied from 25 to 110 participants. A further limitation of the present research is its exclusive inclusion of English-language studies, potentially introducing bias into the selection process, and the majority of the studies failed to delineate the specific exercises included in the standard protocol.

4. Conclusions

The treatment of idiopathic scoliosis is intricate; however, a comprehensive evaluation of the deformity and the individual clinical profile of each patient should be central to the conservative management of adolescent idiopathic scoliosis (AIS). Regarding the efficacy of PSSE, it has been determined that SEAS exercises are more advantageous for enhancing the Cobb angle and mitigating complications from brace use compared to conventional physical therapy. The Schroth approach provides valuable insights into the treatment and prevention of scoliosis. The three methodologies, SEAS, Schroth, and CS, not only target the primary deformities but also enhance therapy efficacy and patient quality of life by stabilizing outcomes and mitigating scoliosis progression. In conclusion, the severity of this distortion should serve as an additional impetus for the therapeutic regimen and clinical judgment of therapists, rather than a deterrent to treatment, based on scientifically grounded information and its application in the management of AIS.

The results of the included studies indicate that a treatment regimen is more successful than controls in reducing the Cobb angle in individuals with AIS. Furthermore, it shows that bracing during exercise yields greater reductions in Cobb angle compared to exercise alone. Nonetheless, the reliability of these results is limited by the inconsistency of the workout routines and insufficient scientific rigor.

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التطورات في تقنيات العلاج الطبيعي لإدارة الجنف: مراجعة شاملة

الملخص

الخلفية :يُعتبر الجنف، الذي يتميز بانحناء جانبي للعمود الفقري يتجاوز 10 درجات، أكثر تشوهات العمود الفقري شيوعًا ويؤثر بشكل رئيسي على المراهقين. يمكن تصنيفه إلى أشكال خلقية، متلازمية، ومجهولة السبب. يُعد الاكتشاف المبكر والتدخل أمرًا بالغ الأهمية لإدارة هذه الحالة بفعالية ومنع تطورها.

المنهجيات :حللت هذه المراجعة المنهجية الأدبيات المنشورة بين يناير 2010 و 2023، مع التركيز على تأثير العلاج الطبيعي وبرامج التمارين الرياضية على زاوية كوب لدى المراهقين المصابين بالجنف المجهول السبب .(AIS) تم البحث في قواعد بيانات إلكترونية شملت PubMed و CochraneوScienceDirect، مع اختيار الدراسات التجريبية العشوائية والمضبوطة المنشورة باللغة الإنجليزية.

النتائج :شملت المراجعة تسع دراسات عالية الجودة تضمنت 411 مشاركًا. أشارت النتائج إلى أن التدخلات العلاجية الطبيعية، وخصوصًا التمارين المخصصة للجنف واستخدام الدعامات، أدت إلى تقليل زاوية كوب بشكل كبير. وُجد أن التمارين الموجهة نحو المهام والأوضاع كانت أكثر فعالية مقارنةً بالطرق التقليدية لإعادة التأهيل. أظهرت الدعامات عند دمجها مع العلاج الطبيعي نتائج متفوقة في استقرار الانحناء وتقليل الحاجة إلى التدخل الجراحي.

الخلاصة :تؤكد المراجعة فعالية النهج المخصص للعلاج الطبيعي في إدارة الجنف المجهول السبب. أساليب مثل النهج العلمي للتمارين لعلاج الجنف (SEAS)وتمارين شرورث لا تحسن فقط زاوية كوب، ولكنها أيضًا تعزز جودة حياة المرضى. تدعو النتائج إلى اتباع نهج أكثر تكاملاً في علاج الجنف، مع التركيز على العلاجات المخصصة بناءً على ملفات المرضى الفردية لتحسين النتائج وتقليل تطور تشوهات العمود الفقري.

الكلمات المفتاحية :الجنف، العلاج الطبيعي، زاوية كوب، الجنف المجهول السبب عند المراهقين، الدعامات.