



Brace Compliance Model in Adolescents with Idiopathic Scoliosis: A Qualitative Research

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Received: 1 Sep 2024

Published: 17 Feb 2025

Abstract

Background: Evaluating the performance of a brace in the treatment of adolescents with idiopathic scoliosis, without considering the process of brace compliance, is not comprehensive and valuable. This study aimed to evaluate the multifaceted and complex modality of brace compliance by drawing a comprehensive model with a qualitative approach.

Methods: This study employed the grounded theory methodology to systematically explore and interpret factors affecting brace compliance, uncovering patterns and themes that influence treatment success. Data collection involved nonrandom convenience sampling of individuals from local clinics specializing in orthotic management of scoliosis. A semi-structured interview guide was utilized to explore participants' experiences, challenges, and perceptions related to brace compliance and orthotic treatment. We engaged in constant comparison analysis as data were collected until we reached saturation, where no new themes emerged from additional data.

Results: A total of 133 codes about the experiences of patients, parents, and specialists were extracted from the transcripts and categorized into 42 subthemes. The study identified 8 interconnected themes—including extensive lifestyle changes, visible improvements, supervision dynamics, result maintenance, a sense of difference, long-term commitment, monotony, and hope for a definitive treatment without surgery.

Conclusion: This comprehensive analysis provides valuable insights into the multifaceted nature of compliance with braces and the dynamic interplay between patients, their families, and the treatment process.

Keywords: Adolescent Idiopathic Scoliosis, Brace, Compliance, Adherence, Orthotic Treatment

Conflicts of Interest: None declared

Funding: None

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Cite this article as: Sharifi P, Kamali M, Ranjbar H, Akbarfahimi M, Babaee T. Brace Compliance Model in Adolescents with Idiopathic Scoliosis: A Qualitative Research. *Med J Islam Repub Iran.* 2025 (17 Feb);39:27. <https://doi.org/10.47176/mjiri.39.27>

Introduction

Scoliosis is characterized by lateral curvature of the spine of $>10^\circ$, accompanied by axial vertebral rotation and/or sagittal plane imbalance (1, 2). The most common form of scoliosis known as idiopathic scoliosis, reveals without any recognizable reason, encompassing 72% to 80% of patients with scoliosis (3). The prevalence of scoliosis is 2% to 4% of the population during the critical growth period between

the ages of 10 and the skeletal maturity (2, 4, 5). The primary complaint of scoliotic patients is the deformity of the spine and associated appearance deformity. If scoliosis is left untreated, consequential effects—including low back pain, cardiopulmonary problems, and psychosocial challenges—can be anticipated (6).

Treatments for scoliosis are categorized into nonsurgical

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↑What is “already known” in this topic:

The complexity of brace adherence protocols is multifaceted, shaped by various factors—including personal choices, behaviors, perspectives, social dynamics, personal relationships, family characteristics, and stress levels.

→What this article adds:

The compliance pattern of wearing braces was found to comprise 3 distinct phases of its immediate effect (from brace receipt to the first follow-up radiography), mid-term effect (from the first follow-up radiography to the completion of the first year of treatment), and long-term effect (the period from the end of the first year to the conclusion of the entire treatment process).

and surgical interventions (7). In adolescents with idiopathic scoliosis, the primary treatment action is nonsurgical interventions (8). Spinal braces as the most documented treatment option in nonsurgical interventions are prescribed for adolescents with Cobb angles between 20° to 45° (9-12). These braces aim to prevent progression or correct scoliosis (1). The effectiveness of orthotic treatment depends on several factors—including age, sex, the magnitude of the scoliotic curvature, joint flexibility, the recommended duration of brace usage, type of the brace, and in-brace curve correction (13, 14). Despite these significant variables, compliance with the brace as the central variable cannot be underrated, as noncompliance leads to a significant risk to the treatment's success (13).

The complexity of brace adherence protocols is multifaceted, shaped by various factors— including personal choices, behaviors, perspectives, social dynamics, personal relationships, family characteristics, and stress levels (15-19). Examination of the effective factors on brace compliance determines diverse and occasionally conflicting results (13, 16, 17, 20, 21). Perception of the pattern of brace compliance in adolescents with idiopathic scoliosis holds the potential to provide healthcare professionals and families with valuable approaches to the orthotic treatment process. This comprehension can facilitate the effective provision of support to improve brace adherence.

A plenary perception of the brace compliance procedure in adolescents with idiopathic scoliosis necessitates the exploration of patients' perspectives and an emphasis on asking for patient feedback. The research should conceptualize brace compliance as a human choice and behavior, admitting its complexities. Qualitative approaches, ordinary in behavioral science studies, play a crucial role in exhaustively clarifying the dimensions influencing brace compliance by delving into the depths of an individual's inner self.

Evaluating the performance of a brace in treating adolescents with idiopathic scoliosis, without considering the process of brace compliance, is not comprehensive or valuable. Understanding the compliance process can give an obvious perspective of the challenges ahead in using a brace to people involved with scoliosis, that is, patients, parents, and therapists. Therefore, this study aimed to bridge the gap in understanding the multifaceted process of brace compliance by exploring the barriers and motivators shaping adherence. A qualitative approach allows for in-depth insights into patient and family dynamics, contributing to improved treatment strategies.

Methods

Study Design

This study was approved by the ethics committee of Iran University of Medical Sciences. The qualitative research study adopted a naturalistic research paradigm, emphasizing the construction of reality by individual participants. Grounded theory methodology was employed to systematically uncover theory from data, focusing on the process of brace compliance in adolescents with idiopathic scoliosis. Ethical considerations were prioritized; all participants provided informed consent, and confidentiality along with data anonymization was strictly maintained.

Participant Selection

Data collection involved nonrandom convenience sampling of patients from local clinics specializing in orthotic management of scoliosis. Participants were diagnosed with idiopathic scoliosis aged between 10 and 16 years, were prescribed a brace by a specialized physician, and had used the brace for a minimum of 1 month.

Data Collection

Interviews were the primary data collection method, conducted either face-to-face or via phone over 6 months from February 2020 to August 2020. A semi-structured interview guide was utilized to explore participants' experiences, challenges, and perceptions related to brace compliance and orthotic treatment. Audio recordings and field notes were used to capture and document the discussions comprehensively. We engaged in constant comparison analysis as data were collected until we reached saturation, where no new themes emerged from additional data.

Analysis and Findings

The data analysis process involved one primary coder, who carefully coded the data. To ensure the reliability and accuracy of the coding process, a second coder, independently reviewed and double-checked the codes. Themes were derived through an iterative process involving data familiarization, initial coding, identification of patterns, code refinement, and theme development. The coding process involved the development of a classified coding tree. Initially, broad thematic categories were identified based on the research questions and interview content. Subsequently, these broad categories were further broken down into sub-themes and specific codes to capture the nuances and details within each thematic area. The coding tree was designed to be comprehensive, allowing for a systematic and exhaustive analysis of the data. The MAXQDA software facilitated data organization, coding, and thematic analysis. Participant checking was integrated to validate themes with participants' experiences.

Reporting

Quotations selected for the research report were chosen based on relevance, representativeness, and illustrative value. Ethical considerations were quite important, ensuring participant confidentiality and anonymity. Findings were presented transparently, with major and minor themes clearly described and supported by evidence from the data. Visual aids—such as diagrams— were used to enhance clarity, and an iterative review process ensured alignment with research objectives as follows:

1. Selection criteria: Quotations were selected based on their relevance to identified themes and their ability to capture participants' experiences, ensuring diversity and depth.
2. Representativeness: Carefully selected quotations reflected a range of participant perspectives and experiences.
3. Contextual Significance: Each quotation was contextualized to provide a clear understanding of participants' circumstances and experiences.
4. Ethical considerations: Quotation selection adhered to ethical guidelines, maintaining participants' privacy and

confidentiality.

5. Alignment with themes: Quotations directly aligned with identified themes from qualitative data analysis.

6. Illustrative value: Chosen quotations illustrated key points, emotions, or challenges expressed by participants.

7. Reflexive considerations: The selection process involved critical reflection on the representativeness and interpretive significance of each quotation.

Trustworthiness and Rigors

To enhance rigor and trustworthiness, various measures were implemented—including confirmability, transferability, credibility, dependability, and authenticity. To reflect the integrity of the findings and ensure confirmability, member checking was employed. In addition, maximum variation sampling was utilized to promote transferability. Credibility was established through peer debriefing, data triangulation, and the expertise of the first author in the subject matter. The involvement of each author in the data analysis phase enhanced dependability, ensuring the reliability and repeatability of the results. Authenticity, demonstrating the researchers' commitment to presenting diverse realities, was addressed by incorporating citations from multiple sources. Last, adherence to the combined criteria for reporting qualitative research and the standards for reporting qualitative research was maintained throughout all stages of the study process.

Results

A total of 55 individuals participated in this study—including 30 adolescents diagnosed with idiopathic scoliosis (22 girls and 8 boys), 20 parents, and 8 specialized scoliosis

healthcare providers. All participating patients were selected from adolescents with idiopathic scoliosis, aged between 10 and 16 years. These patients were at various stages of brace treatment, but all had been using a brace for at least 1 month (22). Each interview lasted about 45 minutes on average but generally, the duration of the interviews was structured to allow for in-depth exploration of the research topics while respecting the participant's time commitment.

The compliance pattern of wearing braces was found to comprise 3 distinct phases: The first phase, "Brace Immediate Effect," spans from the receipt of the brace to the first follow-up radiography, typically occurring around a month later. The subsequent phase, "Brace Mid-term Effect," extends from the first follow-up radiography to the completion of the first year of treatment. The final phase, "Brace Long-term Effect," encompasses the period from the end of the first year to the conclusion of the entire treatment process (Figure 1).

Several factors were observed to influence compliance across these phases, each exhibiting patterned properties that were analyzed as themes. Our data revealed the following integrated themes. A total of 133 codes related to the experiences of patients, parents, and specialists were extracted from the transcripts and categorized into 42 sub-themes. Finally, 8 broad themes were identified. The themes and subthemes are presented in Table 1.

Theme 1: Extensive Changes in Lifestyle

When employing a brace that encompasses a considerable portion of an individual's trunk, it becomes imperative to implement significant modifications to their lifestyle.

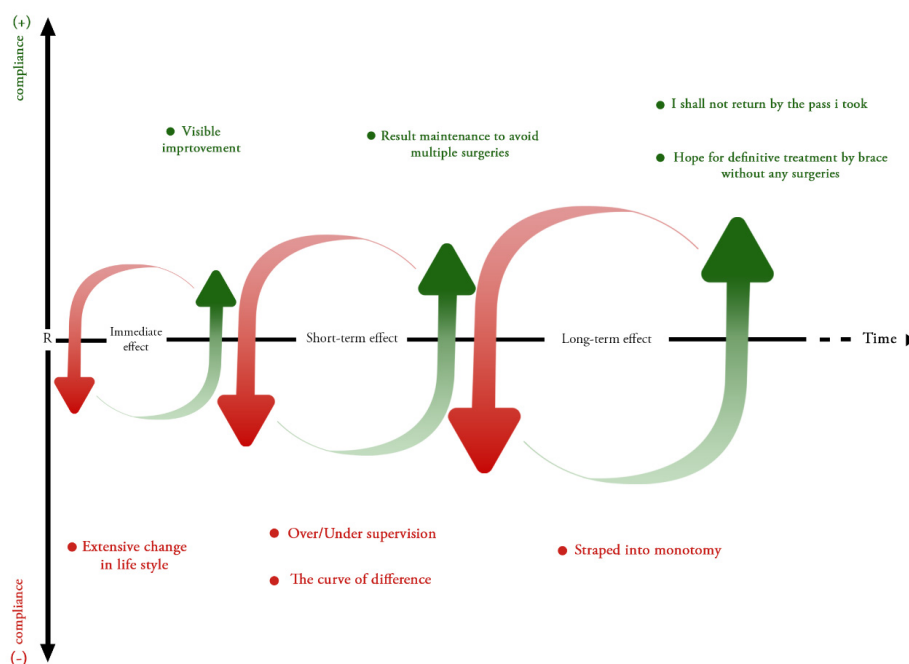


Figure 1. Representation of brace compliance over time in adolescents with idiopathic scoliosis

Table 1. Themes and Subthemes of Brace Compliance in Adolescents with Idiopathic Scoliosis

Themes	Sub-themes
Extensive changes in lifestyle	Damage to clothes Fear of physical contact Limitation in social activities sleeping Problems with a brace Restrictions on clothing choices Restrictions on hairstyle choices (in CTLSOs only) Educational decline Decreased concentration Skin issues difficulties in eating & drinking Limitations in crouching Limitations in looking down (in CTLSOs only) Overheating and excessive sweating in the brace Acoustic noise of the brace during movements Suffocation feeling Increased stress-level Physical pain Limitations in sitting Restrictions in professional sports activities Restrictions in professional musical activities
Visible improvement	Improved respiratory condition Posture improvements Increased height Reduction in visible humps Decrease in Cobb-angle on radiography
Over/Under supervision	Excessive or insufficient sympathy with the patient Disproportionate Reward / Punishment Decisions made on behalf of the patient
Result maintenance to avoid multiple surgeries Sense of difference	Fear of surgery Feeling of commiseration Fear of negative reactions and judgment Depression Self-image concerns with the brace Facing labels Self-comparison with others
I Shall Not return by the path I took Strapped into monotony	Rationalizing the treatment Long treatment duration with a brace Depression Prolonged lifestyle limitations Distress
Hope for definitive treatment by brace without surgeries	Eliminating the need for surgery

These modifications entail the wearing of the brace for prolonged durations, encompassing both daytime and nighttime, often extending over several years. The extensive lifestyle adjustments imposed on the patient are not inherently desirable for them or their family. Changes in standing, sitting, and sleeping positions, alterations in patterns of using sanitary facilities and eating, and even modifications in clothing choices and the type and level of daily activities will pose considerable challenges over a prolonged period of several years.

“...When I was at home, I wanted to draw, it was difficult for me how to sit, how to stand up, how to do my work, or when I wanted to bend down and pick something up, I didn't know what to do.”

In essence, patients must undergo lifestyle modifications across 3 biopsychosocial dimensions for effective compatibility with a brace.

Theme 2: Visible Improvements

The optimal therapeutic impact of bracing on scoliosis,

improving associated symptoms, and reducing Cobb-angles is most pronounced at the initiation of treatment. This defined timeframe extends from the commencement of brace application until the first radiographic assessment, typically occurring within the initial month. Improvements in the patient's condition at this stage are often manifested as observable changes, fostering an increased motivation for brace treatment in both the patient and their family. These changes encompass a noticeable reduction in trunk deformity, an increase in height, enhanced respiratory capacity, improved posture, and the like.

“...My back was straight while I wore a brace. Every female should make sure that the clothing she wears fits properly. I felt much better in the clothes after using the brace.”

Theme 3: Over / Under Supervision

Maintaining therapeutic achievements considering the progressive nature of scoliosis and preserving the procedure of scoliosis improvement, albeit at a slower rate, is a therapeutic goal that comes into focus for the treatment

team after the immediate effective period of brace intervention. Achieving this therapeutic goal requires the patient's concerted effort, sufficient and timely follow-ups, meticulous periodic assessments, and maintaining the patient's morale. Considering the patient's age group and the challenges in justifying the treatment to adolescents, coupled with the difficulty in obtaining 100% cooperation from them, achieving this goal necessitates parental supervisory roles as much as required. Parental supervisory actions should be "sufficient." Excessive or insufficient strictness in supervision can lead to reduced compliance or even abandonment of the brace by the adolescent.

"...They keep telling you something like a robot that stays in your brain, it's very annoying, and worse, it makes you want to not do it. When someone bothers me too much to do something or tries to make me understand something, I get angry and I say to myself, now that I'm like this, I won't do it at all."

Theme 4: Result in Maintenance to Avoid Multiple Surgeries

The success of the brace in controlling the progression of scoliosis prevents the need for multiple surgeries until the end of the patient's growth period. As long as the patient's growth plates are open, undergoing surgery implies the loss of the patient's chance to achieve their maximum growth potential. This may necessitate multiple surgeries in some cases. The side effects of surgery before the closure of growth plates are a factor that underscores the necessity of using a brace, despite the challenges associated with its usage:

"...I endure the difficulties of the brace so that my condition does not lead to surgery."

Therefore, avoiding multiple surgeries and awareness of the side effects of premature surgery in patients with open growth plates serve as motivational factors for improving the adherence of the brace.

Theme 5: Sense of Difference

Using braces during adolescence can make young individuals feel different from their peers. Over time, this might create challenges in how they interact with others or lead to a sense of being apart from the community. Additionally, the idea that wearing braces may imply a form of disability and limit lifestyle choices can make adolescents reluctant to use them, despite the recognized threat of scoliosis and the practical advantages of braces.

"...When I look in the mirror, sometimes I am scared. I say, what is this?"

Even if these concerns do not materialize, there's a significant risk of causing serious emotional stress to the adolescent, and this aspect should be carefully considered.

Theme 6: I Shall Not Return by the Path I Took

The objective of utilizing a brace in the "long term" is not solely for comprehensive improvement but primarily directed toward the stabilization of the patient's condition. At this stage, treatment progression does not signify extensive

changes in reducing the Cobb angle and creating observable changes in the patient. The perceived benefits of the brace are restricted to controlling the natural progression of scoliosis. In other words, the significance of the brace lies in its absence; neglecting its use leads to the advancement of the deformity.

"...Whenever I leave my braces for a while, my spine's deformity increases again."

As the adolescent's growth plates gradually close, the chance and advantage of the brace for correction and control deformity progression become more limited in the event of scoliotic deformity recurrence. The patient's tendency to complete the brace treatment and not abandon the achieved results, which have been the culmination of considerable effort and hardship, serves as a long-term motivation to deter the patient from discarding the brace abruptly.

Theme 7: Strapped into Monotony

Despite the patient's understanding of the role of the brace in deformity amelioration, disease progression control, and the potential postponement or avoidance of surgery in the treatment process, the prolonged duration of brace therapy, coupled with its extensive impact on the adolescent's lifestyle and the imposition of significant constraints relative to the general population, dissuades the patient from continuing brace treatment under circumstances where they become receptive to the repercussions of their decision.

"...It made me tired and bored. It was monotonous for me"

Theme 8: Hope for Definitive Treatment by Brace without Surgeries

Throughout the initiation of orthotic treatment, patients and their families often maintain hopes for a comprehensive and conclusive treatment outcome with the brace, despite the treatment team emphasizing its role in disease prevention rather than absolute cure.

"...I know that by the age of 16 if I wear the brace regularly and do my exercises, the problem will be solved. This makes us hopeful."

This enduring optimism serves as a motivational force for brace adherence until the concluding phases of orthotic treatment.

Contextual Variables

Understanding the multifaceted nature of brace compliance in adolescents with idiopathic scoliosis necessitates a comprehensive evaluation of contextual variables. These variables, encompassing demographic, psychological, social, and environmental factors, play a critical role in shaping attitudes and behaviors toward brace usage. Given the complexity of brace adherence, it is imperative to examine these contextual variables to identify potential barriers and facilitators that influence treatment outcomes. This evaluation not only facilitates a deeper understanding of the factors influencing compliance but also informs the development of targeted interventions that can mitigate challenges and strengthen motivators, thereby enhancing the overall

Table 2. Contextual Variables Influencing Brace Compliance in Adolescents with Idiopathic Scoliosis

	Contextual variable	Facilitator performance	Obstructor performance
1	Awareness/Knowledge	Comprehensive understanding of scoliosis	Lack of awareness or misinformation
2	Expertise of the treatment team	Highly specialized expert team	Involvement of non-specialist
3	Trust in the treatment team	Strong trust in the therapist	Distrust toward the therapist
4	Cost of brace (finance aspects)	Insurance coverage for brace costs	The prohibitive cost of the brace
5	Moral/personality type	Compatible personality traits	Incompatible personality traits
6	Cognitive biases	Positive past experiences	Negative past experiences
7	Interest in the practitioner	Genuine interest in the therapist	Disliking the therapist
8	Weather condition	Cold and dry climate	Hot and humid climate
9	Season of year	winter season	summer season
10	Time of brace usage initiation	During school holidays	During school term
11	Counseling	Expert consultant on the treatment team	Lack of expert consultants; reliance on non-specialist
12	Parental perspective on brace use	Parental agreement on the importance of brace use	Parental disagreement or single parenthood
13	Communication with other patients	Active group therapy & patient communication	Limited interaction with other patients
14	Brace design	Customizable design to meet patient preferences	Inflexible & non-customizable brace design
15	Clinic environment	Well-organized & suitable clinic atmosphere	Chaotic & poorly planned clinic environment
16	Instructions for brace use	Detailed explanations & training provided	Insufficient training & instructions given
17	Brace fitting	Custom design	Prefabricated design
18	regular brace adjustment	Timely & disciplined adjustments	Irregular & undisciplined adjustment
19	Accessibility of treatment center	Convenient access to treatment center	Difficult access to treatment center
20	Self-comparing	Comparison with other patients' experiences	Comparison with non-affected individuals

success of orthotic treatment in scoliosis management. The main contextual variables are presented in Table 2.

Discussion

Our research evaluated the multifaceted nature of brace compliance among adolescents with idiopathic scoliosis, as revealed by the study's results. It explored the dynamic interplay between perceived benefits and barriers, which shaped compliance patterns throughout treatment. The study identified 3 distinct phases of compliance: the "Brace Immediate Effect," the "Brace Mid-term Effect," and the "Brace Long-term Effect." Each phase presented unique challenges and motivations for patients and influenced their compliance with orthotic treatment.

Maintaining and controlling short-term brace compliance was found to be achievable with simple methods and supplementary guidelines. However, keeping long-term adherence needs cognitive adjustments and behavioral management (1). Therefore, acceptance of the brace at a specific time frame did not necessarily guarantee acceptance in preceding or subsequent phases. As highlighted in a study by Ugwonali et al, comparing the quality of life between scoliotic patients using braces at different stages of treatment was noted as a limitation of the study. The authors suggested that the experience of wearing a brace varied at different time points and that the psychosocial impacts differed throughout the treatment phases (2-4).

Thematic analysis of the experiences of adolescents with idiopathic scoliosis undergoing bracing identified 8 core themes influencing adherence. These themes included extensive lifestyle changes, visible improvements, varying degrees of supervision by parents, result maintenance to avoid multiple surgeries, a sense of difference, long-term commitment, monotony, and hope for definitive treatment without surgery. The extracted themes demonstrated the

complex interaction between physical, emotional, and social factors affecting brace compliance (2). These findings emphasized the importance of proper interventions to support adolescents throughout their orthotic treatment journey. An essential component for providing appropriate and effective intervention protocols was the understanding of the brace compliance procedure and understanding the contextual variables, enabling the treatment team to realistically perceive the prognosis of brace application (5).

Considering the multifaceted nature of brace compliance, which is dependent on various factors and critical treatment milestones, our findings underscored the importance of addressing barriers and motivations in treatment adherence. By recognizing these complexities, specialists, and families could have developed appropriate strategies to reduce constraints and enhance motivations, ultimately optimizing treatment outcomes (1).

Within the realm of brace compliance, quantitative studies have often yielded conflictive or nongeneralizable findings. This trend was attributed to a prevalent static and linear conceptualization of compliance in these studies (5), whereas compliance was found to be a layered, dynamic, and variable phenomenon shaped by a complex interplay of factors. Examining the contextual variables helped identify obstructers and facilitators, which informed targeted interventions to improve treatment outcomes and the overall success of orthotic treatment.

Facilitators—such comprehensive knowledge about scoliosis and a specialized treatment team—laid the foundation for a strong therapeutic alliance. Trust in the treatment team emerged as a critical component, highlighting the importance of an intense patient-therapist relationship. Financial accessibility, sometimes overlooked, played a pivotal role in ensuring continued treatment adherence. Personality traits and past experiences can exert a profound influence

on treatment outcomes. A patient's interest in their practitioner and the compatibility of their moral or personality type with the treatment regimen either enhanced or reduced the success of the intervention acceptance. Environmental factors—including weather conditions and the season—introduced another layer of complexity. The findings suggested that patients were more compliant with brace usage in colder, drier climates, which could inform the timing of treatment initiation. The role of counseling and expert consultants could not be understated. A multidisciplinary approach that included expert consultants as part of the treatment team provided a holistic view of the patient's condition and offered additional support and guidance. Parental consensus on the importance of brace use and the ability to communicate with other patients creates a supportive network that can amplify a patient's resolve during treatment. Conversely, dissension among parents or limited communication with peers led to feelings of isolation and reduced treatment adherence. The design and fitting of the brace, along with the clinic environment and the instructions provided, were practical considerations that directly impacted the patient's experience. Customizable designs, a well-organized clinic atmosphere, and clear instructions are all facilitators that contributed to a positive treatment experience. Accessibility to the treatment center and the opportunity for self-comparison with other patients completed the spectrum of contextual variables. Easy access to the treatment center reduces logistical barriers, while self-comparison with peers can provide a sense of community and shared experience. By recognizing and addressing these variables, healthcare providers could optimize treatment outcomes and improve the overall experience for patients with scoliosis.

Limitations

Several cognitive limitations may have impacted our results—including recall bias and social desirability bias. In addition, the subjective nature of qualitative data interpretation admitted a risk of researcher bias, despite precise coding and peer review attempts. The sampling from local clinics limited the generalizability of our findings. Cultural differences, healthcare system variations, and differences in type and design of brace may have affected the applicability of our results to other populations. Building on the insights gained from this study, future research should aim to develop predictive models or tools that can objectively evaluate brace compliance likelihood in adolescents with idiopathic scoliosis before the initiation of treatment. These tools could leverage identified barriers and motivators, providing a standardized means of prognostic assessment. In addition, the implementation of structured intervention programs designed to enhance compliance may improve bracing outcomes in adolescent idiopathic scoliosis. Such programs could include educational initiatives, tailored counseling sessions, and behavior modification strategies aimed at addressing patient-specific challenges. Furthermore, the effectiveness of these interventions should be rigorously evaluated through objective metrics, such as brace usage monitoring and clinical outcomes. Comparing these metrics with conventional treatment protocols will provide

valuable data for the feasibility and efficacy of predictive and interventional approaches, ultimately refining best practices in the management of idiopathic scoliosis.

Conclusion

One of the fundamental issues in the brace treatment of adolescents with scoliosis is individual compliance, as its psychological and social consequences can lead to non-use of the brace and ultimately result in treatment failure. This study reveals the complex interplay of factors influencing brace compliance, offering actionable insights to enhance adherence strategies and optimize treatment outcomes.

Authors' Contributions

P.Sh., the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article, and revising it critically for important intellectual content, final approval of the version to be submitted; M.K., H.R., M.A., and T.B., the conception and design of the study, revising the article critically for important intellectual content, and final approval of the version to be submitted.

Ethical Considerations

The study protocol was approved by the Ethics Committee of Iran University of Medical Sciences (IR.IUMS.REC.1399.420).

Acknowledgment

The authors would like to thank the participants for their cooperation with the study.

Conflict of Interests

The authors declare that they have no competing interests.

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