Proceedings of the 5th International Conference on Modern Medicine and Global Health
DOI: 10.54254/2753-8818/2027.38940

Adolescent Idiopathic Scoliosis and Lifestyle Factors: A Critical Review and Community Survey Research

Yulin Zhu

Shanghai Starriver Bilingual School, Shanghai, China
yoyozyl2023@163.com

Abstract. Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity that develops during adolescence without an identifiable underlying disorder. Although genetic susceptibility and skeletal growth are critical, the contribution of modifiable lifestyle factors remains uncertain. This narrative review critically examines evidence concerning physical activity, body composition, nutrition, screen use, and school-related behaviors. The study gives attention to whether reported associations precede scoliosis, how exposures and outcomes are measured, and whether findings support causal interpretations. Prospective studies suggest that differences in childhood activity and body composition may precede later scoliosis identification. However, these findings remain observational, and key studies share an underlying cohort and use scoliosis assessments that differ from routine clinical diagnosis. Questionnaire-based associations are additionally vulnerable to recall bias, confounding, and reverse causation. Current evidence supports further investigation of lifestyle factors but does not establish that habits cause AIS or that lifestyle changes prevent its onset. This review also proposes to conduct future community research that would improve the public awareness of AIS, while examining associations of lifestyle factors using reliable measures, and ultimately promote healthy living in the community.

Keywords: Adolescent Idiopathic Scoliosis, Lifestyle Factor, Community Health, Epidemiology

1. Introduction

Adolescent idiopathic scoliosis (AIS) is a structural spinal deformity involving lateral curvature and vertebral rotation that appears between approximately ten years of age and skeletal maturity. Scoliosis is conventionally identified by a Cobb angle of at least 10 degrees on a standing radiograph, while the term "idiopathic" indicates that no underlying congenital, neurological, or other identifiable disorder explains the deformity [1]. Therefore, AIS differs from temporary slouching, muscular discomfort, and other conditions commonly described as poor posture.

AIS is sufficiently common to represent an important health concern among adolescences. For example, Konieczny and colleagues reported estimates ranging from 0.47% to 5.2%, reflecting differences in study populations, age groups, diagnostic thresholds, and screening procedures [2]. More severe spinal curves are more common in girls than boys. It is noteworthy that the course of

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DOI: 10.54254/2753-8818/2027.38940

AIS could vary, as a mild curve does not necessarily worsen over time or cause major limitations in daily life.

Public explanations of scoliosis often emphasize individual behaviors, including daily examples such as prolonged sitting, smartphone use, heavy school bags, and insufficient exercise. These explanations suggest that the condition might be prevented through individual behavioral choices. Yet a plausible explanation is not necessarily an established mechanism in the case of AIS. Associations between lifestyle and scoliosis may reflect multiple aspects such as biological susceptibility, shared social circumstances, measurement differences, or changes occurring after the deformity develops.

The central question of this review is therefore not simply which lifestyle factors have been associated with AIS, but what those associations establish. It is critical to distinguish disease onset from progression and consequences. By comparing prospective evidence, retrospective questionnaires, and treatment studies, this review evaluates the strength and limitations of lifestyle-related claims and identifies appropriate directions for further research.

2. Review approach

This study serves as a review based on relevant literature addressing topics including AIS epidemiology, genetic susceptibility, skeletal maturity, physical activity, body composition, school-related behaviors, and conservative treatment, thus providing opportunities to further research in AIS and promote community health.

The review has been guided by three main questions to study the association between lifestyle factors and AIS. First, was the proposed exposure measured before scoliosis was identified? Second, were behavior and disease assessed using methods appropriate to the claim? Third, could another factor explain the association?

These questions distinguish bibliographic reliability from inferential strength. A genuine, peer-reviewed study may provide credible descriptive findings while offering limited evidence of causation. Similarly, a randomized treatment trial can establish benefits for an existing curve without answering why scoliosis initially developed. The evidence must therefore be interpreted according to the specific population, exposure, and outcome studied.

3. Biological susceptibility and the risk factors

Genetic evidence establishes that AIS cannot be adequately explained because of careless posture. Takahashi and colleagues identified common variants near LBX1 associated with AIS in a genome-wide association and replication study involving Japanese female participants [3]. This finding supports inherited susceptibility, but it does not identify a single deterministic scoliosis gene. Its original population also requires consideration when interpreting applicability across ancestry and sex.

Genetic susceptibility does not exclude environmental influences. Rather, it suggests that behavioral associations occur within a biological context. Individuals may differ in developmental characteristics that influence both spinal structure and participation in physical activity. Family history is consequently relevant, although it may capture shared environments and greater awareness of scoliosis as well as inheritance.

Growth is particularly important when considering progression. Sanders and colleagues demonstrated the value of skeletal maturity assessment for understanding curve behavior [4].

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Adolescents with similar chronological ages and curve magnitudes may have different progression risks because their remaining growth differs.

It is also important to pay attention to the ambiguity in the term of risk factor, as it may refer to different meanings such as susceptibility to developing a curve, the probability that a curve worsens, or the likelihood of receiving a diagnosis. These outcomes are not interchangeable. Healthcare access and family awareness can influence diagnosis without affecting biological onset. Likewise, a factor associated with progression among diagnosed patients need not explain disease initiation. The research on AIS lifestyle risk factors becomes more interpretable when it specifies which of these outcomes it addresses.

4. Physical activity

4.1. Evidence from prospective observation

Physical activity is one of the more informative lifestyle research directions because it has been measured before later scoliosis assessment. Tobias and colleagues used the Avon Longitudinal Study of Parents and Children (ALSPAC) to examine childhood physical ability and activity in relation to scoliosis identified at age fifteen. Their measurements included reported activity and accelerometry at age eleven, and children with scoliosis identified at age ten were excluded [5]. The study found that lower childhood activity was associated with subsequent scoliosis. Measuring behavior before the later outcome strengthens temporal interpretation compared with asking diagnosed adolescents about their current routines. Objective accelerometry also reduces reliance on recalled activity alone.

However, prospective observation does not establish that relationship that low activity causes AIS. Differences in coordination, growth, body composition, or other developmental characteristics may precede both reduced activity and scoliosis. Excluding identified scoliosis at baseline reduces one source of reverse causation but cannot exclude every subtle pre-existing difference.

It is also important to consider outcome measurement. Scoliosis was assessed using a DXA-based method rather than routine standing diagnostic radiography [5]. The study therefore provides valuable population evidence, but its identified outcome should not be treated as identical to every clinically diagnosed AIS population.

4.2. Why current activity is difficult to interpret

Activity measured after diagnosis presents a different problem. Adolescents may change participation due to various reasons including discomfort, brace use, treatment schedules, self-consciousness, or professional advice. Those receiving prescribed rehabilitation may exercise more frequently precisely because they have scoliosis. A cross-sectional association could consequently differ from the relationship between earlier activity and disease onset.

It can be noted that exercise also encompasses different levels of exposures. Organized sport, recreational movement, physical education, strength training, and scoliosis-specific rehabilitation differ in purpose and intensity. Combining them into one category may obscure rather than clarify an association.

The current evidence supports investigating physical activity as a developmental correlate and a component of adolescent wellbeing. It does not establish a specific activity prescription that reliably prevents AIS. General benefits of movement should not be converted into disease-specific prevention claims without corresponding evidence.

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5. Body composition and nutrition

Clark and colleagues investigated childhood body composition before later scoliosis assessment within ALSPAC. Lower earlier body mass index and differences in lean and fat mass were associated with scoliosis identified during adolescence [6]. The temporal sequence challenges explanations based entirely on weight changes following diagnosis.

However, body composition may be a marker of shared developmental processes rather than a direct cause. Growth, maturation, endocrine characteristics, and activity could influence both body composition and spinal development. Statistical adjustment addresses measured variables but cannot determine the complete underlying mechanism.

An important limitation of the evidence base is that the body composition and physical activity studies used the same underlying cohort [5, 6]. They investigate different exposures, but they are not fully independent replications. Consistent findings may reflect related developmental processes within a shared population and assessment framework.

Body mass index itself also requires careful interpretation. It does not directly distinguish fat from lean tissue, and its meaning changes with age and development. An association with lower childhood BMI should therefore not be simplified into a recommendation that adolescents gain weight to prevent scoliosis.

Nutritional behavior provides a related but distinct research question. Dou and colleagues reported an association between not habitually consuming milk or dairy products and AIS in a Chinese case-control study [7]. This does not demonstrate that dairy avoidance causes scoliosis or that increasing dairy intake prevents it. The reported habit may reflect wider dietary patterns, cultural practices, socioeconomic circumstances or other related characteristics.

Nutritional studies should distinguish reported food consumption from measured nutritional status and biological mechanisms. Treating these as equivalent can create misleading conclusions. The existing findings justify further investigation of growth and nutrition, while offering no basis for blaming body size or individual food choices for AIS.

6. Screen use and school related behaviors

6.1. Findings from questionnaire research

School-related habits are important research topics in the domain of AIS because they are familiar and potentially modifiable. For instance, Dou and colleagues compared 491 radiographically diagnosed AIS cases with 1,346 controls in Shenzhen. It can be found that questionnaire-reported reading and writing posture, perceived heavy school bags, weekday screen time, and dairy habits were associated with AIS [7].

The radiographic case definition strengthens disease classification compared with studies relying entirely on self-reported scoliosis. The relatively large sample also permits comparisons across several exposures. Nevertheless, clearly identifying cases does not resolve uncertainty about when or how the reported behaviors occurred.

A case-control questionnaire is vulnerable to differential recall. Adolescents who know they have scoliosis may evaluate past posture or backpack burden differently from those without a diagnosis. Public beliefs about spinal health may influence how respondents describe behaviors, especially when questions resemble familiar explanations of disease.

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6.2. Perceived exposure and objective measurement

Perceived backpack heaviness is not equivalent to measured load. The same bag may feel different depending on strength, fatigue, discomfort, and existing spinal concerns. An association with perceived heaviness may therefore describe burden or symptoms rather than an exposure responsible for deformity. Therefore, in the community-based survey that potentially conducted in the future, objective measurement should be applied for quantifying the backpack load to study the association.

Posture is similarly difficult to summarize, which could pose challenges for the AIS study and future research. A broad category of poor reading or writing posture may combine leaning, viewing distance, sitting position, and other behaviors. These measures can identify patterns but may not isolate a reproducible biomechanical exposure.

Screen time also represents multiple activities. Educational computer use, gaming, television, and online social interaction differ in context and may relate differently to activity, sleep, academic demands, and family circumstances. A single daily total cannot identify which component, if any, contributes to the association.

These limitations do not make questionnaire studies uninformative. They define their contribution as the following: identifying behavioral patterns and generating hypotheses that require further testing. Replication using clearly specified exposure measures would thus strengthen interpretation and the reproducibility aspect should be taken into account for the community survey design.

6.3. Sleep and the limits of plausible explanations

Sleep may be relevant to adolescent functioning, discomfort, and daily activity, but plausibility should not be mistaken for established AIS susceptibility. The evidence reviewed here does not establish insufficient sleep as an independent cause of scoliosis.

Research should distinguish sleep duration, sleep quality, and sleeping position rather than treating them as interchangeable. More broadly, neither ergonomic discomfort nor an association with sedentary routines demonstrates that these behaviors initiate structural deformity. Improving comfort and preventing AIS are different outcomes, and evidence for one should not be presented as proof of the other.

7. Treatment evidence does not establish primary prevention

Treatment trials offer an important comparison because randomization can support stronger conclusions than observational exposure studies. However, their relevance depends on the outcome being tested.

The Bracing in Adolescent Idiopathic Scoliosis Trial (BrAIST) examined adolescents at risk of progression. In the randomized intention-to-treat analysis, 75% assigned to bracing reached skeletal maturity without progression to at least 50 degrees, compared with 42% assigned to observation [8]. This supports bracing for appropriately selected patients with established scoliosis, while not showing that bracing prevents initial disease development.

Scoliosis-specific exercise must likewise be distinguished from ordinary recreational activity. Schreiber and colleagues randomized fifty adolescents to standard care with or without additional Schroth exercises. After six months, the between-group difference in the largest curve favored the exercise group by 3.5 degrees [9]. The result concerns a structured intervention, a selected clinical population, and a short-term radiographic outcome.

DOI: 10.54254/2753-8818/2027.38940

In CONTRAIS, 135 adolescents received physical activity alone or activity combined with nighttime bracing or scoliosis-specific exercise. Success, defined as progression of no more than 6 degrees, occurred in 76%, 58%, and 53% of the respective nighttime-bracing, exercise, and activity-only groups. Nighttime bracing outperformed activity alone; the exercise comparison was not statistically significant [10].

These trials need not be interpreted as directly contradictory. Their interventions, participants, and endpoints differ. The SOSORT guidelines place exercise within a broader conservative-care approach [11], but neither recommendations nor treatment effects establish that everyday exercise prevents AIS onset.

8. Quantitative evidence synthesis

The studies reviewed provide complementary quantitative evidence on AIS epidemiology, lifestyle associations, and the management of established curves (Table 1). Their different designs offer distinct contributions: prospective cohorts examine whether childhood characteristics precede later scoliosis identification, case-control studies identify potentially relevant behavioral patterns, and randomized trials evaluate interventions after diagnosis. Given differences in exposures, measurement methods, and outcomes, these findings are presented as a structured narrative synthesis rather than combined into a single pooled estimate. The shared ALSPAC cohort underlying the activity and body composition studies [5, 6] is also considered when assessing the independence of the evidence.

Table 1 summarizes the study populations, exposure measurements, outcome definitions, key numerical findings, and considerations relevant to interpretation. Together, these results help identify promising research questions and distinguish evidence concerning disease development from evidence concerning progression.

Table 1. Quantitative evidence on lifestyle factors and adolescent idiopathic scoliosis

Study (design)	Sample	Exposure as measured	Outcome definition	Key quantitative result	Principal limitation
Konieczny et al. [2] (review of prevalence series)	Published screening and school-based series	Not applicable (descriptive review)	Cobb angle ≥ 10°	Prevalence 0.47%–5.2%	Range reflects differing populations, age groups, diagnostic thresholds and screening procedures
Tobias et al. [5] (prospective cohort, ALSPAC)	Population-based birth cohort; accelerometry at 11 y; cases identified by 10 y excluded	Device-measured and reported physical activity at 11 y	Scoliosis at 15 y, DXA-based assessment	Lower childhood activity associated with later scoliosis	Observational; outcome not equivalent to a standing diagnostic radiograph
Clark et al. [6] (prospective cohort, ALSPAC)	Same cohort as [5]	Childhood BMI, lean mass and fat mass	Scoliosis identified in adolescence	Lower childhood BMI and altered lean and fat mass associated with scoliosis	Not an independent replication of [5]; body composition is a marker, not a mechanism

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Table 1. (continued)

Dou et al. [7] (case-control, Shenzhen)	491 radiographically confirmed cases; 1,346 controls	Questionnaire: reading and writing posture, perceived bag weight, weekday screen time, dairy intake	Radiographically diagnosed AIS	All four reported exposures associated with AIS	Differential recall; perceived rather than measured exposure; timing of exposure uncertain
Weinstein et al., BrAIST [8] (randomized trial, intention-to-treat)	Adolescents with AIS at risk of progression	Bracing versus observation	Skeletal maturity reached without progression to ≥ 50°	75% versus 42%	Treats an established curve; does not test primary prevention
Schreiber et al. [9] (randomized trial, assessor-blinded)	50 adolescents	Schroth exercises added to standard care for 6 months	Change in the largest Cobb angle	Between-group difference of 3.5° favoring exercise	Small sample; short follow-up; selected clinical population
Charalampidis et al., CONTRAIS [10] (three-arm randomized trial)	135 adolescents	Night-time bracing, scoliosis-specific exercise, or activity alone	Progression of ≤ 6° defined as success	Success 76%, 58% and 53% respectively	Exercise versus activity alone not statistically significant; moderate curves only

Several findings provide a foundation for further investigation. First, the prospective activity and body composition studies show that measurable childhood differences can precede scoliosis identification in adolescence [5, 6]. Although these analyses share a cohort and therefore require replication in independent populations, their temporal design supports further investigation of developmental pathways linking activity, growth, and spinal health. The activity study also reported graded associations across activity levels, providing a specific pattern for future studies to test. Such observational gradients strengthen the rationale for investigation without establishing that increasing activity prevents AIS.

Second, the case-control findings identify school-related behaviors and dietary habits that can be examined using more precise exposure measures [7]. Reported associations with posture, perceived backpack burden, screen use, and dairy habits suggest practical questions for subsequent research, including whether similar patterns are observed when exposures are measured objectively and recorded before diagnosis. Third, randomized trials demonstrate that appropriately selected interventions can improve outcomes in adolescents with established AIS [8-10]. These treatment findings illustrate the value of clearly defined interventions and outcomes, while addressing a different question from primary prevention.

Taken together, the quantitative evidence supports a research agenda centered on independent replication, reliable measurement, and longitudinal follow-up. Future studies could clarify whether lifestyle associations vary with age, sex, growth stage, and family history, and whether they persist across populations and assessment methods. A community survey could make a useful preliminary contribution by describing AIS awareness, lifestyle patterns, reported diagnoses, and barriers to evaluation. Where feasible, objective exposure measurements could be incorporated to assess the practicality of methods for a later longitudinal study. This approach would connect the existing literature with feasible community research while maintaining a clear distinction between exploratory associations and evidence of prevention.

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9. Implications for clinical communication

Current findings support a balanced explanation that AIS has biological and developmental foundations, while the contribution of modifiable lifestyle factors remains uncertain. This avoids both attributing the condition to personal habits and assuming that behavior can have no relevance.

Healthy activity and comfortable daily routines can be encouraged without promising scoliosis prevention. Similarly, identifying an association with body composition should not translate into unsupported weight-change advice. Families should understand the difference between general health recommendations and interventions shown to influence an established curve.

Disease burden also extends beyond radiographic magnitude. A fifty-year study of untreated late-onset idiopathic scoliosis found substantial adult functioning alongside back pain and cosmetic concerns [12]. Its historical population limits universal application, but it reinforces the importance of patient-centered outcomes.

Population screening is another separate question. The 2018 US Preventive Services Task Force found insufficient evidence to determine the balance of benefits and harms of screening asymptomatic adolescents [13]. This does not mean visible concerns should be ignored. Communication should distinguish uncertainty about screening programs from the need for appropriate individual evaluation.

10. Future research directions

Future studies should specify whether they investigate disease onset, progression, diagnosis, or consequences. Independent longitudinal cohorts combining repeated behavioral measurements with clinically appropriate scoliosis assessment would strengthen the evidence. Exposure definitions should distinguish recreational activity from prescribed rehabilitation, educational from recreational screen use, and perceived backpack burden from measured load.

Community surveys can provide a preliminary contribution by examining scoliosis knowledge, daily routines, family history, and barriers to evaluation. Specifically, the community survey can be proposed to examine AIS awareness, lifestyle patterns, and access to spinal health information among adolescents aged 10–18 years. Approximately 200–300 participants would be recruited through local schools and community organizations, with parental consent and adolescent assent following appropriate ethics review and institutional permissions. This would be a feasibility sample intended primarily for descriptive analysis and potential statistical analyses. A brief questionnaire, piloted with 10–15 adolescents to assess clarity and completion time, would collect the following information including age, sex, family history of scoliosis, reported clinician-diagnosed scoliosis, treatment history, recreational physical activity, educational and recreational screen time, sleep duration, and dietary habits. Questions would distinguish ordinary exercise from prescribed scoliosis rehabilitation and record whether behaviors changed after diagnosis. If feasible, trained staff would measure height, weight, and backpack weight using standardized procedures. An AIS knowledge score would summarize understanding of diagnosis, treatment, and common misconceptions. The primary analysis would describe knowledge scores, exposure distributions, and reported barriers to evaluation, with confidence intervals and explicit reporting of missing responses. Exploratory comparisons would examine whether awareness and lifestyle patterns differ by reported diagnosis and family history. Only if sufficient diagnosed cases were available would a limited logistic regression examine selected associations while accounting for age, sex, and family history. Participants without a reported diagnosis would not be assumed to be clinically free of scoliosis, and the survey would not estimate AIS incidence or establish causal effects. After questionnaire

DOI: 10.54254/2753-8818/2027.38940

completion, participants would receive an evidence-based information sheet explaining AIS and appropriate routes to professional assessment. The project would generate locally relevant educational findings, evaluate recruitment and measurement feasibility, and guide the design of a subsequent longitudinal study with clinically confirmed outcomes.

11. Conclusion

Lifestyle-related AIS research contains informative associations but limited evidence of causation. Prospective activity and body-composition studies strengthen temporal interpretation, although shared cohort membership and outcome measurement constrain the breadth of their support. School-related questionnaire findings generate additional hypotheses but remain vulnerable to recall, confounding, and reverse causation. Treatment studies address progression after scoliosis develops and cannot establish primary prevention. The most defensible interpretation is that lifestyle warrants further investigation within a biological and developmental framework, without attributing AIS to individual behavior or presenting unproven prevention strategies as established care.

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