

Associations Between Motor Competence and Adaptive Behavior and Their Predictive Value in Children With Severe Intellectual Disability

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Abstract

Purpose

This study examined associations between motor competence and adaptive behavior and evaluated the discriminative utility of TGMD-2 scores for identifying low adaptive functioning.

Methods

In this cross-sectional study, 227 children with severe ID (6–12 years) were recruited from six social welfare institutions in China. Motor competence was assessed using the Test of Gross Motor Development–Second Edition (TGMD-2; total score, locomotor skills, and object control skills). Adaptive behavior was assessed using the Adaptive Behavior Questionnaire for Children (ABQC), yielding an Adaptive Deviation Quotient (ADQ) and domain scores (independence, cognition, socialization); low adaptive functioning was defined as $ADQ < 70$. Pearson correlations and multiple linear regressions were conducted, and ROC analysis evaluated TGMD-2 total score discrimination.

Results

TGMD-2 total score correlated strongly with ADQ ($r = 0.813$, $p < 0.001$), with moderate-to-strong associations for independence ($r = 0.536$) and socialization ($r = 0.655$), and a weaker association for cognition ($r = 0.292$) (all $p < 0.001$). In regression models, TGMD-2 total score explained substantial variance in ADQ ($R^2 = 0.74$), independence ($R^2 = 0.36$), cognition ($R^2 = 0.15$), and socialization ($R^2 = 0.51$) (all $p < 0.001$). ROC analysis showed excellent discrimination for low adaptive functioning ($AUC = 0.947$); the optimal cut-off was 34.5 (sensitivity 93.1%, specificity 87.9%).

Conclusion

Motor competence is strongly associated with adaptive functioning in institutionalized children with severe ID. TGMD-2 total score demonstrates excellent discriminative performance for identifying low adaptive functioning, supporting its potential utility as a pragmatic screening indicator in resource-limited residential settings; external validation and longitudinal studies are warranted.

1.Introduction

Intellectual disability (ID) is characterized by profound limitations in both intellectual functioning and adaptive behavior, originating during the developmental period (Dakopoulos et al., 2024; *Diagnostic and statistical manual of mental disorders: DSM-5™*, 5th ed, 2013; *Intellectual disability: Definition, classification, and systems of supports*, 11th ed. of AAIDD definition manual, 2010). Within this diagnostic spectrum, children with severe ID represent a clinically important group and often show substantial limitations

across conceptual, social, and practical domains (Tassé et al., 2016). Profound limitations in adaptive behavior among children with severe ID can translate into sustained support needs in daily living and self-care and are associated with substantial downstream health vulnerabilities across the life course (Cooper et al., 2015). Population evidence indicates that people with ID experience markedly poorer physical and mental health profiles, including high multimorbidity occurring at much younger ages, and elevated premature mortality compared with the general population (Smythe & Kuper, 2024). As the primary determinant of quality of life, mastery of adaptive behavior—comprising the collection of skills required for daily independent functioning—is essential for reducing the lifelong support needs of these individuals (*Intellectual disability: Definition, classification, and systems of supports, 11th ed. of AAIDD definition manual*, 2010; Tasse, 2013).

Emerging evidence suggests that motor competence may serve as a critical enabling factor that drives broader developmental trajectories (Adolph & Hoch, 2019; Bowler et al., 2024). According to the Embodied Cognition framework, motor development is not merely a physical attribute but is intrinsically linked to independence and social mastery, providing building blocks for the development of function. Recent studies have consistently demonstrated that motor skills explain a significant proportion of the variability in adaptive behavior among children with neurodevelopmental disorders, often serving as a more robust predictor of functional outcomes than IQ alone (Fears et al., 2022). Specifically, gross motor proficiency facilitates environmental exploration and social engagement, which are precursors to autonomous functioning (Chichinina et al., 2025; Leung et al., 2011).

Despite the theoretical significance of the motor-adaptive nexus, a key gap concerns children with severe ID residing in residential care or social welfare institutions, where opportunities for individualized motor practice and participation may be constrained. In these institutional settings, children with severe ID are at an elevated risk for profound deficits in both motor development and adaptive domains (van et al., 2011). Previous research has examined the relationship between motor competence and adaptive behavior in specific conditions like Down syndrome and Autism Spectrum Disorder; however

empirical data on how specific motor sub-domains predict adaptive thresholds in this high-risk institutionalized cohort remain insufficient. Determining whether motor competence can serve as a reliable predictor of adaptive behavior is paramount for optimizing early screening protocols and designing targeted intervention strategies within these environments.

If standardized motor assessments can accurately differentiate levels of adaptive risk, they could provide clinicians and institutional caregivers with high-efficiency screening tools. However, the precise predictive utility and optimal clinical cut-off values for identifying adaptive functioning risk in children with severe ID have yet to be rigorously established. Building upon these theoretical and clinical imperatives, the current study aims to: (1) elucidate the multidimensional associations between gross motor competence (locomotor and object control skills) and adaptive behavior in a large cohort of children with severe ID residing in residential care settings; (2) evaluate the discriminative performance of TGMD-2 scores in predicting low adaptive behavior (Kim et al., 2012; Palmer et al., 2025). We

hypothesize that motor competence will uniquely contribute to adaptive outcomes and that a specific motor proficiency threshold can serve as a sensitive marker for identifying functional risks in this vulnerable population.

2. Materials and Methods

2.1 Participants

A total of 227 children with severe ID were recruited from six social welfare institutions (orphanages) in China using a convenience sampling approach. All participants were orphaned children who had been residing in institutional care for extended periods.

The inclusion criteria were as follows: (1) a clinical diagnosis of severe ID according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5); (2) basic auditory and visual abilities and the capacity to understand and follow simple motor instructions; (3) written informed consent obtained from institutional administrators and caregivers; and (4) age between 6 and 12 years. The exclusion criteria were: (1) the presence of severe musculoskeletal disorders, neurological comorbidities (e.g., active epilepsy), or other physical conditions that could restrict participation in gross motor assessments; and (2) a history of major surgery within the previous six months.

2.2 Measures

2.2.1 Test of Gross Motor Development–Second Edition (TGMD-2)

Gross motor competence was assessed using the TGMD-2. The TGMD-2 has been standardized and validated in large samples of Chinese children. Previous research has demonstrated excellent psychometric properties of the instrument in children aged 3–12 years in China, with high internal consistency (Cronbach's $\alpha = 0.91$) (Griffiths et al., 2018). The TGMD-2 consists of two subtests—locomotor skills and object control skills—which together provide a comprehensive evaluation of motor competence development (Downs et al., 2020).

2.2.2 Adaptive Behavior Questionnaire for Children (ABQC)

Adaptive behavior was assessed using the Adaptive Behavior Questionnaire for Children (ABQC), developed by Yao Shuqiao. This instrument was constructed based on a large national normative sample of Chinese children and is one of the most widely used standardized measures of adaptive behavior in China. The ABQC comprises three domains: independence, cognition, and socialization. National norming studies have demonstrated good structural validity and discriminant validity, with test–retest reliability coefficients ranging from 0.96 to 0.99, indicating high measurement stability across developmental stages. Standardized scoring procedures were applied. Raw scores for each subdomain

were first converted into T-scores based on normative tables, and an overall adaptive deviation quotient (ADQ index) was subsequently calculated. Classified according to the norm level, an ADQ index < 70 was used as the clinical cut-off to classify participants as having a low level of adaptive behavior (Yao Shuzhao et al., 1993; Yao Shuzhao, 1993).

2.3 Procedures

All assessments were conducted on site at the participating social welfare institutions between May and June 2024 by a research team who had completed unified training before data collection. To enhance procedural consistency across institutions, the same assessment protocol, equipment specifications, and scoring instructions were used at all sites. Prior to formal testing, staff members at each institution were informed of the testing sequence and environmental requirements to minimize disruption and ensure that the children were assessed under comparable conditions. TGMD-2 testing was administered individually in spacious, flat, and low-distraction activity areas within each institution. Given the cognitive and attentional characteristics of children with severe ID, a standardized “instruction–demonstration–imitation” procedure was used throughout testing. For each task, the assessor first provided a brief and simple verbal instruction, followed by a live demonstration of the target movement. The child was then encouraged to imitate the movement. Additional prompts were limited and standardized to reduce variability in examiner assistance. Short rest intervals were allowed when necessary to maintain compliance and reduce fatigue. All TGMD-2 performances were video-recorded to permit detailed post hoc scoring and quality control. Two trained raters independently scored each recording according to the TGMD-2 performance criteria. When a movement component was unclear during real-time observation, the recording was reviewed in slow motion. Discrepancies between raters were resolved through joint review and consultation with a third senior rater until consensus was reached. Inter-rater reliability was evaluated using the intraclass correlation coefficient (ICC) in a randomly selected subset of recordings, demonstrating acceptable agreement for scoring consistency. The ABQC was completed with the assistance of caregivers who were familiar with the child’s daily functioning in the institution. To improve response accuracy and completeness, trained researchers administered the questionnaire in a face-to-face format, clarified item meanings when needed, and checked all forms for missing responses immediately after completion. This procedure helped reduce missing data and improved the consistency of caregiver-reported adaptive behavior information.

2.4 Statistical Analysis

Statistical analyses were performed using SPSS software, with the level of significance set at $P < 0.05$. Continuous variables with normal distributions were summarized as means and standard deviations, the harman single-factor test was used to evaluate the common method bias of the questionnaire. Descriptive statistics were used to characterize participants’ demographic and clinical characteristics. Pearson correlation coefficients were calculated to examine associations between TGMD-2 total scores, locomotor and object control subscale scores, and T-scores of the ABQC domains. Multiple linear regression analyses were conducted to evaluate the unique contributions and explanatory power of TGMD-2 total score, locomotor skills, and object control skills for overall adaptive functioning (ADQ

index) and each ABQC subdomain. Age and sex were controlled for in the initial model, and then locomotor skills and object control skills were added separately to examine their incremental contributions to the prediction of each dependent variable. Additionally, Receiver operating characteristic (ROC) analysis is a tool used to describe the discrimination accuracy of a diagnostic test or prediction model (Obuchowski & Bullen, 2018). Using the TGMD-2 total score to predict low adaptive functioning (defined as ADQ index < 70). The area under the curve (AUC), sensitivity, specificity, and Youden index were calculated to determine the predictive value of motor competence for identifying adaptive behavior deficits in children with severe ID and to establish an optimal clinical cut-off point.

3. Result

3.1 Analysis of population and data characteristics

Descriptive statistics for the study variables are presented in Table 1. The sample comprised 227 participants, including 152 boys (67%) and 75 girls (33%). The mean age of the participants was 10.46 years (SD = 1.65). On average, children had a height of 1.31 m (SD = 0.20) and a body weight of 31.39 kg (SD = 11.29), corresponding to a mean body mass index (BMI) of 17.68 kg/m² (SD = 3.29). With respect to motor competence, the mean total score on the TGMD-2 was 32.44 (SD = 24.59). Mean scores for the locomotor and object control subtests were 16.58 (SD = 13.13) and 15.86 (SD = 12.89), respectively. In terms of adaptive behavior, the average ADQ index was 62.61 (SD = 25.21), for the ABQC subdomains, participants obtained mean scores of 8.79 (SD = 14.83) for independence functioning, 3.78 (SD = 7.45) for cognitive functioning, and 17.64 (SD = 18.25) for socialization. The Harman single-factor test showed that a total of 14 factors with eigenvalues greater than 1 were extracted. The first factor explained 28.60% of the variance, which was far below the critical value of 40%, indicating that there was no serious common method bias.

Table 1
Descriptive statistical analysis

Variables	N(%)	M	SD
Boys	152(67%)	-	
Girls	75(33%)		
Age	-	10.46	1.65
Height(m)		1.31	0.20
Weight(kg)		31.39	11.29
BMI(kg/m ²)		17.68	3.29
Total score of TGMD-2		32.44	24.59
Locomotor Skills		16.58	13.13
Object Control Skills		15.86	12.89
ADQ Index		62.61	25.21
Independence		8.79	14.83
Cognition		3.78	7.45
Socialization		17.64	18.25

3.2 Correlation analysis

Pearson correlation analyses revealed significant associations between gross motor competence and adaptive behavior (Table 2, Fig. 1). The TGMD total score was strongly correlated with the overall ADQ index ($r = 0.813$, $P < 0.001$), indicating that higher levels of motor competence were associated with better adaptive behavior. Both locomotor skills ($r = 0.809$, $P < 0.001$) and object control skills ($r = 0.859$, $P < 0.001$) demonstrated similarly strong relationships with adaptive behavior. At the subdomain level, TGMD total scores showed moderate-to-strong correlations with independence ($r = 0.536$, $P < 0.001$) and socialization ($r = 0.655$, $P < 0.001$), whereas the association with cognitive functioning was weaker but still significant ($r = 0.292$, $P < 0.001$). Comparable patterns were observed for locomotor and object control skills. Correlations were moderate for Independence ($r = 0.499$ and 0.549) and Socialization ($r = 0.634$ and 0.682), but weaker for Cognition ($r = 0.253$ and 0.289).

Table 2
The correlation coefficient between motor competence and adaptive behavior

1.Total score of TGMD-2	1	2	3	4	5	6	7
	1						
2.Locomotor Skills	0.789***	1					
3.Object Control Skills	0.947***	0.943***	1				
4.ADQ Index	0.813***	0.809***	0.859***	1			
5.Independence	0.536***	0.499***	0.549***	0.695***	1		
6.Cognition	0.292***	0.253***	0.289***	0.423***	0.615***	1	
7.Socialization	0.655***	0.634***	0.682***	0.858***	0.672***	0.471***	1

Note: *** $P < 0.001$

Table.3 Results of multiple linear regression analysis

3.3 Multiple linear regression analysis

As shown in Table 3 and Fig. 2, Multiple linear regression analyses were conducted to examine the associations between gross motor competence and adaptive behavior outcomes. The total TGMD-2 score was a strong predictor of overall adaptive behavior, explaining 74% of the variance ($R^2 = 0.74$, $F = 211$, $P < 0.001$). The regression model for Independence explained 36% of the variance ($R^2 = 0.36$, $F = 42$, $P < 0.001$), the total TGMD-2 score was the strongest predictor ($B = 0.63$, $P < 0.001$), followed by locomotor skills ($B = 0.39$, $P < 0.001$) and object control skills ($B = 0.27$, $P = 0.002$). The model for Cognition explained 15% of the variance ($R^2 = 0.15$, $F = 13$, $P < 0.001$). The total TGMD-2 score showed a significant association ($B = 0.36$, $P < 0.001$), but locomotor skills ($B = 0.25$, $P = 0.01$) and object control skills ($B = 0.13$, $P = 0.19$) had weaker or non-significant contributions. For Socialization, the regression model explained 51% of the variance ($R^2 = 0.51$, $F = 78$, $P < 0.001$). The total TGMD-2 score was the strongest predictor ($B = 0.75$, $P < 0.001$), followed by locomotor skills ($B = 0.42$, $P < 0.001$) and object control skills ($B = 0.37$, $P < 0.001$).

Table 3
Results of multiple linear regression analysis

Dependent variables	Independent variables	B(95%CI)	SE	t	P	R	R ²	F
ADQ	Total score of TGMD-2	0.84(0.77,0.93)	0.03	23.01	< 0.001	0.86	0.74	211
	Locomotor Skills	0.45(0.66,1.09)	0.10	8.19	< 0.001	0.85	0.73	156
	Object Control Skills	0.42(0.61,1.05)	0.11	7.54	< 0.001			
Independence	Total score of TGMD-2	0.63(0.31,0.44)	0.03	11.04	< 0.001	0.60	0.36	42
	Locomotor Skills	0.39(0.24,0.63)	0.09	4.48	< 0.001	0.60	0.36	31
	Object Control Skills	0.27(0.11,0.51)	0.10	3.07	0.002			
Cognition	Total score of TGMD-2	0.36(0.07,0.14)	0.02	5.54	< 0.001	0.39	0.15	13
	Locomotor Skills	0.25(0.30,0.25)	0.05	2.50	0.01	0.39	0.15	10
	Object Control Skills	0.13(-0.03,0.19)	0.05	1.30	0.19			
Socialization	Total score of TGMD-2	0.75(0.48,0.62)	0.03	15.01	< 0.001	0.71	0.51	78
	Locomotor Skills	0.42(0.37,0.79)	0.10	5.49	< 0.001	0.71	0.51	58
	Object Control Skills	0.37(0.31,0.74)	0.11	4.80	< 0.001			

3.4 Receiver operating characteristic (ROC) analysis

As shown in Fig. 3, ROC analysis was conducted to evaluate the discriminative performance of the TGMD-2 total score in identifying children with low adaptive behavior (defined as ADQ < 70) (Yao Shuzhao et al., 1993; Yao Shuzhao, 1993). The AUC was 0.947, indicating excellent discriminative accuracy for distinguishing children with low adaptive behavior from those with non-low adaptive behavior. The ROC curve demonstrated a favorable trade-off between sensitivity and specificity across a broad range of thresholds. Using the Youden index to determine the optimal cut-off value, a TGMD-2 total score of 34.5 yielded the best balance between sensitivity and specificity, with a sensitivity of 93.1% and a specificity of 87.9% (Youden's J $\approx$ 0.81). This cut-off correctly identified the majority of children

with low adaptive behavior while maintaining a low false-positive rate among children with typical adaptive behavior.

4. Discussion

The present study examined the associations between gross motor competence and adaptive behavior and evaluated the predictive utility of TGMD-2 scores for identifying low adaptive functioning in 227 institutionalized children with severe ID. Three main findings emerged. First, gross motor competence was strongly associated with overall adaptive behavior (ADQ index) and with each adaptive domain. Second, domain-specific patterns were observed, with locomotor and object-control skills showing relatively stronger links to independence and socialization than to cognition. Third, TGMD-2 total scores demonstrated excellent discriminative performance for identifying children with low adaptive behavior ($ADQ < 70$), yielding a clinically interpretable screening threshold. Collectively, these results support motor competence as a clinically relevant functional indicator in resource-limited institutional environments, while also highlighting important boundaries regarding causality and generalizability.

4.1. Why is motor competence so strongly linked to adaptive behavior?

The remarkably high explanatory power (74%) of the TGMD-2 total score for adaptive behavior underscores motor competence as core enabling factors for adaptive behavior in children with severe ID, suggests a robust functional synergy between motor mastery and adaptive skills in children with severe ID. Although the cross-sectional nature of these data rules out direct causal reasoning, the strength of this relationship is theoretically consistent with the existing framework of neurodevelopment.

First, this pattern may reflect a Compensatory Deficiency within an Embodied Agency framework. In individuals with higher cognitive functioning, linguistic or symbolic strategies can often be recruited to bypass motor limitations. However, in children with severe ID, such higher-order compensatory pathways are profoundly constrained, rendering adaptive behavior almost entirely action bound. As proposed in the Embodied Cognition framework, when cognitive mediation is minimal, the motor system remains the principal vehicle for agency (Adolph & Hoch, 2019; Iverson, 2022; Wilson & Golonka, 2013). Second, Research in Nature Reviews Neuroscience and Child Development indicates that executive functions (e.g., planning, inhibition) and motor control share deeply overlapping neural circuits, particularly within the prefrontal-cerebellar and basal ganglia pathways (Diamond, 2000; Mastrangelo et al., 2024). In children with severe neurodevelopmental impairment, these systems may remain in a highly integrated, undifferentiated state. Consequently, motor performance serves as a potent phenotypic marker of the central nervous system's global functional integrity (Gillberg, 2010). Third, these results align with the Neurodevelopmental Cascade hypothesis. Evidence from recent longitudinal studies suggests that motor competence plays a critical role in determining a child's functional reach—their ability to engage with and learn from their environment independently (Iverson, 2010; Katagiri et al., 2021). In the case of severe ID, restricted motor exploration may lead to a form of intrinsic deprivation, where the inability to

move effectively hampers the development of both motor and adaptive skills (Bowler et al., 2024; Hill et al., 2024). This creates a synchronized developmental path, explaining the strong correlation observed in our regression models.

4.2. Functional Specificity: Locomotor vs. Object Control Skills

Our regression models further indicate domain-specific predictive patterns. Locomotor competence showed robust associations with Independence and Socialization, consistent with the idea that mobility expands access to peer interaction, shared activities, and environmental exploration (Imms et al., 2017; Iverson, 2022). This is supported by evidence that fundamental movement skills relate to daily living and social adaptive outcomes in children with developmental disabilities (e.g., intellectual disability and autism spectrum disorder), where stronger locomotor competence promotes engagement across structured and unstructured settings (Hilton et al., 2023; MacDonald et al., 2013; Zhang et al., 2024). From a mechanistic perspective, locomotor competence may increase access to learning opportunities, reduce reliance on caregivers for movement, and allow more independence practice of everyday task sequences—core components of adaptive functioning. Dynamic systems and embodied cognition frameworks similarly propose that more efficient movement increases interaction with the environment and social partners, reinforcing functional independence and social skills over time (Barnett et al., 2016; Piotrowski et al., 2025; Smith & Thelen, 2003).

In contrast, although object control skills predicted Independence and Socialization, their association with Cognition was weaker. This pattern is consistent with research suggesting that object control skills (e.g., catching, throwing, kicking) are closely embedded in social play and peer-group participation, which directly supports adaptive interaction and cooperation but may be less tightly coupled to cognitive performance (MacDonald et al., 2013; Zeng et al., 2017). Prior work in children with disabilities likewise reports stronger links between gross/object control skills and social adaptive measures than with cognitive functioning (MacDonald et al., 2013; Zeng et al., 2017). More broadly, reviews and conceptual models indicate that motor competence does not uniformly predict cognitive outcomes; effects on cognition often depend on task demands, context, and specific executive processes, rather than reflecting a simple direct relationship (Capio et al., 2024; Hill et al., 2024). Accordingly, intervention studies targeting locomotor and object control skills have reported mixed effects on formal cognitive domains (e.g., executive function, academic performance), underscoring the conditional nature of the motor–cognition association (Capio et al., 2024; Hill et al., 2024).

4.3. Predictive Utility and Clinical Cut-offs

From a clinical and institutional management perspective, the ROC findings represent one of the most practically meaningful contributions of the present study. In many social welfare institutions, especially those with limited staffing and constrained access to specialist assessment resources, comprehensive adaptive behavior evaluations may be difficult to implement routinely for all children. In contrast, field-based motor assessments such as the TGMD-2 are relatively structured, observable, and operationally

feasible, making them potentially valuable as a first-line screening tool. The excellent discriminative performance observed in this study (AUC = 0.947) suggests that gross motor competence is not only correlated with adaptive functioning, but may also serve as a pragmatic indicator for identifying children at elevated functional risk (Perkins & Schisterman, 2006). The cut-off value of 34.5 yielded both high sensitivity (93.1%) and high specificity (87.9%), indicating that this threshold may provide a useful balance between identifying most children with low adaptive functioning and limiting over-referral of children who do not meet the risk criterion (McCulloch et al., 2024; Ruopp et al., 2008). In practice, this means that children scoring below this threshold could be prioritized for more comprehensive adaptive behavior assessment, individualized support planning, and closer developmental follow-up. Importantly, the clinical value of this cut-off should not be interpreted as replacing formal adaptive behavior assessment. Rather, it may be used as an efficient triage indicator within a staged screening framework. For example, institutions could use TGMD-2 as an initial screening step and then refer children with scores below the identified threshold for more detailed functional evaluation. Such a tiered approach may help optimize limited assessment resources while improving the timeliness of identification and intervention in high-risk institutionalized populations.

In addition, because developmental outcomes in children exposed to early deprivation may still be responsive to improvements in caregiving quality and environmental enrichment, early recognition of motor-related functional risk may carry broader implications than screening alone (Humphreys et al., 2022; King et al., 2023). Identifying children with particularly low motor competence may allow institutions to initiate structured movement opportunities, environmental supports, and targeted rehabilitation planning earlier, thereby potentially improving both motor and adaptive developmental trajectories over time.

4.4. Limitations and Future Directions

Despite the robust sample size (N = 227), this study is cross-sectional, which limits causal interpretations. Longitudinal research is needed to determine if improvements in motor competence directly lead to gains in adaptive behavior over time. Secondly, while we controlled for age and sex, future studies should consider institutional variables, such as caregiver-to-child ratios and environmental stimulation levels, which significantly influence developmental trajectories in orphanages. Thirdly, this study focused solely on children from social welfare institutions (orphanages), a specific group that may limit the generalizability of the results, and there are fewer girls.. While this sample provides valuable insights into children in institutional care, future research should include more diverse samples (e.g., community-based children, children from other educational settings) to examine whether the results apply to a broader population. This will help assess whether the relationship between motor competence and adaptive behavior differs in various contexts or settings.

5. Conclusion

This study demonstrates that gross motor competence is a strong correlate of adaptive behavior in children with severe ID. TGMD-2 total scores explained substantial variance in overall adaptive behavior

and showed domain-specific associations, with locomotor and object-control skills more strongly linked to independence and socialization than to cognition. In addition, TGMD-2 total scores showed excellent discriminative accuracy for identifying low adaptive behavior ($ADQ < 70$), and the derived cut-off (34.5) may serve as a practical screening threshold to flag children who warrant more comprehensive functional assessment and early support.

Abbreviations

ABQC

Adaptive Behavior Questionnaire for Children

ADQ

Adaptive Deviation Quotient

AUC

Area Under the Curve

BMI

Body Mass Index

DSM-5

Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition

ID

Intellectual Disability

ICC

Intraclass Correlation Coefficient

ROC

Receiver Operating Characteristic

SD

Standard Deviation

TGMD-2

Test of Gross Motor Development–Second Edition

Declarations

Ethics approval and consent to participate

All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee and with the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of Shanghai University of Sport (Approval No. 102772024RT062). Written informed consent to participate was obtained from the institutional administrators and primary caregivers of all participants prior to data collection. This observational study was registered at ClinicalTrials.gov (Identifier: NCT07358143, registered on January 14th, 2026).

Consent for publication

Not Applicable

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. No financial support from companies with a vested interest in the results of this study was received.

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Author Contribution

X.W. and D.W. designed the study, performed the data collection at the social welfare institutions, and analyzed the data; they are co-first authors of this study. L.Z. and X.S. contributed to the gross motor development assessments (TGMD-2) and video scoring quality control. X.W. (Xueping Wu) provided the conceptual framework, secured the funding for the project, and supervised the entire research process. X.W. (Xili Wen) and D.W. wrote the primary manuscript text, and L.Z. prepared the figures and tables. All authors reviewed and approved the final manuscript.

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Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

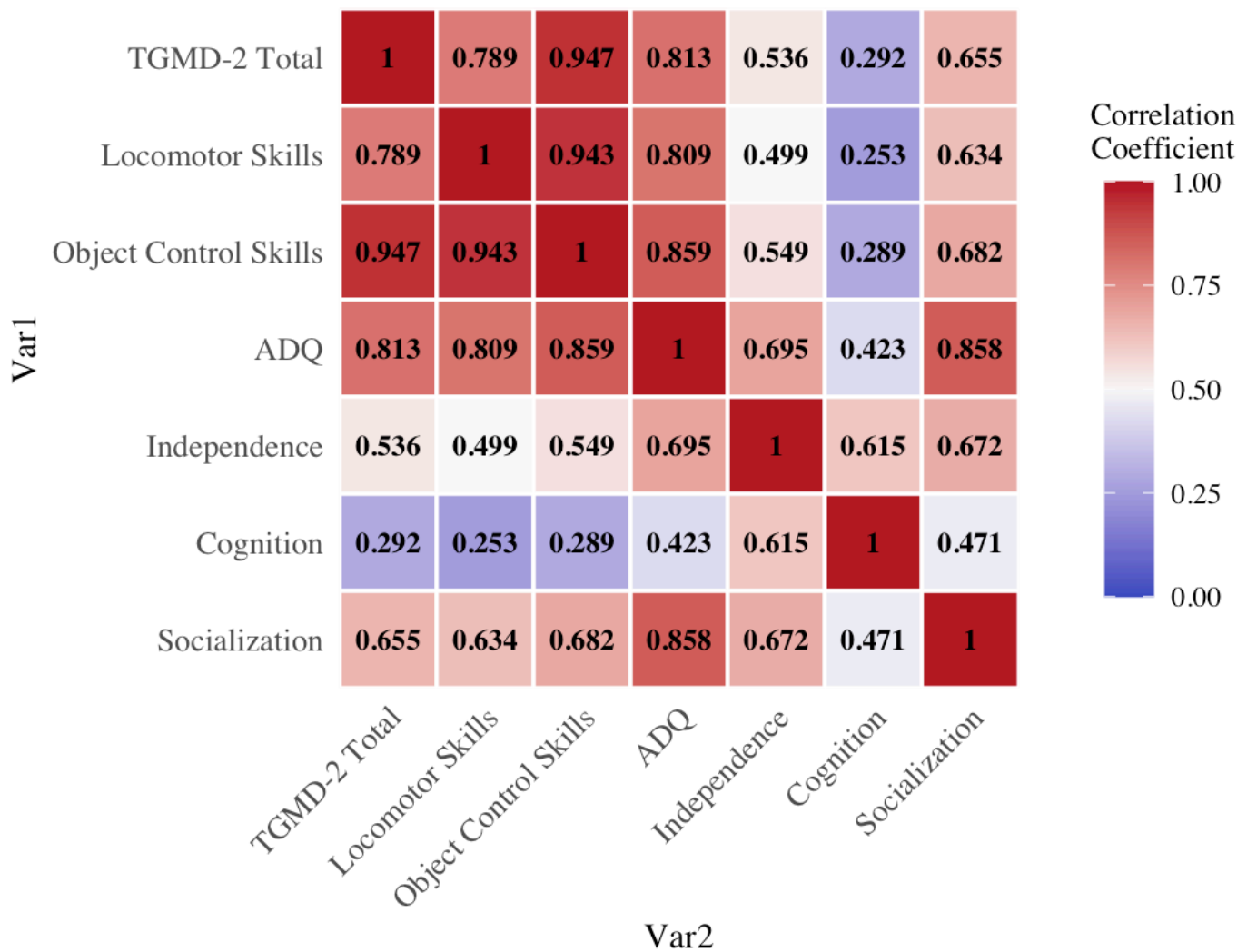


Figure 1

Correlation heat map

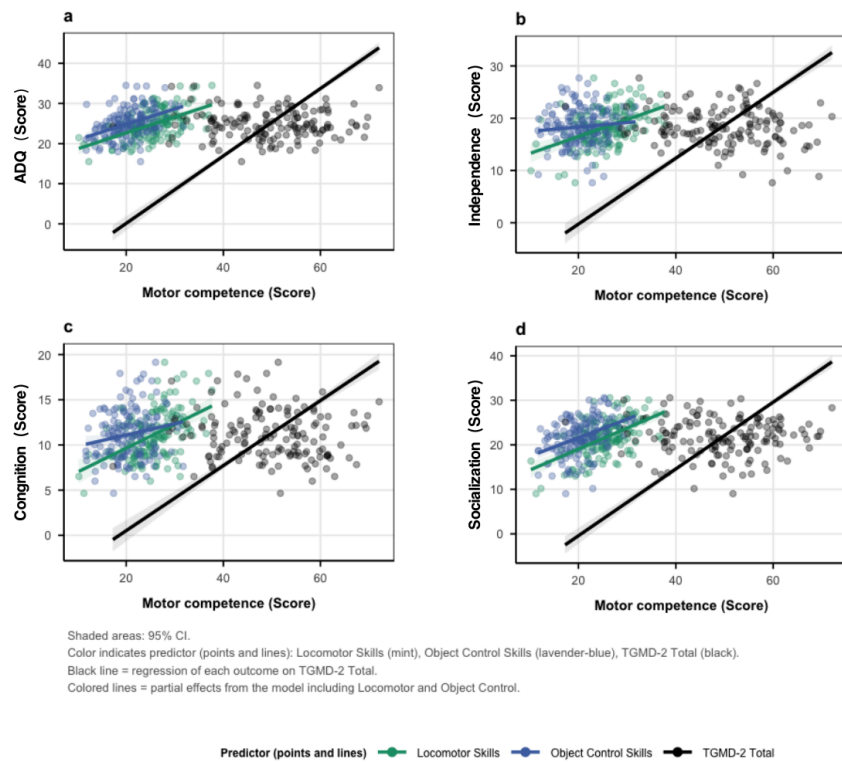


Figure 2

Scatter plot of multiple linear regression analysis

ROC curve: TGMD-2 total score for identifying low adaptive beh

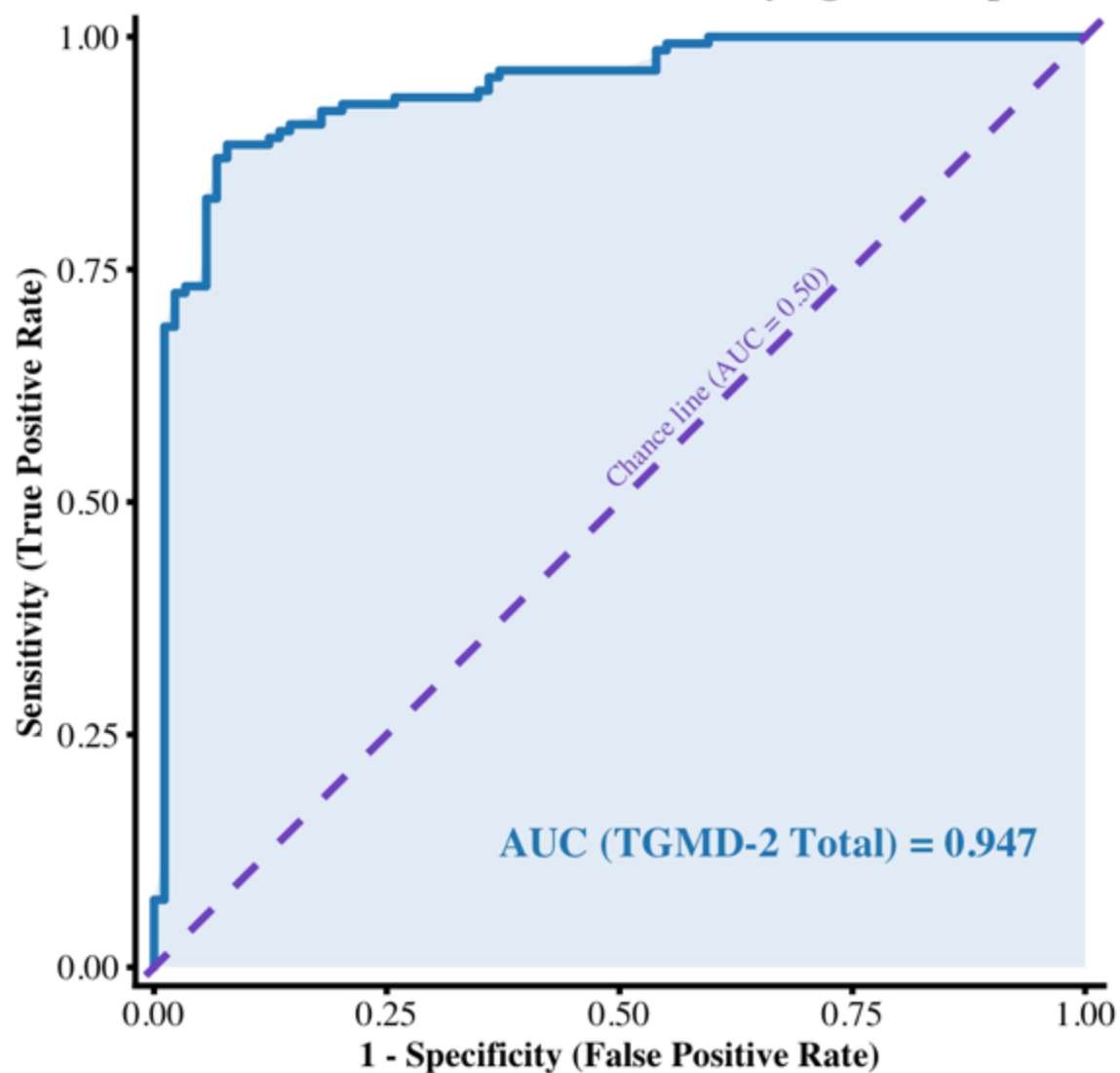


Figure 3

ROC curve analysis graph

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