International Platform of Registered Systematic Review and Meta-analysis Protocols

INPLASY

# Monitoring Tools in Conservative AIS Treatment: A Scoping Review Protocol

INPLASY2025100032

doi: 10.37766/inplasy2025.10.0032

Received: 9 October 2025

Published: 9 October 2025

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**ADMINISTRATIVE INFORMATION**

**Support -** No external funding declared.

**Review Stage at time of this submission -** Data analysis.

**Conflicts of interest -** None declared.

**INPLASY registration number:** INPLASY2025100032

**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 9 October 2025 and was last updated on 9 October 2025.

## INTRODUCTION

**Review question / Objective** Objective This scoping review aims to identify the available evidence for monitoring AIS patients, including the methodology and application of intelligent or innovative technology solutions for conservative treatment (bracing/ exercises), and excludes surgical interventions. The following sub-questions will be used to answer the main objective:
(A) What evidence is available on subjective data concerning user experience, perception, and needs related to monitoring during brace treatment?
(B)Monitoring Tools: What evidence is available on monitoring tools (e.g., applications or questionnaires) used during brace treatment of AIS?
(C) What evidence exists regarding the methodology and application of intelligent/smart vests in scoliosis brace treatment? What types of sensors are used, and what biometric parameters are collected by intelligent vests in this context?

**Background** The term scoliosis means crooked or curved. In general, scoliosis refers to all different types of spine, thorax, and trunk deformities. The International Scientific Society on Scoliosis, Orthopaedic, and Rehabilitation Treatment (SOSORT) suggests that 80% of reported cases are idiopathic scoliosis (IS). The term idiopathic refers to a condition or disease for which the cause is unknown. Intensive studies are needed to identify the cause of idiopathic scoliosis (Negrini et al., 2018).The adolescent patients aged 10 to 17 years (when they reach skeletal maturity) are our desired age group (Negrini et al., 2012).
The Cobb angle defines the curvature of the spine in degrees. It helps to determine the severity of the disease condition. Brace treatments are proven effective for non-operative treatment (Weinstein et al., 2013). Different types of braces are used as part of scoliosis brace treatment (Cordani et al., 2023; Costa et al., 2021; Karimi & Rabczuk, 2018; Maruyama, 2008). As health professionals recommend, patients wear braces for months or years, which can be full-time, part-time, or nighttime. Full-time brace treatment has more evidence for greater control over the progression

of the Cobb angle; however, keeping the adolescent patient motivated to use it for 18 to 23 hours is challenging.(Kaelin, 2019). It adversely affects their social life and behavior and is often considered a traumatic experience. (Rivett et al., 2009). Additionally, patients are not satisfied with the limited healthcare support. There is a need to improve the user experience for brace treatment (Sapountzi-Krepia et al., 2006; Willson et al., 2021). Making brace treatment effective is a significant challenge for patients and healthcare professionals.

**Rationale** Can the technology help motivate adolescents to wear their braces with quality and consistency?

Intelligent brace systems have demonstrated utility across various applications, including the monitoring and management of scoliosis. Research conducted by Lou et al. indicates that smart braces can effectively monitor and maintain appropriate brace pressure during daily activities (Lou et al., 2004). Healthcare professionals can monitor objective data collected through sensors to facilitate timely treatment adjustments and enable remote patient engagement (Zhu et al., 2021). Monitored data can support follow-up treatments at the hospital by providing clinicians with longitudinal insights into patient compliance. Data collected over time enables a more informed evaluation of adherence to prescribed interventions (Donzelli et al., 2012).

Sensors integrated into smart garments enable continuous, real-time tracking of patient performance during daily activities. Such monitoring supports remote supervision, personalised rehabilitation strategies, as well as data-driven clinical decision-making (Patel et al., 2012). Monitoring helps to give feedback to improve patients' home training and maintenance of body posture (Sardini et al., 2012). Scoliosis-related mobile and web-based applications vary in functionality and user-friendliness, providing support to both patients and healthcare professionals. These platforms can provide remote guidance for adolescents undergoing home training (Bottino et al., 2023). Integrating technology-assisted monitoring with the conventional clinical approaches presents promising opportunities to enhance scoliosis management. However, detailed research is needed to understand user perspectives, acceptability, and future opportunities to use technology-based sensor monitoring systems as part of brace treatment. Studies on sensors, biometric parameters observed, and challenges faced by patients in regular use are essential for designing an effective monitoring system (Wang et al., 2015). The development of clinically validated and user-accepted solutions is crucial for improving adherence and outcomes in scoliosis treatment.

Joarder et alal. report on the successful treatment outcomes in the scoping review, classifying 158 articles into two categories: radiographic outcomes, which are dominated by quantitative measures such as the Cobb angle, and HRQoL outcomes, assessed using questionnaires to evaluate AIS treatment success, while noting the absence of qualitative approaches. Integrating patient narratives to capture the biopsychosocial aspects can drive patient-centred care (Joarder et al., 2023). The study on multifactorial risk factors of adolescent idiopathic scoliosis, emphasising gender, physical activity, BMI, and backpack-related variables as influential contributors to its development and psychosocial impact (Almahmoud et al., 2023). Bertuccelli et al in the scoping review studies about body image from 24 articles and body schema from 4 articles, highlighting the prevalence of psychological distress and body schema alterations among adolescents (Bertuccelli et al., 2023). Advancements in technology have also influenced scoliosis treatment. The literature review examines emerging technologies to enhance brace treatment for adolescent idiopathic scoliosis, including sensor-based compliance tracking, 3D brace design, and finite element modeling. The author highlights that these innovations can improve treatment precision, patient adherence, and biomechanical outcomes compared to traditional methods and supports integrating patient-centred technologies to optimise conservative management (Chan et al., 2013). With this scoping review, we aim to synthesize the evidence from various studies that describe the application of smart technology integrated with patient-centered solutions for idiopathic scoliosis patients during their brace treatment in adolescence.

## METHODS

**Strategy of data synthesis** The following online databases will be searched: Medline via Ovid, Embase via Ovid, PsycINFO via Ovid, Cochrane Library via Wiley, CINAHL via EBSCOhost, Web of Science Core Collection, and Scopus. The university library experts will systematically search the electronic databases, guided by the research team and using the proposed search keywords. We will search bibliographic databases only. However, because some of these databases have index records from clinical trial registries (e.g., ClinicalTrials.gov), registry-linked results may also appear among retrieved records. Search limits will

be provided to include articles published in English. The proposed search keywords includes 'scoliosis'/ 'adolescent idiopathic scoliosis(AIS)', 'brace'/ 'corset'/ 'orthos'/ 'vest'/ 'garment'/ 'fabric'/ 'suit'/ 'velcro'/ 'Tshirt'/ 'wearables', 'sensors'/ 'intelligent'/ 'electronic'/ 'smart'/ 'digital', 'user'/ 'patient'/ 'client'and 'experience'/ 'perception'/ 'view'/ 'preference'. Discussions with librarians and the research team will be held to discuss the research question and keywords. The expert opinion from the librarians will guide the definition of the search strategy to include all the predefined research questions.

**Eligibility criteria** Types of participants
The Population, Intervention, Comparison, and Outcome (PICO) framework is the eligibility criterion used to determine which articles will be included in this proposed scoping review. Adolescent patients aged between 10 and 17 years, diagnosed with idiopathic scoliosis, are the target population (P). As part of this scoping review, surgical interventions will not be considered.

Concept
Intervention(I) refers to conservative treatment only. Various types of conservative treatment approaches have been recommended for patients with scoliosis, including brace treatments and scoliosis-specific exercises that are helpful for scoliosis patients (Negrini et al., 2012). This review is limited to conservative treatment (bracing/ exercises) and excludes surgical interventions. There are no specific Comparators (C) needed for this scoping review. Outcomes (O) are broad, encompassing all possibilities of evidence related to monitoring tools and user experience.

To address the research objectives, a broad range of study designs will be considered. These include experimental and quasi-experimental designs such as randomized controlled trials (RCTs), non-randomized controlled trials, before-and-after studies, and interrupted time-series studies. Analytical observational designs will also be included, encompassing prospective as well as retrospective cohort studies, analytical cross-sectional studies, and case-control studies. Descriptive observational designs, including case series, individual case reports that illustrate technological evidence, descriptive cross-sectional studies, and qualitative studies exploring user experience, acceptability, or feasibility, will be considered (Siripanyakhemakul et al., 2023). In addition, studies that discuss failures or challenges associated with the use of intelligent vests or mobile applications in the monitoring of adolescents with idiopathic scoliosis will also be considered for inclusion.
Context
In this review, studies will be excluded if they do not focus on adolescents diagnosed with idiopathic scoliosis (AIS) or relevant monitoring tools, or if they involve only surgical treatment approaches without reference to conservative monitoring or technology-assisted tools. Studies that do not report empirical data, including purely theoretical or conceptual discussions without applied study components or patient participation, will also be excluded. Articles published in English will be considered; publications in dual languages will be excluded to maintain consistency. Additional exclusions include opinion papers, editorials, letters to the editor, and conference abstracts lacking full-text availability. Non-peer-reviewed preprints and grey literature, such as short or one-page conference proceedings in medical contexts, will also be excluded. However, peer-reviewed, detailed conference papers published in engineering disciplines will be considered for inclusion.

Table 1: Inclusion and exclusion table
Population / Patient (P)
Inclusion criteria : Patient needs to be an adolescent who is diagnosed with idiopathic scoliosis (IS) who is undergoing conservative treatment.
Exclusion criteria: (1)Patients who had surgical interventions or non-IS pathology. (2) Non-AIS patient population.

Intervention (I)
Inclusion criteria : Conservative treatments (bracing/exercises)
Exclusion criteria: Surgical intervention

Comparators (C) : There are no specific Comparators (C) needed.
Outcomes (O) : To be broad, all outcomes related to monitoring tools and user experience will be included.

Study :
Inclusion criteria : All articles based on the search criteria will be considered.
Exclusion criteria: A readable full article cannot be obtained.

Publication type
Inclusion criteria : Peer-reviewed articles, peer-reviewed conference papers (published in engineering disciplines), opinions, and medical hypotheses

Exclusion criteria: Book reviews, editorial articles, conference abstracts (1 page), commentaries, errata, or letters to the editor. Clinical trials without a published article. Protocols that are not completed

Publication date
Inclusion criteria : All publications until 22 May 2024
Exclusion criteria: Articles after 22 May 2024

Language
Inclusion criteria : Only English
Exclusion criteria: Foreign language-based publications.

**Source of evidence screening and selection**
The Rayyan tool (https://www.rayyan.ai/) will be used collaboratively by the co-authors to manage references and facilitate joint screening. It supports the import of citations from various bibliographic databases. Collaborators will be invited to share their email addresses to access the shared workspace. Duplicate records will be identified and removed through pairwise comparison of articles using Rayyan's built-in functionality, supplemented by manual verification. Screening will be guided by predefined inclusion and exclusion criteria, with relevant labels applied throughout the process. Screening will be conducted in two main stages. In the first stage, the two authors (AM and PG) will independently assess titles and abstracts based on PICO eligibility criteria.

Disagreements will be resolved through discussion, either in person or virtually. Articles with unclear eligibility at the abstract level will proceed to full-text screening before a final decision is made. If consensus cannot be reached, a third reviewer will be consulted. This scoping review will include studies involving adolescent participants diagnosed with idiopathic scoliosis. Studies focusing on surgical interventions or non-AIS patients will be excluded. If there are any articles that need closer verification, they are done at full text screening and excluded at the second stage. Additionally, studies will be excluded during full-text screening if the full text is unavailable in a readable format.

**Data management** Data extraction will be conducted using Microsoft Excel. Full texts will be reviewed to capture relevant information in a structured table with rows representing individual studies. The framework will reflect the PICO model- Population, Intervention, and Outcome- alongside supplementary details such as author, year, journal, study design, and participant demographics (age, gender, setting). Missing information will be left blank or marked as "NR" (Not Reported). The table will be refined iteratively based on preliminary findings and discussions between two independent reviewers, with input from co-authors as needed.

The data extraction table will serve as a living document, adapting to the scope and diversity of the literature. Articles will be categorized according to specific research questions, with preliminary data on study characteristics, relevance, and methodology. This flexible approach supports meaningful synthesis and ensures responsiveness to emerging patterns. Appraisal of the article is optional for scoping reviews, but can be added if needed for internal insights.

Data charting
Data charting will be conducted as a systematic process to extract and organize key information from the included studies. This process will support the synthesis of evidence and facilitate the identification of patterns, gaps, and themes relevant to the research questions. An initial data charting template can be developed and used during the pilot screening phase to refine inclusion and exclusion criteria, identify study characteristics, and enhance inter-reviewer consistency. Based on insights gained during this phase, a revised and more structured data extraction table will be created to capture information aligned with the research objectives. Any updates to the charting framework can be made through discussion and consensus among the research group.

**Reporting results / Analysis of the evidence**
Synthesis
Data synthesis will be supported by the use of the Rayyan software tool, which will facilitate collaborative screening and cleaning of references among co-authors. Access will be granted to all team members to enable shared management of citations and screening decisions. For each included article, relevant information will be systematically recorded. The synthesis of findings will be guided by the objectives of the scoping review and the nature of the evidence obtained from the included studies.

**Presentation of the results Presentation**
Search results and screening information will be summarized with the help of the flow diagram inspired by the PRISMA-Scoping Reviews website (https://www.prisma-statement.org/scoping, https://knowledgetranslation.net/wp-content/uploads/2019/05/PRISMA-

ScR_TipSheet_Item14.pdf) and from Tricco et. al. ((Tricco et al., 2018; Tricco et al., 2016). Other observations will be presented in a meaningful way, for example, in a table format, illustrative diagrams, and detailed discussions. The data will be summarized into an article and compared against the PRISMA-ScR checklist to ensure transparent reporting of the process.

**Language restriction** Articles published in English will be considered; publications in dual languages will be excluded to maintain consistency.

**Country(ies) involved** Norway.

**Other relevant information**
ACKNOWLEDGEMENTS The authors would like to thank the university library staff Ingjerd Legreid Ødemark and Elisabeth Karlsen, , for their support in developing the search strategy. The authors would like to thank Klaus Jøran Tollan for his valuable assistance in cleaning the full-text links and Vegard Syrstad for his support in collecting the full-text literature. Their contributions are instrumental to the progress of this work.

**Keywords** brace, monitoring, scoliosis, sensor, vest.

**Dissemination plans** The findings will be disseminated through publication in a peer-reviewed journal and a conference presentation.

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