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Enhancing Physical Mobility in Children with Exceptional Needs Through a Three-Dimensional Evaluation Paradigm: A Tripartite Synergistic Study

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Abstract This study investigates how tripartite collaboration among teachers, parents, and professional support staff may enhance physical activity among children with special educational needs, using a three-dimensional evaluation framework. To develop a comprehensive understanding of the current level of physical activity among these children and their performance in practical educational activities, the study combines potential, practical, and developmental assessments within a multidimensional, individualized assessment approach. The study reports that 412 special education students from two elementary schools were included as participants. Accelerometers were used to monitor physical activity (PA) and sedentary behavior (SB), while motor competence and behavioral problems were assessed concurrently. The reported findings indicate an inverse association between physical activity and behavioral problems, and suggest that moderate-to-vigorous physical activity (MVPA) may be associated with fewer behavioral difficulties. Physical activity duration was also examined as a potential mediator of the association between motor competence and behavioral performance. Together, these analyses underscore the importance of examining movement-related outcomes and behavioral functioning within an integrated educational assessment framework. The findings are interpreted in relation to individualized educational support and the proposed collaboration among families, schools, and professional personnel.

Index Terms Children with special educational needs; Motor competence; Moderate-to-vigorous physical activity; Sedentary behavior; Behavioral problems; Three-dimensional evaluation; Tripartite collaboration

I. Introduction

In recent years, researchers, educational practitioners, and the wider community have devoted increasing attention to the physical and psychological development of children with special educational needs. The term generally refers to children who experience differences or limitations involving physical, intellectual, sensory, language, emotional, or behavioral functioning [1]. These children may encounter substantial barriers in everyday life and educational participation, including difficulties associated with mobility and the development of motor competence. Appropriate physical activity can support physical fitness and independent functioning while also creating opportunities for social participation, emotional regulation, and interpersonal engagement. Accordingly, the scientific assessment of physical activity and the development of appropriate strategies for improving mobility among children with special educational needs have become important topics within educational and health-related research [2], [3].

Improving physical mobility among children with special educational needs has implications not only for health and quality of life but also for educational inclusion, participation, and social equity [4]. Physical and psychological development can facilitate participation in social activities, adaptation to everyday challenges, and increased independence across home and school settings. Nevertheless, compared with typically developing peers of similar ages, children with special educational needs frequently experience barriers to regular physical activity related to motor competence, accessible facilities, instructional support, and opportunities for social interaction [5]. Such differences may affect self-esteem, emotional well-being, and participation in peer activities, particularly when adequate educational and environmental accommodations are unavailable. Promoting meaningful and sustainable participation in physical activity is therefore a significant objective in both inclusive education and child development research [6].

Research on physical mobility among children with special educational needs has primarily addressed two related questions: how physical and motor functioning should be assessed, and which educational or movement-based interventions may improve it [7]. Many existing investigations

use conventional quantitative measures, including physical fitness tests, standardized motor assessments, and indicators of physical health. Although these instruments provide valuable information about current functioning, their scores may not fully reflect the diversity of individual abilities, opportunities for learning, and developmental needs among children with different educational profiles. In particular, standardized assessment procedures can be less informative when they are not adapted to a child's specific communication, cognitive, sensory, and motor characteristics. Consequently, assessment findings may offer an incomplete basis for designing individualized educational activities and selecting appropriate intervention strategies [8], [9].

Educational intervention studies have often emphasized discrete behavior-management techniques or structured physical training, with comparatively limited attention to the individual characteristics and ongoing needs of children with special educational needs. Conventional exercise programs may not consistently support the development of lasting physical activity habits, especially when activities are not adapted to participants' abilities, preferences, and everyday environments. An additional limitation is the insufficient integration of the contributions made by families, schools, and wider support services. Without coordinated participation, educational resources may be distributed unevenly, and strategies implemented in one environment may not be reinforced in another. More systematic cooperation and communication are therefore relevant to the continuity, appropriateness, and effectiveness of physical activity support [10].

A three-dimensional evaluation paradigm offers a means of considering several aspects of physical mobility and educational development together rather than relying exclusively on one physical performance indicator. Within this approach, assessment is multidimensional and individualized, allowing educators to examine the abilities, participation, and developmental needs of children with special educational needs from complementary perspectives. The framework comprises three interrelated components: potential evaluation, practical evaluation, and developmental evaluation. Each component addresses a different aspect of the child's functioning and contributes information that may inform subsequent educational planning and physical activity support.

Potential evaluation involves examining the cognitive, manual, adaptive, and movement-related abilities of children with special educational needs. This dimension seeks to identify capacities that may be further developed through educational support and appropriately adapted physical activities. Information obtained through this assessment provides a foundation for selecting realistic objectives and designing subsequent intervention activities.

Practical evaluation focuses on how children participate in and perform meaningful activities in everyday settings. It helps teachers evaluate task execution, cooperation, sustained attention, and engagement during educational and physical activities. Developmental evaluation, by contrast, examines progress in relation to individualized goals and broader developmental needs, thereby contributing to the design and adjustment of personalized educational programs. Together, these dimensions provide complementary descriptions of current functioning, observable participation, and longer-term developmental progress.

Individualized assessment additionally emphasizes developmentally appropriate criteria that account for each child's physical, cognitive, emotional, and behavioral characteristics. Rather than applying identical expectations to every participant, this approach seeks to identify individual strengths, support requirements, and areas in which further development may be possible. Such information may help educators formulate more targeted and achievable plans while retaining transparent and scientifically interpretable assessment procedures. Nevertheless, implementing a three-dimensional paradigm introduces several practical challenges, including the development of valid assessment instruments, the maintenance of fairness and objectivity across individualized procedures, and the translation of assessment findings into educational interventions that can be monitored over time.

Within the three-dimensional evaluation paradigm, this study proposes a tripartite collaborative educational model intended to support the physical mobility of children with special educational needs. The model emphasizes contributions from the family, the school, and wider professional or community support, with coordinated communication linking assessment findings to practical activities. The study identifies three principal contributions that motivate the proposed approach and inform the interpretation of its assessment and behavioral data.

First, the proposed model calls for a stable communication and cooperation mechanism among families, schools, and relevant professional services. Coordinated participation is intended to connect educational activities with support available at home and in the community, thereby offering children a wider range of physical activity opportunities and more consistent guidance. The approach is also intended to address limitations in resource allocation by enabling educational and professional participants to exchange information about individual needs and progress, while reducing inconsistencies between support arrangements in different settings.

Second, the framework incorporates individualized and diversified evaluation criteria that reflect the needs and characteristics of children with special educational needs. By integrating potential, practical, and developmental assessments, the approach seeks to provide a more detailed account of motor functioning, activity participation, and changes over time. This combination is expected to assist teachers and other support personnel in selecting realistic educational targets and in providing differentiated guidance that is responsive to each child's circumstances.

Third, the study uses quantitative information about motor competence, physical activity intensity, sedentary behavior, and behavioral problems to inform the evaluation of possible intervention priorities. Its analysis examines associations among movement-related abilities, activity duration, and be-

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havioral functioning, with particular attention to the potential mediating roles of activity and sedentary time. Such findings can contribute to a more evidence-informed discussion of educational planning, although the observational analyses must be distinguished from evidence demonstrating that any particular collaborative intervention caused the reported outcomes.

II. Research Methods

A. Research Population

The required sample size was estimated in advance using G*Power 3.1. An efficacy value of 0.6 and a medium effect size of 0.16 were specified, resulting in a reported minimum sample size of 105 students. Using a whole-population sampling approach, the study initially selected 410 children younger than ten years from classes in Grades 3–5 at two local elementary schools attended by left-behind children. Following the provision of informed consent by parents or legal guardians, 410 students without medical contraindications to exercise agreed to participate. Physical activity (PA) and sedentary behavior (SB) were monitored by accelerometers over one week. A day was considered valid when device wear time reached at least 10 hours, and valid PA data required at least three qualifying days, including two weekdays and one weekend day [11]. A total of 325 children completed the relevant tests and survey procedures, while 320 met the validity criteria and were included in the assessment of motor competence and behavioral problems. Body mass and height were subsequently measured, and body mass index (BMI) was calculated. The different participant totals reported in the abstract, recruitment description, and final analysis require confirmation against the original study records.

B. Research Tools

Motor competence was assessed using the Test of Gross Motor Development–Second Edition (TGMD-2), a standardized measure for which validity and reliability evidence has been reported in China [12]. The instrument contains 12 movement skills organized into two domains: locomotor skills and object-control skills. The six locomotor activities described in the study are running, standing long jump, stride jump, side step, front step, and single-leg jump. The six object-control activities are stationary ball shooting, kicking, catching, striking a stationary ball, overhand throwing, and bouncing a ball on the ground. Before formal assessment, the researcher demonstrated each movement twice and gave the students an opportunity to practice. Each student then performed two trials of every skill, and two motor-skill specialists independently scored the recorded performances using video footage. Individual performance criteria were scored as 1 when fulfilled and 0 when not fulfilled; each movement had three to five criteria, as described in the assessment procedure. Scores from the two evaluators were averaged for each movement. The reported inter-rater reliability coefficient was $R = 0.85$, indicating the level of agreement obtained for this assessment procedure.

Physical activity was measured with accelerometers, which are widely used in studies of activity and sedentary time among children [13]. Participants wore each device on the right hip during the monitoring week and removed it during sleep and water-based activities, including swimming. Researchers explained correct device use to parents or guardians and checked daily wear information to assess compliance with the protocol. Recording began at 00:00 on the second day following distribution, and the devices were retrieved on the eighth day. Accelerometer data were screened and processed using ActiGraph 6.5 software with a 15-second recording interval. The study applied a physical activity intensity classification attributed to Zhu and colleagues, distinguishing sedentary behavior (SB), light physical activity (LPA), moderate physical activity (MPA), and vigorous physical activity (VPA). The present analyses focused on daily SB time and moderate-to-vigorous physical activity (MVPA), defined as the combined time spent in MPA and VPA; LPA was not examined as a separate outcome because its relation to the selected health indicators was considered less certain. Average recorded wear time exceeded 15 hours per day, suggesting substantial compliance with the device-wearing instructions during the assessment period.

Behavioral difficulties among left-behind children were assessed using the Strengths and Difficulties Questionnaire (SDQ) [14]. The Chinese-language version of the SDQ has been used in child behavioral research, with published evidence concerning its psychometric properties [15]. The questionnaire consists of 25 items across five domains: conduct problems, emotional symptoms, peer relationships, hyperactivity or attention difficulties, and prosocial behavior. Responses were recorded on a three-point scale ranging from 0, indicating that a statement was not applicable, to 2, indicating that it was clearly applicable. In this study, the total behavioral-problem score was calculated by combining the first four difficulty domains; higher values indicated more substantial reported behavioral problems. The aggregate Cronbach's alpha coefficient for these four difficulty domains was reported as 0.82, indicating the internal consistency estimated from the study responses.

C. Statistical Analysis

SPSS 26.0 was used to summarize participants' demographic characteristics, motor competence, MVPA duration, SB duration, and behavioral-problem scores, and to examine differences and associations among the principal variables. Hierarchical regression models assessed the reported relationships of motor competence, MVPA, and SB with behavioral problems, while controlling for sex, age, and BMI among the left-behind children [16]. The potential mediating roles of MVPA and SB in the association between motor competence and behavioral problems were examined using bias-corrected, nonparametric bootstrap estimates of 95% confidence intervals (CIs). Under the specified inferential rule, an indirect effect was regarded as statistically significant when its 95% CI excluded zero. Because MVPA and sedentary time reflect distinct components

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of daily activity behavior and may be associated with one another, analyses evaluating each candidate mediator separately also included the other activity measure as a covariate. The observational nature of these associations should be considered when interpreting the direction of any estimated mediation effects.

III. Results

A. Correlation Analysis, Tests of Variance, and Descriptive Statistics

The final analytical sample comprised 150 non-left-behind children and 170 left-behind children. Table 1 presents descriptive statistics and between-group comparisons for the measured variables, including age, BMI, locomotor competence, MVPA duration, sedentary time, and behavioral-problem scores. The reported results indicate lower motor competence and higher behavioral-problem scores among left-behind children than among their non-left-behind counterparts. Sedentary time was also higher in the left-behind group, whereas the difference in MVPA duration between the groups was not statistically significant. Correlation coefficients for the left-behind children are presented in Table 2. Motor competence was positively correlated with MVPA and negatively correlated with sedentary time and behavioral problems. MVPA was negatively associated with both sedentary time and behavioral-problem scores, whereas sedentary time showed a positive association with behavioral problems. These observed relationships motivated the subsequent regression and mediation analyses, although the coefficients alone do not establish a causal direction.

Table 1: Descriptive Statistics and Between-Group Comparisons of Study Variables

Variable	Children who are not left behind (150)	Children who are left behind (170)	t	p	d
Male Female	80 70	70 100			
Age	9.88 ± 0.55	9.86 ± 0.62	-0.32	0.786	0.01
BMI	15.86 ± 0.52	17.52 ± 2.6	-0.58	0.125	0.12
Locomotion	68.58 ± 7.25	63.58 ± 8.56	3.25	0.005	0.36
MVPA time (min)	46.25 ± 10.78	45.44 ± 12.87	0.55	0.587	0.10
SB time (min)	528.47 ± 54.26	542.44 ± 61.26	-2.12	0.033	0.25
Problem behavior	12.23 ± 2.21	12.86 ± 2.36	-2.77	0.005	0.25

Table 2: Correlations Among Motor Competence, Physical Activity, Sedentary Time, and Behavioral Problems

Variable	1	2	3
Locomotion			
MVPA time (min)	0.38		
SB time (min)	-0.25	-0.27	
Problem behavior	-0.35	-0.66	0.22

B. Mediating Effects of Physical Activity and Sedentary Behavior on Motor Competence and Behavioral Problems

Hierarchical regression was employed to examine the indirect association between motor competence and behavioral problems through MVPA and SB among the left-behind children. The narrative results report that motor competence positively predicted MVPA ($\beta = 0.39$, $p < 0.001$), as discussed alongside Table 3. When MVPA and motor competence were entered jointly, MVPA was reported as a negative predictor of behavioral problems ($\beta = -0.72$, $p < 0.01$), while the coefficient associated with motor competence was reported as $\beta = -0.29$ ($p < 0.01$). The bootstrap mediation analysis summarized in Table 4 reported an indirect-effect 95% confidence interval of $[-0.39, -0.10]$, which excluded zero. The associated narrative estimate of the mediated effect was -0.25, representing 67.57% of the total effect. These results were interpreted as evidence of partial statistical mediation of the relationship between motor competence and behavioral problems by MVPA. However, the numerical values in the narrative and corresponding tables are not identical and should be reconciled with the underlying regression output before publication [17], [18].

The second set of regression models examined whether sedentary behavior statistically mediated the relationship between motor competence and behavioral problems. The narrative results report negative associations between motor competence and SB ($\beta = -0.24$, $p < 0.001$), as well as between motor competence and behavioral problems ($\beta = -0.34$, $p < 0.001$); the corresponding tabulated estimates appear in Table 3. In the model including both motor competence and SB, sedentary behavior was reported as a positive predictor of behavioral problems ($\beta = 0.18$, $p < 0.001$), while motor competence retained a negative coefficient ($\beta = -0.21$, $p < 0.001$). The bootstrap results described in relation to Table 4 reported a 95% confidence interval for the indirect effect of $[-0.12, -0.02]$, excluding zero. The narrative estimated the mediated effect at -0.06, or 17.65% of the total effect. These results were interpreted as partial statistical mediation through sedentary behavior. The differences between the narrative and table entries warrant further verification, particularly because the study relies on observed associations rather than experimentally assigned levels of sedentary behavior.

Table 3: Regression Models Evaluating the Mediating Roles of MVPA and Sedentary Behavior

	Outcome	Predictive variables	R	R^2	β	t
MVPA	MVPA	Locomotion	0.33	0.16	0.38	7.15
MVPA	Problem behavior	Locomotion	0.32	0.14	-0.35	-6.25
MVPA	Problem behavior	Locomotion	0.82	0.68	-0.28	-3.28
MVPA		MVPA			-0.74	-14.85
SB	SB	Locomotion	0.26	0.04	-0.22	-4.15
SB	Problem behavior	Locomotion	0.33	0.13	-0.35	-6.25
SB	Problem behavior	Locomotion	0.82	0.66	-0.23	-5.68
SB		SB			0.16	3.74

Table 4: Bootstrap Estimates of Indirect Effects Through MVPA and Sedentary Behavior

	Effect	Effect value	Standard error	Upper 95% CI limit	Lower 95% CI limit	Effect ratio (%)
MVPA	Total effect	-0.35	0.06	-0.42	-0.15	99.9
	Motor competence–behavioral problems	-0.14	0.05	-0.22	-0.03	32.52
	Motor competence–MVPA	-0.24	0.04	-0.38	-0.09	67.52
	Total effect	-0.35	0.08	-0.45	0.17	100.00
	Motor competence–behavioral problems	-0.26	0.04	-0.36	-0.22	82.56
	Motor competence–SB	-0.05	0.02	-0.14	-0.05	17.58

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C. Effects of Adapted Physical Activity on Fundamental Motor Skills and Quality of Life

The reported TGMD-2 outcomes are illustrated in Figure 1, including its panels addressing total motor skill scores, locomotor performance, and object-control skills. Both the intervention group (IG) and comparison group (CG) were reported to improve in overall TGMD-2 scores following a six-month period. However, the IG was reported to exceed the CG by 13.02 points in total score, 5.26 points in motor skills, and 7.5 points in object-control performance; the narrative states that the associated p values were below 0.01 [19], [20]. These numerical differences have been retained as reported, although the methods section does not describe the allocation, eligibility, or intervention procedures for these two groups.

Quality-of-life outcomes following the reported intervention are shown in panel D of Figure 1. The manuscript states that participants' quality-of-life scores increased after six months of physical activity intervention ($p < 0.001$). It further reports that the IG improved by 6.47 points more than the CG, suggesting a larger observed change in the intervention group. This interpretation should remain conditional on verification of the group definitions, the quality-of-life instrument, and the corresponding baseline and follow-up measurements, none of which are fully described in the available methods.

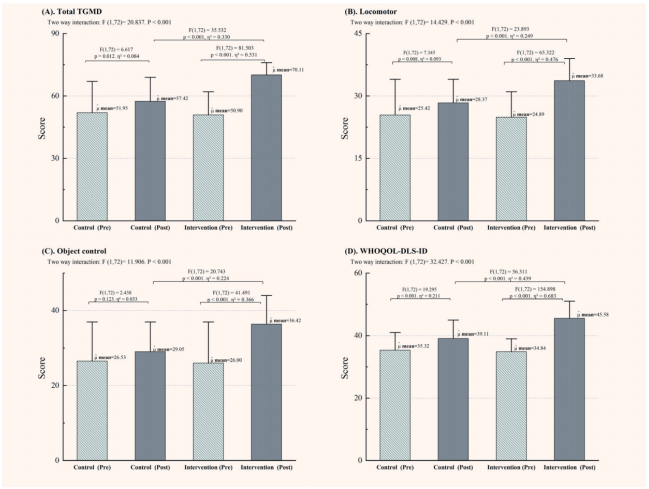


Figure 1: Motor Skills and Quality-of-Life Assessments Among Adolescents with Intellectual Disabilities: (A) TGMD-2 Total Score; (B) Locomotor Skills; (C) Object-Control Skills; (D) WHOQoL-DLS-ID Score

D. Effects of Adapted Physical Activity on Physical Fitness

The reported post-intervention physical fitness (PF) outcomes are presented in Figure 2, including the grip-strength assessment in panel B, the 30-second sit-to-stand test in panel C, and the 20-m progressive aerobic cardiovascular endurance run (PACER) in panel D. The narrative reports statistically significant group-by-time interactions for these outcomes and interprets them alongside the changes in quality of life. Grip strength, measured in kilograms, increased in both the CG and IG, with an increase reported to be 9.97 kg greater in the IG. The IG was also reported to improve by 8.11 laps in the 20-m PACER test and by eight repetitions in the 30-second sit-to-stand test, with reported p values below 0.01. In contrast, the manuscript reports no appreciable changes in the one-minute sit-up test, seated forward-bend test, or BMI. These comparisons preserve the supplied outcomes and require confirmation of the intervention design and measurement protocols.

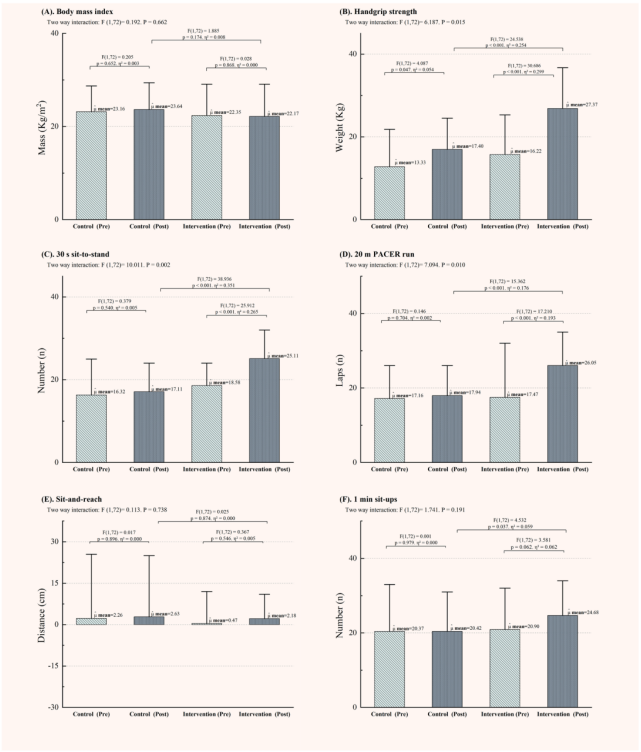


Figure 2: Changes in Physical Fitness Among Adolescents with Intellectual Disabilities: (A) BMI; (B) Grip Strength; (C) 30-Second Sit-to-Stand Test; (D) 20-m PACER; (E) Seated Forward-Bend Test; (F) One-Minute Sit-Up Test

E. Correlations Among Fundamental Motor Skills, Physical Fitness, and Quality of Life

The associations among fundamental motor skills (FMS), quality of life (QoL), and physical fitness (PF) in adolescents with intellectual disabilities are presented in Figure 3. The manuscript reports a strong positive correlation between FMS and QoL ($r = 0.71$, $p < 0.01$), indicating that higher motor skill scores were associated with higher reported quality-of-life scores. Positive correlations were also reported between FMS and most PF measures ($r = 0.34$–0.56, $p < 0.05$), consistent with an association between motor competence and several components of physical performance. An additional range of positive associations with PF indicators ($r = 0.32$–0.59, $p < 0.05$) was reported, although the variable associated with this second range was not identified in the source text. No

statistically significant correlation was reported for the seated forward-bend test. This ambiguity should be resolved from the original analysis before the final statistical interpretation is approved.

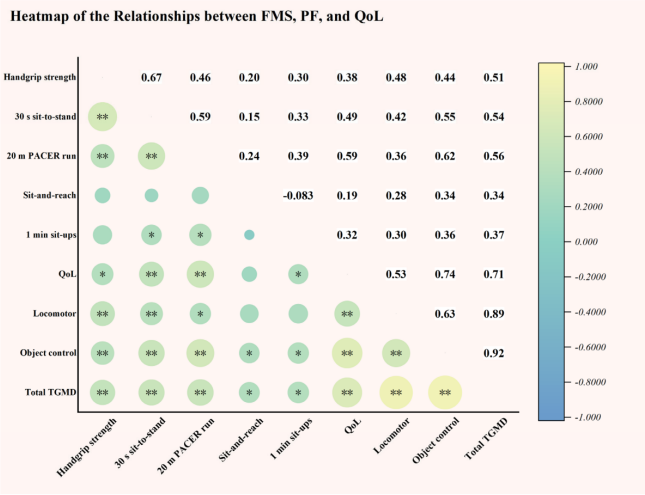


Figure 3: Correlation Heatmap of Quality of Life (QoL), Physical Fitness (PF), and Fundamental Motor Skills (FMS). $^{**}p < 0.001$; $^{*}p < 0.05$

IV. Conclusion

This study examined the proposed contribution of tripartite collaboration among teachers, parents, and professional support personnel to the physical mobility of children with special educational needs within a three-dimensional evaluation paradigm. The reported analyses identified a negative association between motor competence and behavioral problems and documented relationships involving moderate-to-vigorous physical activity (MVPA), sedentary behavior, and behavioral functioning. The findings were interpreted as indicating that greater MVPA may be associated with fewer behavioral difficulties, although the observational analysis does not establish that an increase in MVPA directly caused a reduction in those difficulties. By combining accelerometer-based measurements with motor and behavioral assessments, the study offers a framework for discussing how potential, practical participation, and developmental progress might inform individually tailored physical activity support.

The proposed tripartite mechanism emphasizes that cooperation among parents, teachers, and professional support personnel may facilitate continued monitoring and adjustment of physical activity opportunities for children with different educational needs. The reported mediation analyses suggest that MVPA and sedentary duration may help explain statistical associations between motor competence and behavioral performance. These findings support consideration of daily activity patterns as part of a broader educational assessment, but they do not independently demonstrate the effectiveness of a coordinated family–school–professional intervention. The analysis also highlights the difficulties of recognizing individual differences accurately and translating general assessment scores into individualized intervention plans. Additional data are required to determine how the proposed collaboration affects participation or developmental outcomes over time.

The principal contribution of the study is the integration of potential, practical, and developmental perspectives into a three-dimensional framework for evaluating physical mobility in children with special educational needs. The framework provides educators with a multidimensional structure for assessment and offers a conceptual basis for cooperation with families and professional support services. Nevertheless, the reported results should be interpreted in light of the available sample, measurement information, and discrepancies between narrative estimates and the numerical tables. Further research is needed to strengthen assessment instruments, refine individualized activity programs, and examine a wider range of intervention formats and outcomes. Future studies could integrate additional physiological and psychological indicators, document intervention implementation in detail, and use longitudinal or controlled designs to examine whether coordinated support produces measurable improvements in participation, motor competence, and behavioral well-being.

Author Contributions

Both authors contributed equally to the conception, development, analysis, and preparation of this manuscript. Both authors critically reviewed the text, approved the final version submitted for publication, and accept responsibility for the integrity of the reported work.

Conflict of Interest

The authors declare that they have no known financial or non-financial conflicts of interest related to the research described in this manuscript.

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Data Availability

No new data were created or analyzed in this study.

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