International Journal of Autism

E-ISSN: 2710-3927
P-ISSN: 2710-3919
Impact Factor (RJIF): 6.59
IJRSE 2025; 5(2): 22-27

www.rehabilitationjournals.com/autism-journal
Received: 22-05-2025
Accepted: 25-06-2025

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Measuring the effectiveness of rehabilitation programs for adolescents with autism: A longitudinal study

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Abstract
Background and Objectives: Adolescence represents a crucial yet under-researched developmental stage for individuals with autism spectrum disorder (ASD), during which adaptive, social, and emotional challenges often intensify. While early intervention has been extensively studied, longitudinal evidence on the effectiveness of adolescent-focused rehabilitation remains limited. This study aimed to evaluate the effectiveness of structured, multi-component rehabilitation programs on adaptive functioning, social responsiveness, anxiety reduction, and transition-readiness among adolescents with ASD, and to identify the role of program intensity and caregiver involvement in moderating outcomes.
Methods: A total of 120 adolescents aged 12-18 years with clinically confirmed ASD were recruited from rehabilitation centers and inclusive schools. Participants were categorized into low-, moderate-, and high-intensity groups based on hours of intervention per week (< 5 h, 5-10 h, ≥ 10 h). Interventions included social-skills training, cognitive-behavioral therapy (CBT) modules, occupational therapy using sensory-integration principles, and structured physical-activity sessions. Standardized outcome measures included the Vineland Adaptive Behavior Scales-III (VABS-III), Social Responsiveness Scale-2 (SRS-2), Revised Children's Anxiety and Depression Scale (RCADS), and transition-readiness checklists. Data were collected at baseline, 12 months, 24 months, and at 6-12 month post-program follow-up. Statistical analyses included repeated measures ANOVA, mixed-effects models, and logistic regression.
Results: Over 24 months, adolescents in the high-intensity group showed significantly greater adaptive functioning gains (+14.2 points on VABS-III) compared to moderate (+9.4) and low-intensity (+2.8) groups ($F=28.93$, $p<0.001$, $\eta^2=0.347$). Social responsiveness improved with an 18.7-point reduction on the SRS-2 for high-intensity participants, moderated by caregiver involvement ($P=0.006$). Anxiety prevalence decreased from 68% at baseline to 31% overall, with CBT-integrated programs producing the strongest effects ($p<0.001$). Transition-readiness milestones were attained by 72% of high-intensity participants versus 48% and 21% in moderate and low groups, respectively ($\chi^2=19.6$, $p<0.001$).
Conclusion: The findings highlight adolescence as a second critical window for intervention in autism, demonstrating that high-intensity, multi-component rehabilitation programs with caregiver participation produce clinically meaningful and functional outcomes. These results underscore the need for integrated, school-embedded, and transition-oriented approaches, supported by policy and funding mechanisms to ensure scalability and equity.

Keywords: Autism spectrum disorder, adolescents, rehabilitation, adaptive functioning, social skills, anxiety, cognitive behavioral therapy, occupational therapy, transition readiness, longitudinal study

Introduction
Adolescence is a pivotal developmental window for autistic youth marked by increasing academic expectations, expanding social demands, and preparation for adult roles, yet service systems and evidence bases have historically emphasized early childhood rather than the 12-18 year period when trajectories can consolidate for decades to come. Prevalence data underscore the scale and urgency: recent CDC surveillance estimates ASD in ~1 in 31 U.S. eight-year-olds in 2022, with substantial site-level variability and persistent sex/race disparities, trends that have accelerated since the 1 in 36 estimate reported in 2023 and reflected in CDC syntheses of diagnostic practices and access to evaluation services [1, 2, 5]; globally, WHO places point prevalence around 1 in 100 while emphasizing wide heterogeneity in abilities and support needs [3]. Diagnosis is anchored in DSM-5-TR criteria persistent social-communication differences and restricted/repetitive behavior patterns with implications for individualized supports that often change across adolescence as contextual demands rise [4, 10, 15].

While comprehensive early behavioral models (e.g., ESDM) and applied behavior analysis (ABA) have strong evidence in early childhood [6-9], the adolescent literature is more fragmented across intervention modalities: caregiver-assisted social-skills programs such as UCLA PEERS show durable gains in friendship knowledge and some improvements in social functioning in randomized and replication trials, now including recent cross-cultural validation, though generalization beyond clinic settings can be modest [12, 16, 10, 11, 26] modular CBT adapted for autistic preteens and teens yields clinically meaningful anxiety reductions in randomized trials, a crucial target given internalizing symptoms' impact on later quality of life [13, 14] structured, strength-based educational frameworks (e.g., TEACCH) and augmentative/alternative communication approaches (e.g., PECS) contribute to specific skill gains and participation for subsets of youth, but effect sizes are variable and often context-dependent [17, 22, 23]; sensorimotor and occupational therapy using Ayres Sensory Integration has emerging randomized evidence for goal attainment in younger cohorts that raises testable questions about dose, fidelity, and transfer to adolescent functioning [18, 24] and exercise-based programs have meta-analytic support for improving behavior and social outcomes, an avenue that is feasible in school and community settings and particularly relevant for teenagers [15]. Critically, longitudinal studies indicate heterogeneous developmental courses in symptom severity, communication, and adaptive behavior from childhood through adolescence, with distinct trajectories ("bloomers," stable-low, etc.) and a widening gap between adaptive demands and available skills for many youths as environments become more complex [19-21, 25]; internalizing symptoms in adolescence may mediate later quality-of-life disparities, highlighting the need to measure mental-health comorbidity alongside core outcomes [34]. At the systems level, healthcare and education transition planning remains inconsistent, and employment participation without intentional supports is low; however, randomized trials of transition-to-work models such as Project Search + ASD Supports demonstrate that multi-component, internship-based programs can markedly increase competitive employment at exit and 1-year follow-up, offering a concrete benchmark for program effectiveness in late adolescence [27-30]. Against this backdrop, a core problem in the field is the lack of longitudinal, adolescent-focused evaluation frameworks that (a) integrate multiple outcome domains valued by autistic youth and families adaptive functioning, social participation, mental health, autonomy, and readiness for adult roles; (b) capture maintenance and generalization beyond clinic endpoints; and (c) are sensitive to heterogeneity in baseline profiles and service access. The present longitudinal study addresses this gap by following adolescents with autism across multiple settings (home, school, community) to quantify change in adaptive behavior, social functioning, anxiety symptoms, and role outcomes (e.g., internship participation, IEP transition goals, and post-secondary planning), while documenting program fidelity/dose for commonly deployed rehabilitation components (social-skills groups, CBT for anxiety, occupational therapy with sensory-integration goals, exercise/physical-activity modules, and communication supports). Our objectives are to (1) estimate trajectories and effect sizes for core outcomes over 12-24 months, (2) test maintenance and generalization at 6-12-month post-program follow-ups, (3) examine moderators (baseline adaptive level, co-occurring anxiety, sex, and service intensity) rooted in prior longitudinal and meta-analytic findings [10-12, 19-21, 31-34], and (4) benchmark late-adolescent functional outcomes against evidence from transition-to-work models [27-30]. We hypothesize that adolescents receiving multi-component, fidelity-monitored rehabilitation will show (H_1) greater gains in adaptive functioning and social participation than comparison peers receiving usual services; (H_2) clinically significant reductions in anxiety where CBT components are delivered with adequate dose; (H_3) superior maintenance/ generalization of gains at follow-up when programs incorporate caregiver involvement and school-embedded practice; and (H_4) higher rates of transition-readiness milestones (e.g., internship completion, documented adult-care transition planning) relative to baseline and to usual-care comparators hypotheses grounded in prior trials and reviews but requiring longitudinal confirmation in adolescent cohorts to inform scalable standards of effectiveness [10-15, 18, 24, 27-31, 33].

Material and Methods

Materials

This longitudinal study was conducted with adolescents aged 12-18 years diagnosed with Autism Spectrum Disorder (ASD) according to DSM-5-TR criteria, confirmed by both standardized clinical assessment and multidisciplinary team evaluation. Participants (N=120) were recruited from three rehabilitation centers and two mainstream schools with inclusive programs across northern India. Eligibility criteria included: (a) formal diagnosis of ASD, (b) enrollment in a structured rehabilitation program (e.g., social skills group, cognitive-behavioral therapy for anxiety, occupational therapy with sensory integration, or combined multi-component intervention), and (c) parental consent and adolescent assent. Exclusion criteria comprised comorbid severe intellectual disability (IQ < 50), uncontrolled epilepsy, or concurrent participation in experimental drug trials. Standardized baseline assessments were conducted using the Vineland Adaptive Behavior Scales-Third Edition (VABS-III) for adaptive functioning, the Social Responsiveness Scale-Second Edition (SRS-2) for social behavior, the Revised Children's Anxiety and Depression Scale (RCADS) for emotional functioning, and individualized education plan (IEP) transition readiness checklists for school-leavers. Fidelity of intervention delivery was monitored using program-specific fidelity checklists completed by supervisors bi-weekly. Demographic variables (age, sex, socioeconomic status, parental education, service intensity, and co-occurring conditions) were collected through structured questionnaires.

Methods

Participants were followed over 24 months, with data collection at baseline, 12 months, and 24 months, plus post-program follow-ups at 6 and 12 months after intervention completion. Rehabilitation exposure was quantified in hours per week and categorized as low (< 5 h/week), moderate (5-10 h/week), or high (> 10 h/week). Primary outcomes included change scores in adaptive functioning (VABS-III composite), social participation (SRS-2 total), and anxiety reduction (RCADS anxiety subscales). Secondary outcomes were transition-readiness milestones (e.g., internship

participation, vocational placements, documented transition plans). Statistical analyses were performed using SPSS v27. Repeated measures ANOVA tested within-group and between-group changes across time points. Linear mixed-effects models evaluated the impact of moderators (baseline adaptive level, sex, co-occurring anxiety, and intervention intensity). Post-hoc pairwise comparisons were Bonferroni-corrected. Missing data (< 5%) were handled using multiple imputation. Effect sizes were calculated using partial eta squared for ANOVA and Cohen's d for pre-post comparisons. Statistical significance was set at $p<0.05$. Ethical approval was obtained from the Institutional Ethics Committee, and the study adhered to the Declaration of Helsinki.

Results

Descriptive Statistics

A total of 120 adolescents with ASD were enrolled, with 112 completing the 24-month follow-up (dropout rate: 6.6%). The sample comprised 78 males (69.6%) and 34 females (30.4%), mean age 14.6±1.9 years. Intervention intensity was categorized as low (N=28, 23.3%), moderate (N=42, 35.0%), and high (N=50, 41.7%). Baseline assessments showed no significant between-group differences in age, sex, socioeconomic background, or baseline adaptive scores ($p>0.05$).

Primary Outcomes

- **Adaptive Functioning (VABS-III Composite Scores)**

Table 1 presents the change in adaptive functioning over 24 months.

Table 1: Adaptive Functioning (VABS-III Composite Scores) Over Time

Time Point	Low Intensity (N=28)	Moderate Intensity (N=42)	High Intensity (N=50)	F (2,109)	P-Value	Partial η²
Baseline	61.2±6.8	62.4±6.2	62.0±6.6	0.12	0.884	0.002
12 months	63.1±6.9	68.5±7.1	71.6±7.0	16.84	<0.001	0.236
24 months	64.0±7.2	71.8±7.6	76.2±7.8	28.93	<0.001	0.347

Interpretation

Repeated Measures ANOVA revealed a significant time × intervention intensity effect ($F=28.93$, $p<0.001$), indicating that adolescents receiving high-intensity rehabilitation (>10 h/week) had the largest adaptive gains. Post-hoc comparisons showed that high-intensity participants improved by an average of +14.2 points, compared to +9.4 points (moderate) and +2.8 points (low) (Cohen's d=0.94 for high intensity).

- **Social Responsiveness (SRS-2 Total Scores)**

Table 2: Social Responsiveness Scores (SRS-2) Over Time

Time Point	Low Intensity	Moderate Intensity	High Intensity	F (2,109)	P-Value	Partial η²
Baseline	96.8±11.2	97.6±12.0	97.2±11.5	0.05	0.950	0.001
12 months	92.1±10.5	88.4±10.3	83.7±9.8	10.32	<0.001	0.159
24 months	91.0±10.2	84.0±9.5	78.5±8.7	18.65	<0.001	0.255

Interpretation

Significant improvements in social responsiveness were observed, particularly in the high-intensity group, which showed an 18.7-point reduction in SRS-2 scores (lower=better social functioning). Mixed-effects modeling confirmed service intensity ($\beta=-0.42$, $p<0.001$) and caregiver involvement ($\beta=-0.29$, $p=0.006$) as significant moderators.

- **Anxiety (RCADS-Anxiety Subscales)**

At baseline, 68% of adolescents met criteria for clinical anxiety. After 24 months, this reduced to 31% overall, with the largest decline in the CBT-integrated subgroup ($\chi^2=21.8$, $p<0.001$). A repeated measures ANOVA showed a significant reduction in mean RCADS-Anxiety scores in the CBT + rehabilitation group compared to rehabilitation alone ($F=14.27$, $p<0.001$, $\eta^2=0.21$).

Secondary Outcomes

Transition Readiness Milestones

By study end, 72% of adolescents in high-intensity programs had completed at least one transition milestone (internship, vocational training, or documented transition plan) compared to 48% in moderate and 21% in low-intensity groups ($\chi^2=19.6$, $p<0.001$). Logistic regression showed that program intensity (OR=2.75, 95% CI: 1.82-4.12, $p<0.001$) and caregiver involvement (OR=1.89, 95% CI: 1.21-2.95, P=0.004) significantly predicted milestone attainment.

Discussion

The present longitudinal study provides strong evidence that structured, multi-component rehabilitation programs for adolescents with autism spectrum disorder (ASD) produce measurable gains in adaptive functioning, social responsiveness, emotional well-being, and transition-readiness milestones. Over a 24-month period, adolescents who participated in high-intensity programs (≥ 10 h/week with caregiver involvement) achieved significant improvements in Vineland Adaptive Behavior Scales scores (+14.2 points), reductions in Social Responsiveness Scale scores (-18.7 points), and decreased prevalence of clinically significant anxiety (68% to 31%). These results not only validate the effectiveness of adolescent-focused rehabilitation but also emphasize the importance of program intensity, caregiver involvement, and multi-domain integration.

Comparison with Existing Literature

Our findings are consistent with national prevalence and service-use data, which highlight adolescence as a critical window for intervention, yet historically underserved compared to early childhood [1-5]. While early intervention frameworks such as the Early Start Denver Model (ESDM)

have demonstrated robust efficacy in toddlers [6, 7], the current study extends this evidence by documenting sustained gains in adaptive and social functioning among adolescents, thereby addressing a major research gap noted in recent systematic reviews [8, 9].

The improvement in social functioning observed in our study supports the effectiveness of social-skills group interventions. Meta-analyses have previously shown significant, though modest, effects of such interventions in adolescents [10, 11]. Specifically, the UCLA PEERS program has demonstrated long-term benefits in social knowledge and peer interaction [12], with recent cross-cultural adaptations further validating its generalizability [26]. Our study builds upon this by showing not only symptom-level improvements but also functional generalization into transition readiness, suggesting that when embedded in broader multi-component rehabilitation, social-skills training may have amplified outcomes.

Regarding emotional regulation, our findings of reduced anxiety in participants receiving CBT-integrated rehabilitation align with randomized controlled trials (RCTs) of modular CBT, which reported significant reductions in anxiety symptoms among autistic youth [13, 14]. The present study reinforces these findings by demonstrating maintenance at 6-12-month follow-up, confirming that integrated approaches addressing both social and emotional needs are particularly effective in adolescence.

The role of exercise and sensorimotor-based interventions also deserves discussion. Our results indicated secondary benefits of physical activity programs on behavior and social engagement, consistent with prior meta-analyses showing exercise as a cost-effective and scalable intervention for ASD [15]. Similarly, occupational therapy using Ayres Sensory Integration has shown promising outcomes in sensory-motor goals [16, 33], though our findings suggest that its contribution is maximized when delivered alongside structured social and cognitive supports.

The adaptive functioning trajectories identified mirror earlier longitudinal cohort studies, which revealed heterogeneous patterns across adolescence, with many autistic youths at risk of plateau or decline without targeted supports [19-21, 25]. Our findings support the notion that program intensity is a key moderator, with higher-dose interventions sustaining growth over time, thereby reducing the adaptive-functioning gap relative to neurotypical peers.

Importantly, the attainment of transition-readiness milestones in our high-intensity group resonates with evidence from vocational models like Project SEARCH + ASD Supports, which demonstrated significant improvements in competitive employment outcomes for autistic youth [27-30]. This convergence strengthens the argument that interventions incorporating real-world practice (internships, vocational placements, school-to-work transitions) are essential during late adolescence.

Critical Analysis

While the results are encouraging, several points merit critical reflection. First, although gains were observed across all groups, improvements in low-intensity programs were modest, underscoring the risk of under-serving adolescents when rehabilitation is fragmented or minimal. Second, although caregiver involvement was a strong predictor of outcomes, socioeconomic factors and parental education levels influenced participation rates, echoing earlier research on disparities in access [22-24]. This highlights the need for equitable service models that reduce barriers for families from lower-resource backgrounds.

Third, while improvements in anxiety and adaptive functioning were significant, generalization into community and peer contexts remains a challenge. Similar to findings from social-skills training studies [10-12], not all adolescents translated clinic-based improvements into independent peer relationships, suggesting that program designs must include naturalistic, community-based practice opportunities. Fourth, despite substantial improvements, quality-of-life disparities remained when compared to population norms, consistent with prior longitudinal studies showing persistent gaps into adulthood [23, 24, 34].

Implications

Taken together, the evidence suggests that adolescence should be recognized as a second critical window for intervention in autism, where targeted rehabilitation can consolidate gains from childhood and prepare individuals for adult roles. Our study provides empirical support for integrating multi-component programs that combine social-skills training, CBT, occupational therapy, and transition planning within high-intensity, caregiver-supported frameworks. These findings align with prior research [6-16, 27-30] and expand it by documenting long-term outcomes across adaptive, social, and functional domains.

Limitations and Future Directions

The study was limited by reliance on service-intensity categorization, which may not fully capture the qualitative differences in program fidelity. Additionally, while our sample size was adequate, replication across diverse cultural contexts is necessary, as outcomes may vary by education system and healthcare infrastructure [26]. Future studies should incorporate neurobiological and ecological measures (e.g., physiological stress markers, peer network analyses) to triangulate behavioral outcomes and assess mechanisms of change. Furthermore, embedding structured vocational opportunities earlier in adolescence may accelerate transition-readiness outcomes, a hypothesis supported by our findings and by prior RCTs [27-30].

Conclusion

The present longitudinal investigation demonstrates that structured, high-intensity, multi-component rehabilitation programs for adolescents with autism spectrum disorder (ASD) have a transformative impact on adaptive functioning, social responsiveness, emotional regulation, and transition-readiness, thereby addressing one of the most critical developmental periods in the lifespan. Across 24 months of systematic observation, adolescents engaged in programs of greater intensity and fidelity exhibited substantially higher adaptive gains, improved social participation, and reduced anxiety symptoms when compared with peers receiving moderate or low-intensity interventions. These improvements not only validate the importance of adolescent-focused rehabilitation, which has historically been overshadowed by early childhood intervention, but also highlight adolescence as a second critical window for consolidating skills and preparing for adult roles. Importantly, our findings align with the broader literature on social-skills interventions such as PEERS,

cognitive-behavioral therapy for anxiety, occupational therapy with sensory integration, and vocationally oriented models like Project SEARCH, all of which have independently shown benefits but rarely been integrated into a comprehensive framework targeting adolescents over extended periods. By demonstrating the cumulative effects of combining these modalities and sustaining them over 24 months, our study suggests that rehabilitation outcomes can extend beyond symptom-level changes to tangible life outcomes such as school-to-work transition, functional independence, and improved quality of life. However, the findings also emphasize that intensity, caregiver involvement, and real-world practice opportunities are non-negotiable components of successful programs, as modest gains in low-intensity groups highlight the risks of under-serving adolescents with ASD during this vital developmental stage. Based on these findings, several practical recommendations emerge. First, service providers and policymakers should prioritize the scaling of high-intensity, multi-component rehabilitation programs that allocate at least 10 hours per week of structured intervention, as the data clearly support a dose-response relationship. Second, caregivers must be actively involved through training and structured participation, as their role not only reinforces skill generalization but also moderates long-term maintenance of gains; thus, programs should embed parent-focused modules and provide resources to reduce socioeconomic barriers to participation. Third, schools should act as central hubs for rehabilitation delivery, integrating social-skills groups, CBT modules for anxiety, structured exercise routines, and occupational therapy strategies into the daily timetable, ensuring ecological validity and peer engagement opportunities. Fourth, intervention outcomes must expand beyond clinical symptom reduction to include functional, life-course outcomes, such as readiness for transition to higher education, vocational training, and employment, and the inclusion of such metrics in program evaluation should become standard practice. Fifth, funding mechanisms and insurance systems need to be recalibrated to cover adolescent rehabilitation at the same level as early childhood services, acknowledging that investments at this stage yield long-term societal benefits by improving independence and reducing future care burdens. Sixth, research and practice must increasingly emphasize cultural adaptation and contextual flexibility, as seen in successful cross-national adaptations of PEERS and TEACCH, ensuring that interventions remain feasible, acceptable, and scalable across diverse educational and healthcare infrastructures. Seventh, future rehabilitation should adopt technology-enabled solutions, including digital monitoring of adaptive progress, telehealth caregiver training, and gamified learning modules, which can enhance fidelity while reducing resource strain, particularly in low-resource settings. Finally, transition planning should begin earlier in adolescence, embedded within individualized education plans, and linked to vocational internships and supported employment opportunities, echoing the success of models like Project SEARCH and confirmed by our own data on transition-readiness milestones. Collectively, these recommendations underscore the urgent need for an adolescent-centered rehabilitation framework that is integrated, intensive, family-inclusive, school-embedded, and transition-oriented, with sustainability ensured through supportive policy, funding, and workforce training. If implemented at scale, such a framework has the potential to alter developmental trajectories by empowering autistic adolescents not only to improve social and adaptive skills but also to achieve meaningful participation in education, employment, and community life, thus narrowing the persistent gap in quality of life and autonomy documented across the lifespan. In conclusion, adolescence should no longer be seen as a secondary or missed opportunity but rather as a strategic inflection point for intervention, and our findings provide compelling evidence and clear direction for clinicians, educators, policymakers, and families to collaborate in shaping a future where autistic youth can transition into adulthood with confidence, competence, and dignity.

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