Comparative Efficacy of Treatment Approaches for Autism Spectrum Disorders: A Systematic Review

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Abstract. This systematic review focuses on evaluating three widely used intervention approaches for autism spectrum disorders (ASD): technology-based parent-mediated programs, developmental social pragmatic (DSP) approaches, and augmentative and alternative communication (AAC) systems. ASD is characterized by challenges in communication, social interaction, and adaptive functioning. The review highlights the unique strengths of each approach, such as empowering parents as active participants, fostering naturalistic social engagement, and supporting communication for non-verbal children. However, variability in implementation and a lack of long-term studies underscore the need for integrated and personalized strategies. Future research should prioritize combining these interventions with emerging technologies to enhance developmental outcomes through collaborative efforts among families, educators, and healthcare providers.

Keywords: Autism Spectrum Disorder (ASD), Early Intervention, Therapeutic Interventions, Technology-Based Tools, Adaptive Behaviors.

1. Introduction

Autism Spectrum Disorders (ASD) are a group of complex neurodevelopmental conditions affecting approximately 1% of children worldwide, with a higher prevalence among males, exhibiting a male-to-female ratio of 4.22 [1]. Core features of ASD include persistent difficulties in social communication, restricted interests, and repetitive behaviors, which can significantly impair verbal and nonverbal communication and the ability to form and maintain interpersonal relationships [2]. The multidimensional impacts of ASD extend beyond the individual, influencing the psychological, physical, and socio-economic well-being of families and caregivers, often necessitating substantial adjustments to daily life to address the unique challenges posed by the condition. Early diagnosis and intervention are widely recognized as pivotal in altering developmental trajectories and improving quality of life for children with ASD. Evidence-based research underscores the efficacy of tailored, highly structured therapeutic programs in enhancing social skills, communication capabilities, and adaptive behaviors over time. Such interventions not only support the developmental needs of children but also alleviate some of the burdens experienced by caregivers, highlighting the importance of early and individualized approaches in the comprehensive management of ASD [1].

Existing research has largely focused on specific therapeutic methods, such as behavioral interventions, developmental social pragmatic approaches, or augmentative and alternative communication systems. However, these studies often operate in isolation, lacking a comprehensive framework to integrate these approaches and address the heterogeneity of ASD profiles. Furthermore, the long-term sustainability and scalability of interventions remain underexplored. This gap highlights the need for a more holistic approach that not only bridges disparate methods but also considers the evolving needs of individuals with ASD across their lifespan.

It is characterized by significant deficits in social communication and social interaction, as well as patterns of restricted and repetitive behaviors. These core features manifest in multifarious ways, adding further diversity to the disorder. The variability in verbal language development presents particular challenges in designing effective educational and therapeutic interventions that can address the unique profiles and strengths of each individual with ASD [3]. Moreover, the impact of ASD extends beyond childhood, affecting educational attainment, employment opportunities, and social integration in adulthood. The lifelong needs of individuals with ASD must be addressed in a

comprehensive manner that spans healthcare, education, employment, and community support systems.

While ASD present significant challenges, advances in research and growing awareness continue to drive improvements in early detection, intervention strategies, and support services. By fostering greater understanding and offering tailored support, we can work toward better outcomes and a higher quality of life for people with ASD and their families, building an inclusive, supportive environment for all.

2. Literature Review

ASD is a complex neurodevelopmental condition characterized by persistent difficulties in social communication, restricted interests, and repetitive behaviors. The condition manifests with significant heterogeneity in its presentation, affecting individuals' cognitive, emotional, and social functioning across the lifespan. Research indicates that ASD can profoundly influence the quality of life for both individuals diagnosed with the condition and their families. Studies suggest that individuals with ASD often experience challenges in life domains such as relationships, safety, future security, and personal achievement, which collectively contribute to reduced overall well-being. This underscores the importance of early diagnosis, effective interventions, and holistic support systems to enhance outcomes and quality of life for individuals with ASD.

Advancements in intervention strategies have shown promise in supporting individuals with ASD and engaging families in the therapeutic process. Rogerson et al. (2018) evaluated Therapy Outcomes by You (TOBY), a tablet-based tool for parent-mediated early behavioral intervention. Parents reported that TOBY facilitated meaningful interactions, provided structured therapeutic activities, and boosted their confidence in supporting their child's development. However, challenges such as variability in children's responses and time-intensive preparation were noted, highlighting the need for adaptability in intervention delivery. Developmental social pragmatic (DSP) approaches have also demonstrated effectiveness in fostering social communication. Binns and Cardy (2019) conducted a systematic review of DSP interventions, which utilize child-led, naturalistic interactions to improve foundational skills like joint attention, initiation, and reciprocity. While language development outcomes varied, the interventions significantly enhanced caregiver responsiveness and synchrony, reinforcing the importance of collaborative efforts between families and practitioners. For children with complex communication needs, augmentative and alternative communication (AAC) systems have been explored as viable solutions. Ganz et al. (2015) compared visual scene displays (VSDs) and exchange-based communication (EBC) systems. Results suggested that VSDs may be particularly effective for children with strong verbal imitation abilities, enhancing spontaneous communication and speech production. However, small sample sizes and methodological limitations restrict the generalizability of these findings, emphasizing the need for further research.

Early diagnosis remains pivotal in improving outcomes for individuals with ASD. Iwasa et al. (2019) highlighted the importance of early identification, reporting an average diagnosis age of 41.6 months in a Japanese sample. Although early diagnosis can be emotionally challenging for parents, supportive and collaborative approaches by healthcare providers can mitigate stress and foster parental engagement, a key determinant of intervention success. Personalized strategies, particularly in speech-language pathology, have proven essential in addressing the unique profiles of individuals with ASD [4,5]. As individuals transition to adulthood, challenges persist in education, employment, and social integration. Research underscores the necessity of ongoing support in these areas to promote successful societal integration [4,6]. Additionally, the co-occurrence of mental health conditions, such as anxiety and depression, highlights the critical need for integrated treatment approaches that address both ASD symptoms and associated mental health concerns [7]. A multidisciplinary, collaborative framework involving families, educators, and healthcare providers is essential for fostering holistic development and improving quality of life across the lifespan [4,6].

Based on the dual perspectives of early intervention and integrated treatment, this review synthesizes the following mainstream therapeutic approaches: (1) technology-based parent-mediated programs such as TOBY; (2) child-led, naturalistic interventions like DSP approaches; and (3) communication-focused AAC systems. The findings aim to provide actionable insights into optimizing these strategies while advocating for their integration into comprehensive, personalized frameworks to meet the diverse and evolving needs of individuals with ASD.

2.1. Methodology

2.1.1. Early Diagnosis and Intervention Studies

The early diagnosis of ASD typically occurs around 41.6 months of age, often preceding parental recognition of developmental anomalies. A majority of parents (58.2%) expressed satisfaction with the timing of the diagnosis, although some desired earlier communication. The diagnostic process encompasses initial screenings at 18 months, followed by comprehensive evaluations by specialists [8]. A study, conducted by researchers from the Yokohama Rehabilitation Center and other institutions, surveyed 80 parents of preschool children diagnosed with ASD to examine their experiences with the diagnostic disclosure process [8]. It advocates for a nuanced approach, suggesting that while early diagnosis is generally advantageous, the timing should be tailored to individual circumstances and parental readiness. This intervention encompasses initial screenings at 18 months during public health checkups to identify developmental disorders. Subsequently, children diagnosed with ASD engage in an intensive early intervention program at the Yokohama Rehabilitation Center, which involves therapy sessions lasting four hours per day, at least two days per week, conducted in small groups. The intervention underscores the significance of parental involvement, providing parents with guidance and support to manage their child's developmental challenges [8]. Continuous monitoring and regular assessments by child psychiatrists and clinical psychologists are integral to the program, ensuring the child's progress is meticulously tracked and the intervention is adjusted as necessary to optimize developmental outcomes.

2.1.2. Vocabulary Acquisition Research

Vocabulary acquisition research for ASD children refers to the study of how they learn and generalize new words across different modalities (receptive and expressive). The research investigates the processes and effectiveness of teaching vocabulary to children with ASD, focusing on their ability to transfer learned vocabulary from one modality to another without direct instruction in the second modality. Vocabulary acquisition research detailed in the article from Su and her team in 2019 examines the cross-modal generalization of receptive and expressive vocabulary in children with ASD. Using a single-case parallel treatments design, the study involved teaching unfamiliar vocabulary words through a combined storybook and play intervention. The findings revealed that while all children learned target words in both conditions, cross-modal generalization was more successful from expressive to receptive vocabulary than the reverse [5]. This research underscores the complexity of vocabulary learning in children with ASD and highlights the need for tailored interventions to enhance both receptive and expressive language skills.

2.1.3. Quality of Life Assessment

A cross-sectional study focusing on Spanish-speaking women with ASD employed an online survey methodology to assess quality of life [6]. The research included a large sample of 1,182 participants across four groups: diagnosed ASD, self-diagnosed ASD, non-ASD women, and ASD men. The study utilized the Personal Wellbeing Index-Adult (PWI-A) for quantitative measurement of quality of life across various domains. Statistical analyses, including chi-squared tests, t-tests, and Welch's corrected ANOVA, were used to compare outcomes between groups. This comprehensive approach provided a nuanced understanding of the unique challenges faced by women with ASD in different life areas [6].

2.1.4. Scoping Reviews of Speech-Language Pathology Interventions

Scoping reviews of speech-language pathology (SLP) interventions provide a comprehensive overview of existing research, focusing on the breadth and characteristics of interventions for individuals with autism spectrum disorder (ASD). It highlights the critical role of SLPs in addressing developmental challenges, particularly in preschool-aged children. For instance, a review spanning studies from 1980 to 2019 identified nine skill development areas targeted by interventions, including social communication, language, augmentative and alternative communication (AAC), and play, with social communication and language being the primary focus. The theoretical approaches underlying these interventions ranged from clinician-directed to child-centered and hybrid models, reflecting the diversity of methodologies in the field. Despite the increase in research output over the past decade, this review revealed significant gaps, including a lack of methodological rigor and insufficient reporting on intervention specifics, such as dosage and delivery models. These limitations highlight the need for aligning research with real-world practices to improve outcomes for children with ASD [4].

Building on this, another study emphasized the importance of interventions across the lifespan, particularly in fostering self-actualization and reducing risks of social maladaptation in individuals with ASD. It underscored the necessity of tailored psychological support that addresses social, emotional, and cognitive deficits, not only in childhood but also in adolescence and adulthood. This approach highlights the critical role of structured environments and individualized support in enabling individuals with ASD to navigate complex social settings and achieve greater independence. By focusing on both immediate developmental needs and long-term social adaptation, this broader perspective complements the targeted emphasis on preschool interventions, creating a more holistic understanding of effective strategies for supporting individuals with ASD [7].

These findings illustrate the multifaceted role of SLP interventions, combining a focus on early skill development with long-term strategies for enhancing independence and quality of life. They also underscore the urgent need for rigorous methodologies, detailed reporting, and practical alignment with clinical settings to bridge the gap between research and real-world application, ultimately improving the outcomes for individuals with ASD at every stage of life [4, 7].

2.2. Comparative Analysis

The Therapy Outcomes by You (TOBY) app, developmental social pragmatic (DSP) approaches, and augmentative and alternative communication (AAC) systems represent distinct yet complementary interventions for children with ASD. TOBY offers a structured, technology-based approach that empowers parents to deliver early intensive behavioral intervention at home, targeting foundational skills such as imitation, language, and joint attention [9]. In contrast, DSP interventions focus on enhancing social-pragmatic competence through naturalistic interactions, aiming to improve skills like initiating conversations and understanding non-literal language in real-world contexts [10]. AAC systems, including speech-generating devices (SGDs) and picture exchange systems, primarily aim to facilitate communication for children with limited verbal abilities, with a strong emphasis on improving requesting skills and overall communication abilities. While TOBY provides a systematic, app-guided framework for skill development, DSP approaches offer more flexibility in adapting to individual needs and social situations. TOBY's structured activities allow for clear progress tracking, whereas DSP interventions rely more on observations of real-life interactions to gauge improvement [9,10]. AAC systems, particularly SGDs, have shown positive outcomes in enhancing communication skills and can be integrated into both TOBY and DSP approaches to support children with limited verbal abilities. Parental involvement is crucial in all three approaches, but the nature of involvement differs. TOBY explicitly guides parents through activities, potentially increasing their sense of empowerment and knowledge about ASD [9]. DSP interventions require parents to adapt strategies flexibly across various social situations, demanding more intuitive parenting skills [10]. AAC implementation often involves collaboration between parents, educators, and speech-language pathologists to ensure consistent use across settings.

Each approach has its strengths and limitations. TOBY's technology-based platform offers accessibility and structured learning but may not fully address higher-order social skills [9]. DSP interventions provide a more holistic approach to social-pragmatic development but can be challenging to implement consistently [10]. AAC systems have shown effectiveness in improving specific communication skills, particularly requesting, but more research is needed on their impact on broader social and academic skills.

While these approaches differ in methodology and focus, they all contribute valuable strategies for supporting children with ASD. An integrated approach, combining elements from TOBY, DSP, and AAC as appropriate to the individual child's needs, may offer the most comprehensive support for communication and social skill development in children with ASD.

3. Intervention

The field of ASD interventions has seen significant advancements in recent years, with research focusing on diverse approaches to support children's communication, social skills, and overall development. Three key areas of intervention emerge from the studies: the Therapy Outcomes by You (TOBY) app, developmental social pragmatic (DSP) approaches, and augmentative and alternative communication (AAC) systems. TOBY is a tablet-based early intervention tool that facilitates parent-child engagement and provides activities for various developmental areas [9]. Developmental social pragmatic (DSP) approaches, as implied in the study on sex differences in social-pragmatic skills, focus on understanding and improving social competence in children with ASD [10]. Augmentative and alternative communication (AAC) methods, including speech-generating devices (SGDs) and picture exchange systems, have shown effectiveness in enhancing communication skills, particularly requesting abilities, for children with ASD.

3.1. Effective of Intervention

The TOBY app, designed as a parent-mediated early intervention tool, has shown promise in empowering parents to actively participate in their child's therapy, fostering improved parent-child engagement and supporting child development across various domains [9]. Parents reported positive experiences with TOBY, noting improvements in their children's verbal skills and visual discrimination abilities, although challenges such as preparation time and aligning activities with individual child needs were identified [9]. Concurrently, research into developmental social pragmatic skills has revealed important insights into sex differences among children with ASD, highlighting the need for tailored assessments and interventions that consider the unique social phenotypes of females with ASD [10]. This research uncovered significant group differences favoring typically developing children in social-pragmatic competence and social motivation with peers, as well as a range of similarities and differences across groups and sexes in children's perspectives on friendship quality [10]. These findings underscore the importance of refining social-pragmatic assessments and developing interventions responsive to the specific needs of females with ASD [11]. In the realm of communication support, augmentative and alternative communication (AAC) systems have demonstrated effectiveness in enhancing communication skills, particularly in improving requesting abilities for children with ASD. Speech-generating devices (SGDs) emerged as the most commonly used and studied AAC method, with a trend towards increased adoption of high-tech, tablet-based solutions in recent years [12]. While AAC interventions showed generally positive outcomes for improving communication skills and generalizing these skills to new contexts, the research highlighted the need for more comprehensive studies with larger sample sizes and diverse outcome measures to fully establish their long-term effectiveness and impact on vocabulary development [12]. Collectively, these studies underscore the multifaceted nature of ASD interventions, emphasizing the potential benefits of integrating various approaches to address the complex needs of individuals with ASD. The research points towards a future where personalized, technology-enhanced interventions, informed by a nuanced understanding of individual differences,

including gender-specific needs, could significantly improve outcomes for children with ASD across communication, social, and cognitive domains (As shown in figure 1).

3.2. Barriers and Facilitators

A comprehensive analysis of the Therapy Outcomes by You (TOBY) app, Developmental Social Pragmatic (DSP) approaches, and Augmentative and Alternative Communication (AAC) systems reveals a range of barriers and facilitators unique to each intervention for children with ASD. For TOBY, key facilitators include its ability to empower parents, provide structured guidance, and offer insights into their child's developmental progress [9]. However, barriers such as time constraints, the volume of introductory information, and the challenge of matching activities to a child's specific abilities can hinder its effectiveness [9]. The app's success is often facilitated by personalized support and the provision of condensed instructions [9]. In contrast, DSP approaches benefit from their focus on naturalistic social interactions and ability to address nuanced social-pragmatic skills, particularly important for capturing the unique presentation of ASD in females [10]. Barriers in DSP implementation may include the complexity of assessing subtle social-pragmatic differences and the need for highly individualized interventions [10]. AAC systems, particularly speech-generating devices (SGDs), are facilitated by their direct impact on communication skills, especially in enhancing requesting abilities [12]. The increasing availability and social acceptance of high-tech, tablet-based SGDs has become a significant facilitator [12]. However, barriers for AAC include the potential mismatch between the system and the child's cognitive or motor abilities, and the limited research on their impact on vocabulary development [12]. Across all three interventions, a common facilitator is the potential for customization to meet individual needs, while a shared barrier is the challenge of maintaining consistent implementation and generalizing skills across different contexts. The trend towards technology-based interventions, as seen in TOBY and modern SGDs, presents both opportunities and challenges, potentially increasing engagement but also requiring technological proficiency from caregivers and educators [9,12]. Ultimately, the effectiveness of each approach is heavily influenced by factors such as parental involvement, the child's individual characteristics, and the availability of ongoing support and resources.

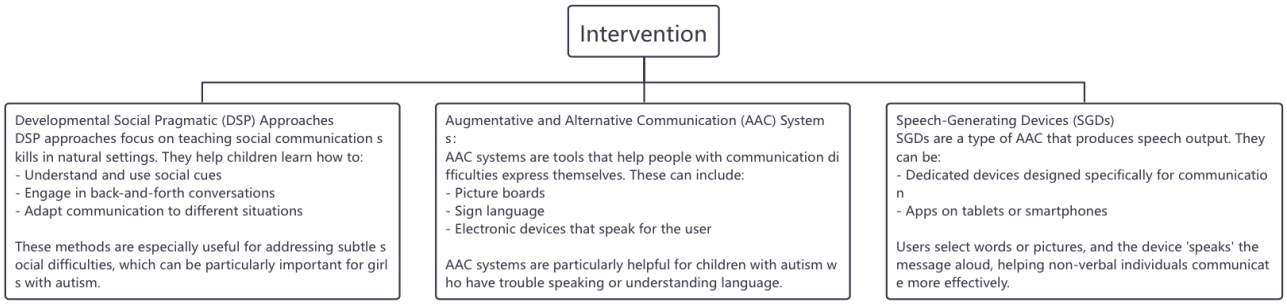

Figure 1. Intervention Strategies for Enhancing Communication in Children with ASD

3.3. Technological Advancements

Hyperbaric Oxygen Therapy (HBOT) is emerging as a notable technological advancement in the treatment of children with ASD due to its ability to address underlying neurological dysfunctions associated with the disorder. HBOT works by delivering oxygen at higher atmospheric pressures, which enhances oxygen delivery to areas of the brain that suffer from hypoperfusion—a condition often observed in individuals with ASD. The study conducted by Fischer et al. (2022) highlights the potential of HBOT in alleviating key symptoms of ASD, such as social behavior dysfunction and neuroinflammation. In their research using a mouse model with the SHANK3 gene mutation, which mirrors a form of ASD, the authors found that HBOT not only improved social behavior, particularly social novelty preference, but also significantly reduced neuroinflammation. This was achieved through the upregulation of Insulin-like Growth Factor 1 (IGF-1) and a reduction in microglia activity, cells that are typically involved in inflammatory responses within the brain. These findings are

significant because neuroinflammation is a common issue in children with ASD, and targeting it can lead to improvements in cognitive and social functioning, which are often impaired in these individuals. Although the study was conducted in animal models, its results suggest that HBOT may hold promise as a therapeutic intervention for certain subtypes of ASD, particularly those linked to genetic mutations such as SHANK3. By enhancing neuroplasticity and reducing brain inflammation, HBOT could offer long-term benefits in improving the quality of life and functional outcomes for children with ASD. As Fischer et al. (2022) indicate, further research is necessary to fully explore the potential of HBOT in clinical settings, but these initial findings are encouraging for its role in treating the core pathophysiological processes of ASD [13].

Superpower Glass represents a groundbreaking technological advancement designed to assist children with ASD in developing social and emotional skills. This wearable system, developed for Google Glass, uses advanced facial expression recognition technology to provide real-time feedback on the emotions of people the child interacts with. By offering unobtrusive visual or audio cues, such as text, colors, or smiley faces, Superpower Glass helps children with ASD recognize and interpret facial expressions more effectively, a skill often impaired in individuals with autism. What sets Superpower Glass apart from traditional therapy methods is its ability to integrate seamlessly into everyday life, offering real-time emotional cues during natural social interactions rather than in a controlled clinical setting. Through gamified activities and interactive features, the system engages children in a playful manner, making the learning process enjoyable and less formal, which is particularly beneficial for ASD therapy. In addition to providing immediate feedback during social interactions, Superpower Glass also features a mobile application that allows caregivers to review recorded sessions, highlighting emotionally significant moments for further discussion. This aspect enhances its use as a therapeutic tool, enabling caregivers and therapists to reinforce emotional learning in real-world contexts. Trials with children have shown promising results, including improved eye contact and social engagement, with parents and teachers noting positive behavioral changes. By addressing key challenges in ASD therapy—such as the difficulty of generalizing social learning outside clinical environments—Superpower Glass is poised to become a valuable tool in enhancing emotional comprehension and social skills in children with ASD [14].

Virtual Reality (VR) represents a significant technological advancement for children with autism spectrum disorder (ASD) due to its ability to create a structured and predictable environment that aligns with their need for routine and repetitive behaviors. The systematic literature review by Valencia, Rusu, Quiñones, and Jamet (2019) emphasize that this technology offers a safe space where children can engage in learning activities without the anxiety that often accompanies unpredictable real-world interactions [15]. VR applications are particularly adept at detecting and responding to children's emotional cues, thereby facilitating the development of crucial social skills. The immersive nature of VR experiences enhances engagement and motivation, making educational activities more enjoyable and effective. Furthermore, VR can be employed in a variety of educational contexts, including the teaching of vocabulary, social communication, and emotional recognition, thereby providing a comprehensive tool for skill development.

4. Conclusion

In conclusion, this review systematically analyzed current intervention strategies for autism spectrum disorder (ASD), focusing on the impact of early diagnosis, tailored therapeutic approaches, and emerging technologies on improving communication, social skills, and overall quality of life. By synthesizing findings from recent studies, we evaluated the efficacy of interventions such as Therapy Outcomes by You (TOBY), developmental social pragmatic (DSP) approaches, and augmentative and alternative communication (AAC) systems. These strategies collectively underscore the potential of targeted, evidence-based interventions to address the unique developmental needs of individuals with ASD. However, several limitations in existing research warrant further investigation. Many studies are constrained by small sample sizes, limited demographic diversity, and variability in

intervention delivery, which hinder the generalizability of findings. Additionally, the long-term effectiveness and sustainability of certain interventions, particularly technology-based solutions like TOBY and Superpower Glass, remain underexplored. Furthermore, most current approaches focus on specific aspects of ASD, such as communication or social skills, without addressing the comprehensive needs of individuals, including co-occurring conditions like anxiety and depression.

Future research should prioritize addressing these gaps by conducting large-scale, longitudinal studies that evaluate the sustained impact of interventions across diverse populations. Developing integrated frameworks that combine multiple therapeutic approaches could better account for the multifaceted nature of ASD, while leveraging emerging technologies such as virtual reality and artificial intelligence offers significant promise for personalized and scalable interventions. Enhancing collaboration among families, educators, and healthcare providers is essential to optimize the practical application and accessibility of these interventions. Moreover, further studies should explore the transition needs of individuals with ASD as they move into adulthood, with a focus on improving vocational, educational, and social integration. By overcoming these limitations and advancing interdisciplinary efforts, we can better address the diverse and evolving needs of individuals with ASD. Ultimately, a deeper understanding of how to integrate innovative, evidence-based approaches into holistic support systems will contribute to a more inclusive society that supports individuals with ASD throughout their lives.

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