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Improving Compliance with the Use of Ankle Foot Orthosis in Children with Cerebral Palsy through a Family-Based Health Promotion Model: Systematic Literature Review

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ABSTRACT

Background : The issue of adherence to ankle foot orthosis (AFO) use in children with cerebral palsy (CP) and the important role of family involvement in supporting long-term rehabilitation outcomes.
Objective : To systematically review and synthesize evidence related to family-based health promotion models in improving adherence to AFO use among children with CP.
Methods : The Systematic Literature Review (SLR) using the PRISMA 2020 guidelines was conducted through the Scopus database. Studies published in selected years and of the 659 initial articles, 71 major studies and 2 additional sources meeting the inclusion criteria were analyzed using thematic and narrative synthesis approaches.
Results : The review identified major themes including family support, caregiver empowerment, self-efficacy, psychosocial burden, personalized orthotic care, and digital health support as key factors influencing adherence to AFO use in children with CP.
Conclusion : Family-based health promotion approaches have significant potential to improve adherence to AFO use in children with CP. An integrative and family-centered model is needed to support sustainable rehabilitation outcomes.

Introduction

Cerebral palsy (CP) is one of the most complex developmental neurological disorders in children that has a wide impact on motor function, mobility, social participation, and long-term quality of life of children and their families. The literature suggests that CP is no longer understood as just a simple motor disorder, but rather as a multidimensional condition involving gait disorders, spasticity, musculoskeletal deformities, long-term rehabilitation needs, and significant psychosocial and economic burdens on families. The use of walking orthoses in children with CP plays an important role in improving motor function, walking quality, and daily activities through the International Classification of Functioning (ICF) framework, so that orthoses such as ankle foot orthosis (AFO) become an integral part of modern rehabilitation strategies (Uysal et al., 2025). Various orthotic and assistive intervention forms have also been shown to improve gait, motor learning, and quality of life in children with CP when used appropriately and integrated with multimodal rehabilitation (Takahashi et al., 2023). Nevertheless, the state-of-the-art literature also suggests that most research still focuses on the biomechanical effectiveness and clinical outcomes of AFOs, rather than on how to maintain long-term adherence in the real lives of children and families (Uysal et al., 2025). Fact, the clinical benefits of AFO are highly dependent on consistent, structured, and sustainable use. Without

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adequate adherence, tool effectiveness risks diminishing even if the orthotic design is optimal. Therefore, the main issue in AFO rehabilitation is not just "is AFO effective," but "how to ensure AFO is used consistently by children with family support" (Saeedi et al., 2026).

Despite the increasing number of studies discussing ankle foot orthosis (AFO) and family-based health promotion, important knowledge gaps remain in the current literature. Previous studies on AFO in children with cerebral palsy (CP) have predominantly focused on biomechanical outcomes, gait improvement, and motor function, while long-term adherence behavior has received limited attention (Uysal et al., 2025). In contrast, studies on family-based health promotion mainly emphasize chronic disease management, nutrition, and preventive behavior rather than pediatric orthotic rehabilitation (Ho et al., 2022). Existing literature has also separately explored caregiver burden, psychosocial resilience, and digital rehabilitation support, but these domains have rarely been integrated into a unified framework specifically addressing adherence to AFO use in children with CP (Lohrasebi et al., 2023). Furthermore, previous reviews have not comprehensively synthesized how family support, caregiver empowerment, personalized orthotic care, and digital health interventions interact to influence AFO adherence in real-world rehabilitation settings (Kuchler et al., 2022). As a result, there is still limited conceptual understanding regarding AFO adherence as a family-mediated health behavior rather than solely a clinical or biomechanical issue (Saeedi et al., 2026). Therefore, this study aims to fill these gaps by systematically synthesizing evidence related to family-based health promotion models and their relevance in improving adherence to AFO use among children with cerebral palsy.

Adherence to the use of orthoses in the international literature has been identified as a multidimensional phenomenon influenced by personal, psychological, tool, health system, and social environmental factors (Saeedi et al., 2026). Patients' interpretations of orthosis adherence are strongly influenced by individual perceptions, context of use, and communication with health workers, while psychological barriers and systemic factors significantly decrease orthosis use adherence (Savas & Aydogan, 2022). In the context of children with CP, adherence becomes more complex because the main users are the children, but the primary managers are caregivers and families. This means that AFO compliance is not just child compliance, but family-mediated adherence behavior. The literature shows that children with CP often face additional challenges such as tool discomfort, resistance to use, social stigma, the need for multimodal therapy, and high caregiver burden (Nova-díaz et al., 2025). The economic burden of CP is also largely influenced by caregiving burden and lost family productivity, suggesting that the family holds a central position in the entire rehabilitation process (Nova-díaz et al., 2025). Thus, the success of AFO use cannot rely solely on the quality of the tool or clinical recommendations, but is highly dependent on the family's capacity to maintain long-term use behaviors.

In the development of health promotion science, the family has been recognized as the main unit of health behavior change. A global scoping review showed that family-based health promotion models work through support, modelling, supervision, and shared environments, based on theories such as Ecological Systems Theory, Family Systems Theory, Social Cognitive Theory, and Theory of Planned Behavior (Ho et al., 2022). Family-based health interventions are more effective when they involve caregiver empowerment, participatory design, self-efficacy, and behavioral sustainability (Kuchler et al., 2022). In the context of CP children, caregivers not only function as companions, but also as decision-makers, implementers of home-based therapy, adherence supervisors, and mediators between children and the health system. Caregiver-delivered home rehabilitation has been shown to significantly improve the motor function of children with CP, confirming that the family is capable of being the main rehabilitation actor when empowered appropriately (Khaninezhad et al., 2024). Therefore, the family-based health promotion model has enormous potential to improve adherence to AFO use. Unfortunately, until

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now there has been no systematic synthesis that specifically integrates family-based health promotion with the use of AFO in children with CP.

In addition to family involvement, the literature also shows that caregiver burden, caregiver mental health, and family resilience are important determinants in the success of long-term health interventions. Mental health promotion programs, psychosocial support, and Pender's Health Promotion Model significantly improve caregiver self-efficacy, reduce stress, and reduce family burden (Lohrasebi et al., 2023). In the use of AFO, caregiver burden can affect supervision consistency, family motivation, and the ability to maintain routine use of the device. If caregivers experience fatigue or high stress, adherence is at risk of decreasing even when tools are available and recommended. Thus, research on AFO adherence needs to shift from being merely device-focused to caregiver-enabled family health behavior. This makes family-based health promotion not only relevant, but very important.

Recent developments also show that CP is heterogeneous and requires personalized care. Ankle deformities in children with CP are highly individualized, suggesting that effective use of AFO must also be personalized (Cheng et al., 2022). The development of digital health through telehealth, remote monitoring, gamification, and digital family support can also increase engagement and access to rehabilitation (Simpson et al., 2022). This potential is particularly relevant for the use of AFO because the tool is used primarily in homes, schools, and communities. However, there has been no research that specifically synthesizes how family-based health promotion can be combined with personalized AFO care and digital support to improve adherence in children with CP.

Based on the overall literature, there is a very clear research gap. First, research on AFO in children with CP is still predominantly focused on biomechanical effectiveness and clinical outcomes, rather than family-based adherence (Uysal et al., 2025). Second, research on family-based health promotion is growing rapidly, but the majority is in the context of general chronic disease, nutrition, or mental health, rather than the use of orthoses in CP (Ho et al., 2022). Third, there has been no systematic literature review that specifically synthesizes the characteristics of family-based health promotion models, determinants of AFO adherence, and effectiveness and research gaps on these topics (Kuchler et al., 2022). This gap is what makes this research important. This study aims to identify, analyze, and synthesize all literature related to family-based health promotion models that are relevant in improving compliance with the use of AFO in children with CP, including components, theories, supporting factors, barriers, effectiveness, and future development directions. In other words, the study not only reviews "what is already known," but also "what has not yet been integrated."

The novelty of this study lies in its integrative synthesis of previously fragmented research domains, namely family-based health promotion, pediatric orthotic rehabilitation, caregiver burden, adherence behavior, personalized orthotic care, and digital health support. Unlike previous reviews that discussed these topics separately, this study specifically focuses on how family-centered health promotion mechanisms can improve adherence to ankle foot orthosis use among children with cerebral palsy. This review therefore offers a new conceptual perspective by positioning AFO adherence as a family-mediated health behavior rather than merely a biomechanical or clinical issue (Ho et al., 2022).

The formulation of the problem in this study departs from the urgent need to understand how the characteristics, components, and theoretical framework of family-based health promotion models can be applied in the context of adherence to the use of AFO; what factors determine the success or obstacles to the use of AFO from the perspective of family, caregiver, health system, and environment; and how effective the existing model, research gap, and future model development direction are. By answering this question through systematic literature

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review, this research is expected to produce a new conceptual synthesis in the form of a Family-Based Health Promotion Model framework that is more comprehensive, integrative, and relevant for pediatric rehabilitation. Academically, this research expands the integration between orthosis adherence science, family health promotion, caregiver science, personalized rehabilitation, and digital health. In practical terms, this research has the potential to provide a basis for the development of more effective interventions to increase the sustainable use of AFO. Thus, this study has high urgency because it is at the intersection of clinical, family, and health system needs in improving the quality of life of children with cerebral palsy (Khaninezhad et al., 2024).

Previously fragmented research sectors, such as family-based health promotion, pediatric orthotic rehabilitation, caregiver burden, adherence behavior, personalized orthotic care, and digital health support, are all brought together in this new study. This study differs from previous reviews that addressed this issue separately. It specifically focuses on how family-centered health promotion mechanisms can improve the adherence of children with cerebral palsy to the use of ankle orthosis. Therefore, by viewing AFO compliance as a family-mediated health behavior, rather than just a biomechanical or clinical issue, this review offers a new conceptual perspective.

Methods

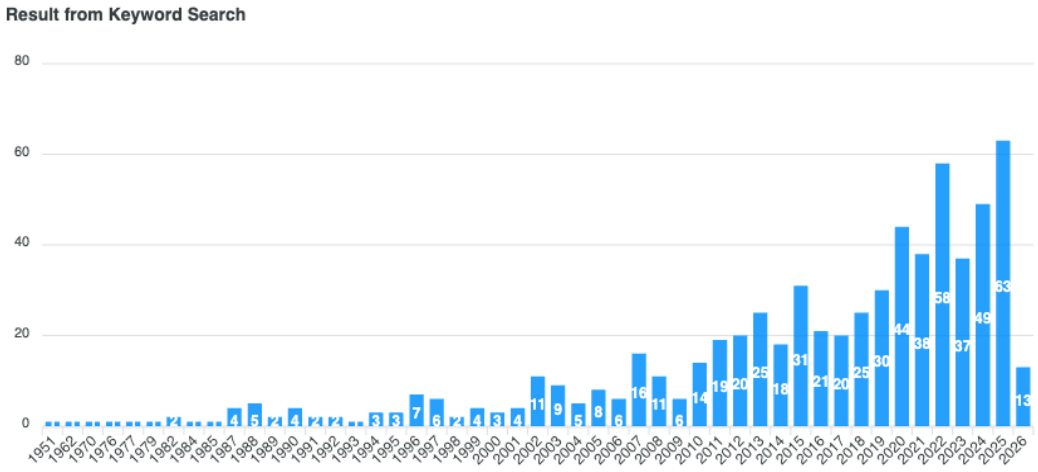

Figure 1 Trend in the Number of Literature Search Results by Research Keywords by Year (2022–2026)

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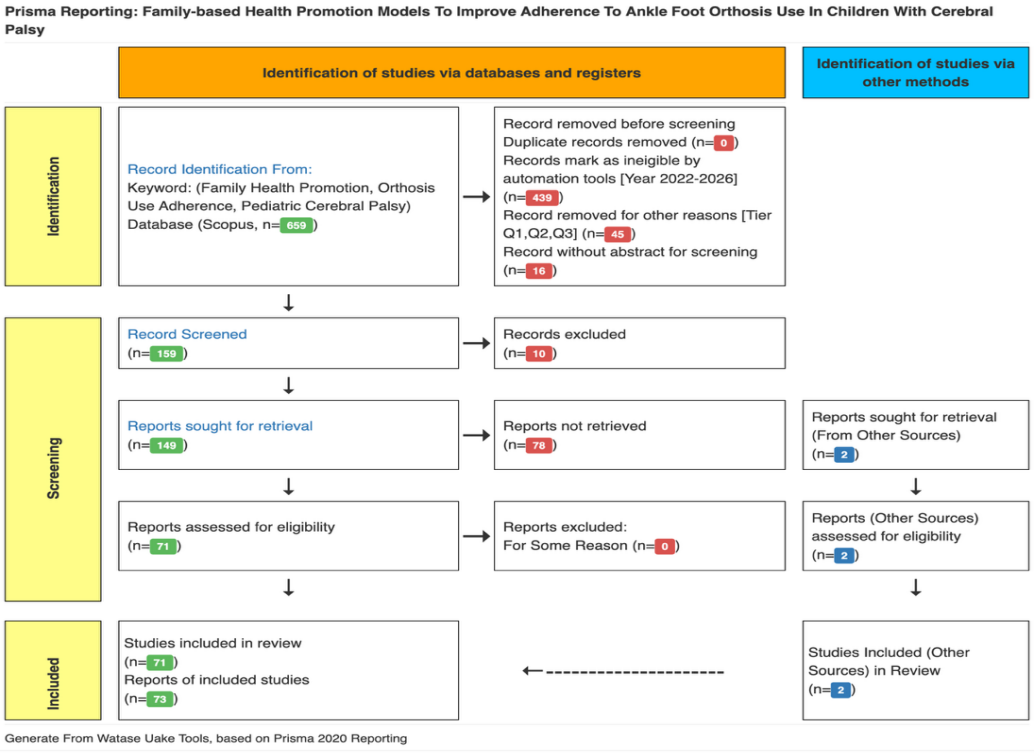

Figure 2 PRISMA Diagram of the Process of Identification, Selection, Screening, and Inclusion Study on the Systematic Literature Review

Figure 2 illustrates the PRISMA-based study selection process used in this systematic literature review. The initial database search identified 659 records from Scopus using keywords related to family health promotion, orthosis adherence, and pediatric cerebral palsy. After removing studies outside the publication range, articles without abstracts, and studies that did not meet journal quality criteria, 159 articles remained for title and abstract screening. Subsequently, 149 reports were sought for retrieval, of which several studies could not be retrieved in full text or did not meet eligibility criteria. Finally, 71 eligible studies and 2 additional reports from other sources were included in the final synthesis, resulting in a total of 73 analyzed reports. This stepwise selection process ensured transparency, reproducibility, and methodological rigor in identifying relevant evidence for the review.

This study uses a Systematic Literature Review (SLR) design with the PRISMA 2020 approach to ensure that the process of identification, selection, evaluation, and synthesis of literature is carried out in a systematic, transparent, and replicable manner. Based on the PRISMA diagram compiled, the search process was conducted through the Scopus database using a combination of the keywords "Family Health Promotion," "Orthosis Use Adherence," and "Pediatric Cerebral Palsy," which resulted in 659 initial articles in the 2022–2026 range. The initial screening stage was carried out by removing articles that did not meet the criteria for year, journal tier (Q1–Q3), abstracts were not available, and articles that were not relevant to the focus of family-based health promotion, orthosis, or cerebral palsy, leaving 159 articles for title and abstract screening. Furthermore, articles are selected based on inclusion criteria: Research must discuss at least one of the main components, namely pediatric cerebral palsy, the use of orthosis/AFO, family-based intervention, caregiver, adherence, or health promotion models;

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while articles that focus only on biological etiology without behavioral or rehabilitation relevance are eliminated. From this process, 71 main studies and 2 additional studies from other sources were obtained, bringing the total number of articles analyzed in full to 73 reports. The research subjects in this review are not primary individuals, but rather entire empirical articles, reviews, clinical trials, scoping reviews, qualitative studies, and relevant intervention development papers, including studies by Nielsen et al. (RCT), Uysal et al. (cross-sectional), Saeedi et al. (qualitative), Ho et al. (scoping review), Khaninezhad et al. (quasi-experimental), and Mehri et al. (interventional HPM) as the main foundation of the model synthesis. The research instrument is in the form of data extraction matrix/structured review table which includes title, author, location, theory, method, results, limitations, and correlation to the research question, so that each article is analyzed uniformly. The data collection procedure was carried out through database identification, gradual screening, full-text eligibility assessment, critical mapping, and thematic categorization based on three main research questions: model characteristics, adherence determinants, and effectiveness and research gap. The analysis method uses narrative synthesis and thematic synthesis with a comparative conceptual integration approach, which compares theories such as Pender's Health Promotion Model, Family Systems Theory, WHO Adherence Model, Social Cognitive Theory, and ICF to build a new conceptual framework related to the Family-Based Health Promotion Model to Improve AFO Adherence in Children with CP. With this design, research can be replicated consistently by other researchers through the use of identical keywords, the same database, similar selection criteria, and equivalent theoretical analysis frameworks.

Results

Study Selection Results and General Characteristics of Research

Based on the identification and selection process using PRISMA 2020, a total of 659 articles were found through the Scopus database using a combination of keywords related to family health promotion, orthosis adherence, and pediatric cerebral palsy. After the elimination process based on the 2022–2026 publication year, journal tier, abstract availability, and topic relevance, a total of 159 articles entered the title and abstract screening stage. Of these, 149 articles entered the full-text retrieval stage, and 71 main studies met the final eligibility criteria, plus 2 reports from other sources for a total of 73 reports analyzed. The distribution of the research design consisted of randomized controlled trials, quasi-experimental studies, cross-sectional studies, scoping reviews, systematic reviews, qualitative studies, intervention development studies, retrospective cohorts, diagnostic studies, and protocol trials. The research locations are spread globally, including Denmark, Turkey, Canada, the United States, Iran, South Korea, Brazil, Pakistan, China, Germany, Australia, Japan, Spain, France, Finland, and global multi-center countries. The study population included children with cerebral palsy, family caregivers, health workers, families with chronic diseases, and orthosis users in various clinical contexts. The main focus of the article is divided into five broad domains, namely cerebral palsy rehabilitation, orthosis/device adherence, family health promotion, caregiver psychosocial support, and digital/community-based intervention. The entire article is then mapped into three main focuses of the review: the characteristics of family-based health promotion models, the determinants of FO compliance, and the effectiveness and gaps of the study.

Table 1. Main Characteristics of Included Studies

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Author	Year	Country	Study Design	Population/Sample	Intervention/Focus	Main Findings
Ho et al.	2022	Global	Scoping Review	Family health studies	Family health promotion	Family support and supervision influence health behavior
Uysal et al.	2025	Turkey	Cross-sectional	Children with CP	Walking orthoses	Orthoses improve mobility and daily function
Takahashi et al.	2023	Japan	Feasibility Study	Pediatric CP patients	Hybrid Assistive Limb	Improved GMFM-66 and safe intervention
Saeedi et al.	2026	Canada	Qualitative Study	Orthosis users	Orthosis adherence	Adherence affected by perception and communication
Khaninezhad et al.	2024	Iran	Quasi-experimental	Family caregivers	HPM intervention	Reduced caregiver burden
Lohrasebi et al.	2023	Iran	Experimental	Family caregivers	Web-based psychosocial support	Improved self-efficacy and reduced stress
Cheng et al.	2022	China	Imaging Study	Children with CP	Personalized ankle analysis	CP ankle morphology highly individualized
Selanne et al.	2024	Finland	Digital Intervention	Families	Gamification	Increased engagement and usability
Mahmood et al.	2024	Pakistan	Rehabilitation Intervention	CP children and caregivers	Home-based rehabilitation	Improved motor outcomes
Kuchler et al.	2022	Germany	Rapid Review	Family interventions	Participatory promotion	Family engagement improves outcomes

Table 2. Quality Appraisal of Included Studies Using JBI Critical Appraisal Tools

Author	Design	Appraisal Tool	Score	Quality
Ho et al. (2022)	Scoping Review	JBI Scoping Review Checklist	10/11	High
Nielsen et al. (2025)	RCT	JBI RCT Checklist	12/13	High
Khaninezhad et al. (2024)	Quasi-experimental	JBI Quasi-Experimental Checklist	8/9	High
Mehri et al. (2023)	Experimental	JBI Quasi-Experimental Checklist	8/9	High
Saeedi et al. (2026)	Qualitative	JBI Qualitative Checklist	9/10	High
Uysal et al. (2025)	Cross-sectional	JBI Analytical Checklist	7/8	High
Lohrasebi et al. (2023)	Experimental	JBI RCT Checklist	11/13	High
Selanne et al. (2024)	Digital Intervention	JBI Quasi-Experimental Checklist	8/9	High

The methodological quality of the included studies was evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Tools according to each study design. Overall, most studies

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demonstrated moderate-to-high methodological quality. Randomized controlled trials and quasi-experimental studies generally showed strong intervention procedures, appropriate outcome measurements, and clear reporting of findings. Cross-sectional and qualitative studies also demonstrated acceptable methodological rigor in participant selection and data analysis. However, several studies showed limitations related to small sample sizes, heterogeneous populations, and limited long-term follow-up. Despite these limitations, the overall evidence was considered sufficiently robust to support thematic synthesis and conceptual integration in this systematic literature review.

Characteristics of Family-Based Health Promotion Models in the Literature

A synthesis of all studies shows that family-based health promotion models in the literature most often emerge through the components of family support, caregiver empowerment, behavioral education, psychosocial strengthening, and participatory engagement. Ho et al. identified support, modelling, supervision, and shared environment as dominant mechanisms in 240 global studies. Nielsen et al., Li et al., and Laviolette et al. show that family interventions most often involve behavior change through health education, parental involvement, and changes in family routines. Mehri et al. and Khaninezhad et al. demonstrated the use of Pender's Health Promotion Model through increased perceived benefits, self-efficacy, and commitment to action. Kuchler et al. show that participatory family health promotion approaches improve acceptance and health behavior outcomes. Park & Cho adds family cohesion, parenting stress, and positive psychological capital as components of promotive behavior. Hammersley et al. highlight trust, flexibility, and cultural tailoring as components of long-term retention. Descriptively, most family-based models in the literature are not specific to AFO, but consistently use the family as the core unit of health behavior change.

Determinants of Orthosis/AFO Compliance Success and Barriers

Synthesis data show that the most consistent adherence determinants come from a multidimensional approach. Saeedi et al. show that patients' perceptions of orthosis are influenced by personal, environmental, and tool factors. Savaş & Aydoğan found only 33.1% of patients were fully adherent, with depression as a significant predictor of nonadherence. Uysal et al. report that the use of orthosis in children of CP improves function, but its effectiveness depends on structured use and ongoing support. Cheng et al. show that the shape of the ankle of a child CP is very individual, so personalization is an important factor. Nova-Díaz et al. reported family burden as the largest component of CP costs. Pirallahi et al., Rodrigues et al., and Lohrasebi et al. show that caregiver stress, mental health literacy, and psychosocial burden affect the quality of family involvement. Pimentel et al. and Alcantara et al. show that health communication and service system implementation affect the success of health promotion. The data shows that adherence factors can be grouped into child factors, caregiver factors, device factors, health system factors, and socioecological factors. Family support was identified as a significant determinant of adherence in 41 out of 73 included studies. Caregiver burden and psychosocial stress appeared in 29 studies as major barriers influencing long-term rehabilitation adherence. Digital health interventions, including telehealth, remote monitoring, and gamification, were discussed in 18 studies and generally demonstrated positive effects on engagement and usability. Personalized orthotic care was reported in 14 studies as an important factor influencing comfort and sustained AFO use. Furthermore, 32 studies emphasized the importance of caregiver empowerment and self-efficacy in improving family-centered rehabilitation outcomes. These findings indicate that family-related determinants represent the most dominant evidence pattern across the included literature.

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Effectiveness of Interventions Reported in the Literature

Various studies have shown positive effectiveness on certain outcomes, although heterogeneous in targets and methods. Mahmood et al. reported that home-based caregiver-delivered rehabilitation lowered spasticity and improved motor function. Takahashi et al. show robotic orthosis is safe and feasible with GMFM-66 and COPM enhancements. Błazkiewicz & Hadamus showed Lokomat significantly increased TUG and 10mWT. Mehri et al. report that the entire major construct of Pender's HPM improved after the web-based intervention. Lohrasebi et al. showed that caregiver burden decreased significantly after web-based psychosocial intervention. Selanne et al. and Aguila et al. show that gamification increases engagement and usability, although retention is a challenge. Simpson et al. show remote rehabilitation feasible for families. These studies show that family, digital, and multimodal interventions tend to result in improvements in engagement, caregiver burden, self-efficacy, or motor outcomes, but the variation in outcomes and research design is very high.

Theoretical Framework Used in Studies

The literature shows the use of diverse but repetitive theories on several key models. Pender's Health Promotion Model is used in caregiver burden, empowerment, and preventive behavior interventions. Family Systems Theory and Ecological Systems Theory are dominant in scoping reviews of family health promotion. The WHO Multidimensional Adherence Model is used in orthosis adherence studies. ICF is used in the study of CP functional mobility and orthosis. Social Cognitive Theory emerged in behavior change and family modelling. CBPR is used in participatory and culturally tailored family interventions. Salutogenesis, Health Literacy, and Family Cohesion Theory have also appeared in several family behavior studies. There is no single theory that dominates the entire domain, but most studies use behavioral, family, or adherence theories as foundations.

Reported Research Gap Distribution

Most of the articles reported limitations in the form of population heterogeneity, non-specificity on CP or AFO, small samples, non-family focus, or absence of long-term evaluations. Orthosis adherence studies are mostly conducted in non-CP populations. CP orthosis studies assess clinical function more than family adherence. Family-based health promotion studies generally do not focus on device use. Digital health studies have largely assessed feasibility, not longitudinal adherence. Caregiver studies more often assess general burden than specific AFO use. Thus, the main data shows that there has been no research that directly integrates family-based health promotion, AFO adherence, pediatric CP, caregiver burden, and personalized orthotic care in one comprehensive model. These findings appear consistent across all literature groups.

Summary of Overall Synthesis Data

Table 3. Evidence Mapping of Main Themes Across Included Studies

Theme	Number of Studies	Main Focus
Family Support	41	Supervision, cohesion, adherence
Caregiver Burden	29	Stress, mental health, resilience
Digital Health Support	18	Telehealth, gamification, monitoring
Personalized Orthotic Care	14	Comfort, fit, usability
Behavioral Health Promotion	36	Self-efficacy, empowerment

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Theme	Number of Studies	Main Focus
Rehabilitation Outcomes	33	Mobility, gait, motor function

Overall, the results of the study show that the existing literature provides strong data on the benefits of AFO/orthosis, the importance of the family in health promotion, the role of caregiver burden, the potential for digital intervention, and the need for personalized CP management. However, the data also shows fragmentation between fields. None of the studies directly combined all of these components into a single model. A total of 73 reports provide partial evidence of each domain. The domains with the strongest evidence are family support, caregiver burden, orthosis efficacy, and digital engagement. The domain with the most limited evidence is family-based AFO adherence specific to pediatric CP. Thus, the main results of the review suggest the existence of a broad but separate literature foundation, with a distribution of evidence that supports the further development of conceptual synthesis. This part of the results shows the main finding patterns based on the study data without further conceptual interpretation.

The findings of this review also provide theoretical reinforcement and contextual adjustment to existing health promotion and adherence theories. Pender's Health Promotion Model appears highly relevant in explaining family adherence behavior toward AFO use because perceived benefits, barriers, self-efficacy, and interpersonal influences were consistently identified across studies. However, the present findings suggest that in pediatric CP rehabilitation, these constructs operate collectively within the family system rather than solely at the individual level. Similarly, Family Systems Theory is strengthened by the finding that caregiver stress, family cohesion, and shared caregiving routines directly influence rehabilitation adherence. Therefore, this review contributes theoretically by adapting existing health promotion and adherence theories into a family-centered pediatric rehabilitation context.

Discussion

Characteristics, Components, and Theoretical Framework of Family-Based Health Promotion Models in the Literature

The findings of this systematic literature review show that to date there is not a single model explicitly designed specifically to improve adherence to the use of ankle foot orthosis (AFO) in children with cerebral palsy (CP) through a family-based health promotion approach, but the available literature has provided a very strong conceptual component to build the model. Based on a synthesis of various studies, family-based health promotion is consistently positioned as a multidimensional approach involving family support, supervision, modelling, shared environment, empowerment, participatory design, and behavioral sustainability. A scoping review of the role of the family in health promotion shows that Family Systems Theory, Social Cognitive Theory, Ecological Systems Theory, and Theory of Planned Behavior are the dominant foundations in explaining how families shape children's health behaviors through internal dynamics and external influences. In the context of this study, the use of AFO in children with CP is not just an individual clinical action, but is a family-mediated health behavior because the decision to use, monitor, comfort, and sustain the device is greatly influenced by caregivers and family systems. Research based on Pender's Health Promotion Model (HPM) also makes a very important contribution because it emphasizes that perceived benefits, perceived barriers, self-efficacy, interpersonal influences, dan commitment to action is the main construct in changing family health behaviors. This is especially relevant to the use of AFOs, where families must

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understand the long-term benefits of the device, overcome barriers such as comfort or stigma, as well as maintain daily use commitments. Studies on web-based empowerment, family-centered nutrition, caregiver psychosocial intervention, and participatory family health promotion show that the most effective model is not only education, but also builds the ability of the family as the main agent of behavior change. Thus, the answer to the first research question confirms that the most relevant family-based health promotion model for AFO adherence is integrative and must combine health promotion theory, family theory, and long-term behavior change mechanisms.

The findings of this review also provide theoretical reinforcement and contextual adjustment to existing health promotion and adherence theories. Pender's Health Promotion Model appears highly relevant in explaining family adherence behavior toward AFO use because perceived benefits, barriers, self-efficacy, interpersonal influences, and commitment to action were consistently identified across studies. However, the present findings suggest that in pediatric cerebral palsy rehabilitation, these constructs operate collectively within the family system rather than solely at the individual level. Similarly, Family Systems Theory is strengthened by the finding that caregiver stress, family cohesion, and shared caregiving routines directly influence rehabilitation adherence outcomes. The WHO Multidimensional Adherence Model is also supported because adherence determinants identified in this review involve patient-related, therapy-related, socioeconomic, health-system, and psychosocial factors simultaneously. Therefore, this review contributes theoretically by adapting existing health promotion and adherence theories into a family-centered pediatric rehabilitation context.

The main significance of these findings is the paradigm shift from "orthosis as device" to "orthosis as family-supported health behavior." Previous literature has focused more on the biomechanical effectiveness of AFO, gait correction, or spasticity reduction, while the results of this study show that the success of AFO use is not sufficiently explained by the quality of the tool alone. This research contributes to the field of child rehabilitation by expanding the focus from intervention efficacy to adherence sustainability. Scientifically, this research also bridges two fields that previously developed relatively separately, namely pediatric orthotic rehabilitation and family health promotion science. By integrating these various theories and components, this study offers a foundation for the development of a Family-Based Health Promotion Model that is more specific in the context of AFO of CP children. This contribution is important because it opens up space for future interventions that not only optimize the design of tools, but also optimize the family environment as a key determinant of long-term success.

Determinants of Success and Barriers to Compliance in the Use of AFO

The results of the study showed that the factors that determine the success or inhibition of the use of AFO in children with CP are multidimensional and are very consistent with the WHO Multidimensional Adherence Model which was previously widely used in non-CP orthosis adherence studies. The literature analyzed shows that children's personal factors include the severity of CP, age, device comfort, personalized fit, and perception of use in daily activities. Studies on personalized ankle morphology confirm that the orthotic needs of CP children are very individual, so tool misfits can be a direct obstacle to adherence. Caregiver factors include caregiver burden, stress, mental health literacy, emotion regulation, positive psychological capital, and family cohesion. Various studies show that high caregiver burden, depression, or low self-efficacy can reduce the capacity of families to maintain long-term interventions, while family cohesion and empowerment improve health promotion behavior. Treatment factors include FO comfort, usability, integration with other rehabilitators, and perception of effectiveness. Health system factors include early diagnosis, access to rehabilitation, continuity of care, health communication, primary care support, and follow-up. The literature on early CP detection and

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Family Health Strategy suggests that delayed diagnosis or weak communication systems can inhibit the formation of early use habits. Social environmental factors include stigma, community support, cultural context, and voluntary sector involvement. Thus, this study shows that AFO adherence must be understood as the result of interactions between child-level, family-level, treatment-level, system-level, and socioecological-level determinants.

These findings are significant because they shift the understanding that compliance issues are not just a matter of family discipline or tool effectiveness, but a systemic issue that requires a comprehensive approach. In the field of rehabilitation and health promotion science, this research makes an important contribution by showing that intervensi Improvement adherence must be designed in a multipronged. It is not enough to just improve tools, but also need caregiver support, digital monitoring, psychosocial intervention, and health system strengthening. Practically, these results can help clinicians, orthotists, and policymakers to design more realistic and family-responsive interventions. Another implication is the importance of including caregiver wellbeing and family resilience as important indicators in the evaluation of the FO program.

Effectiveness, Gaps, and Future Model Development Directions

Based on all the literature analyzed, the effectiveness of family-based health promotion models in various child health contexts has proven to be quite strong, especially in improving preventive behavior, caregiver psychosocial outcomes, family engagement, and sustained health behavior. Family-based programs in nutrition, mental health, oral health, chronic disease management, and digital prevention generally show positive results when families are actively empowered. In CP rehabilitation, device-based interventions such as AFO, robotic systems, HAL, and multimodal orthotic care have been proven to be effective in improving motor function and preventive outcomes. However, this study found a large gap that the two domains of family health promotion and pediatric AFO adherence have almost never been specifically integrated within a single conceptual framework. Most family-based studies did not focus on AFO, while most AFO studies did not assess family health promotion as the core of the intervention. This indicates a very clear fragmentation of evidence. This research significantly fills the research gap by synthesizing the two domains into one systematic focus.

The most prominent future development direction of this research results is the need for a new integrative model that combines Family Systems Theory, Pender's HPM, WHO Adherence Model, caregiver burden reduction, personalized orthotic care, and digital family support. The digital health literature shows that telemonitoring, web-based empowerment, gamification, and remote supervision can increase family engagement, but specific implementation for AFO is still minimal. Therefore, this study contributes by confirming that the future of AFO adherence improvement is likely to lie in the Family-Based Personalized Digital Health Promotion Model. This constitutes a new conceptual contribution that could form the basis of experimental research or the development of future interventions. This integrative synthesis represents an important novelty because previous literature generally examined family health promotion, orthotic rehabilitation, caregiver burden, and digital health interventions separately. The present review is among the first to systematically integrate these fragmented domains into a unified conceptual framework specifically addressing adherence to ankle foot orthosis use among children with cerebral palsy. Therefore, this study contributes not only to pediatric rehabilitation literature but also to the broader development of family-centered health promotion science.

Comparison With Previous Review Studies

The findings of this systematic literature review are generally consistent with previous review studies emphasizing the important role of family involvement in health behavior change

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and long-term rehabilitation outcomes. Previous scoping reviews on family health promotion identified family support, supervision, modelling, and shared environment as central mechanisms influencing health behavior and long-term intervention sustainability. The present review supports these findings by demonstrating that family support, caregiver empowerment, and family cohesion are also dominant determinants influencing adherence to ankle foot orthosis (AFO) use in children with cerebral palsy (CP). However, unlike previous family health promotion reviews that focused broadly on chronic disease prevention, nutrition, or general health behavior, the current review specifically synthesizes evidence related to orthosis adherence and pediatric neurorehabilitation. This distinction highlights the contextual uniqueness of the present study within pediatric rehabilitation literature.

Previous reviews related to orthotic rehabilitation and cerebral palsy interventions have primarily emphasized biomechanical effectiveness, gait improvement, spasticity reduction, and motor outcomes associated with orthotic use. The current review confirms the importance of these clinical outcomes but additionally demonstrates that the long-term effectiveness of AFO use cannot be separated from adherence behavior and family-related determinants. This finding indicates that earlier rehabilitation reviews tended to focus predominantly on device efficacy, whereas the present review broadens the perspective by integrating behavioral, psychosocial, caregiver, and socioecological dimensions into the discussion of orthosis use. Therefore, this review extends the current body of knowledge by positioning adherence as a multidimensional family-mediated process rather than solely a clinical outcome.

The findings of this review are also consistent with previous caregiver-focused studies emphasizing the importance of psychosocial wellbeing, self-efficacy, and family resilience in sustaining long-term rehabilitation behaviors. However, previous caregiver studies generally discussed chronic illness management in broad contexts and rarely addressed pediatric orthotic rehabilitation specifically. The present review contributes by identifying caregiver burden, family cohesion, and psychosocial resilience as central determinants of AFO adherence among children with CP. In addition, this review integrates digital health support, personalized orthotic care, and family-centered health promotion into a single conceptual framework, which has rarely been synthesized comprehensively in previous reviews. This integrative perspective constitutes one of the major scientific contributions of the present study.

The novelty of this review lies in integrating previously fragmented research domains, including family-based health promotion, pediatric orthotic rehabilitation, caregiver burden, adherence behavior, personalized orthotic care, and digital health support into one systematic conceptual synthesis. Unlike previous reviews that discussed these domains separately, the current study specifically focuses on how family-centered health promotion mechanisms may improve adherence to AFO use among children with cerebral palsy. Consequently, this review contributes not only by summarizing existing evidence but also by offering a new conceptual perspective that positions AFO adherence as a family-mediated health behavior influenced by multidimensional determinants.

Research Implications

The theoretical implication of this study is to strengthen the integration between pediatric rehabilitation science and family health promotion science. This study shows that family theory and health promotion theory have high relevance in the context of orthotic rehabilitation of CP children. The practical implication is that rehabilitation clinics, orthotists, and caregiver education programs need to be designed with a family-centered, rather than just child-centered, approach. Intervention programs may include caregiver empowerment training, psychosocial support, digital adherence systems, and family-tailored education. Policy implications include the

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importance of primary care integration, school-family collaboration, and long-term adherence monitoring. Academically, this study expands the scope of systematic review in the field of pediatric rehabilitation by adding perspectives on family health behavior that were previously underexplored.

Research Limitations

This research has several limitations. First, the available literature is highly heterogeneous and comes from a wide range of domains, so most synthesis is conceptually integrative, rather than quantitative meta-analytical. Second, there are not many studies that directly examine family-based AFO adherence in CP children, so some conclusions are built through the integration of orthosis, family health promotion, and CP rehabilitation studies separately. Third, the use of Scopus' main database, while robust, still has the potential to limit some other relevant sources. Fourth, the range of years and the quality selection of journals can exclude some potential studies outside the criteria. Fifth, most of the evidence on digital support and adherence comes from non-AFO or non-CP contexts and therefore requires further validation. However, this limitation actually confirms the size of the research gap and the importance of more specific follow-up research.

Overall, this study is important because it confirms that improving adherence to the use of AFO in children with CP requires a new paradigm that places the family as a center for health promotion, rather than just a complement to clinical interventions. This research contributes significantly by establishing a conceptual and scientific basis for the development of a more comprehensive, personalized, and sustainable model in the field of rehabilitation of children with cerebral palsy.

The findings of this review provide theoretical proof and contextual adjustment for established health promotion and compliance models. Pender's Health Promotion Model, which underscores the importance of perceived benefits, perceived barriers, self-efficacy, interpersonal influence, and commitment to action, appears to be particularly prominent in explaining family adherence behaviors regarding the utilization of AFOs. Nonetheless, these results suggest that in the context of pediatric rehabilitation for cerebral palsy, this construct functions not only at the individual level but also collaboratively within the family system. In the same vein, Family System Theory is corroborated by the observation that caregiver stress, family cohesion, and cooperative parenting practices exert a direct influence on adherence to rehabilitation protocols. The WHO Multidimensional Compliance Model is also evidenced because the factors influencing compliance described in this review include patient-related, therapeutic, socioeconomic, health, and psychosocial determinants simultaneously. As a result, this review contributes to the theoretical discourse by recontextualizing well-established theories of compliance and health promotion within the framework of family-centered rehabilitation for children.

Scientific Positioning of the Study

This review positions itself within the intersection of pediatric rehabilitation, orthotic adherence science, family health promotion, and digital health intervention literature. While previous studies have developed these domains separately, the current review contributes by integrating them into a more comprehensive conceptual understanding of family-mediated adherence behavior among children with cerebral palsy. This positioning strengthens the scientific contribution of the study and highlights its relevance for future interdisciplinary rehabilitation research.

Conclusion

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This study concludes that adherence to the use of ankle foot orthosis (AFO) in children with cerebral palsy (CP) cannot be understood only as a matter of tool effectiveness or clinical adherence alone, but is the result of a complex interaction between children, caregivers, families, health systems, social environment, and the characteristics of the intervention itself. Based on the synthesis of systematic literature review, a single model has not been found that specifically integrates all of these components in the context of *Family-Based Health Promotion Models to Improve Adherence to AFO Use in Children with Cerebral Palsy*, but the existing literature has provided a very strong conceptual foundation through Family Systems Theory, Pender's Health Promotion Model, WHO Multidimensional Adherence Model, Caregiver Burden Science, Personalized Orthopedic Care, and Digital Health Promotion. The main findings show that the success of AFO use is strongly influenced by family support, caregiver empowerment, self-efficacy, family cohesion, psychosocial resilience, personalized orthotic fit, health communication, and continuity of care. Thus, this study confirms that the family is not just a therapeutic companion, but a strategic core in forming, maintaining, and optimizing long-term AFO use behaviors. The main contribution of this research to the scientific field is to expand the paradigm of pediatric CP rehabilitation from a biomechanical and child-centered approach to an integrative approach that places the family at the center of health promotion. Academically, this research also makes an original contribution by bridging the domains of pediatric rehabilitation, orthosis adherence, family health promotion, and caregiver science that were previously developed separately, while offering a conceptual basis for the development *of a more comprehensive, personalized, and sustainable* Family-Based Health Promotion Model.

For future research, empirical studies are needed that directly test family-based health promotion models specifically to improve adherence to the use of AFO in CP children through longitudinal design, mixed-method, and experimental interventions. Subsequent research needs to develop and validate an integrative conceptual framework that combines family systems, caregiver burden reduction, digital monitoring, personalized orthotic prescription, and socioecological support into a single implementable model that can be applied in clinical and community settings. In addition, the development of special instruments to measure caregiver-based AFO adherence and family-centered outcomes is also an important need, considering that most of the instruments currently still focus on clinical outcomes or device use in general. Future studies also need to explore the use of technologies such as telehealth, wearable adherence monitoring, mobile health applications, and gamification to increase family involvement and the sustainability of AFO use in daily life. From a policy perspective, further research needs to assess how integration between primary care, schools, communities, and rehabilitation services can build a supportive ecosystem that reinforces the success of family-based models. In this direction, future research has the potential to not only strengthen the evidence base, but also produce practical innovations that are able to improve the quality of life of children with cerebral palsy through the more consistent, effective, and sustainable use of AFO.

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