Developing a multisensory-based instructional model for adaptive gymnastics: evidence from children with intellectual disabilities

Desarrollo de un modelo instruccional basado en la estimulación multisensorial para la gimnasia adaptada: evidencia a partir de niños con discapacidad intelectual

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Abstract

Introduction: Inclusive education and adapted physical education require instruction that fits the sensory and motor-learning profiles of children with intellectual disabilities (ID), who often show persistent coordination difficulties in school.
Objective: To design, validate, and field-test a five-phase multisensory instructional model for adaptive gymnastics for children with ID aged 7–12.
Methodology: An educational R&D approach was conducted in two phases: (1) expert content validation (n = 3) using Aiken's V across model components; and (2) a preliminary field test with 20 students with ID (7–12 years) in a special school in Makassar, Indonesia. The intervention followed five phases (Sensory Activation, Pattern Cueing, Multisensory Guided Practice, Kinesthetic Reinforcement, Reflective Multimodal Feedback) delivered in seven modules (one session/module; ~40–45 minutes). Fidelity/feasibility were monitored across modules, and pre–post Fundamental Motor Performance (FMP) was analyzed using paired-sample t-tests with effect size (dz) and 95% CI.
Results: Content validity was strong (Aiken's V = 0.853). Fidelity improved from 2.38 (Module 1) to 3.63 (Module 7). Composite FMP increased significantly (+5.80; dz = 1.67; p < .001; 95% CI [4.17, 7.43]), with the largest gains in Independence (+2.45) and Motor (+2.20).
Discussion: Improvements aligned with structured repetition, multisensory cueing, and autonomy-supportive routines; job aids (e.g., icon cards, markers) supported consistent implementation.
Conclusions: The model is valid, feasible, and associated with meaningful gains in fundamental motor performance for children with ID; broader implementation and longer-term evaluation are recommended.

Keywords

Multisensory instruction; adaptive gymnastics; intellectual disabilities; fundamental motor performance; inclusive Physical Education; instructional model development.

Resumen

Introducción: La educación inclusiva y la educación física adaptada (EFA) requieren estrategias de enseñanza acordes con los perfiles sensoriales y de aprendizaje motor de los niños con discapacidad intelectual (DI), quienes suelen presentar dificultades persistentes de coordinación en la escuela.
Objetivo: Diseñar, validar y probar en campo un modelo instruccional multisensorial de cinco fases para gimnasia adaptada en niños con DI de 7 a 12 años.
Metodología: Se empleó un diseño educativo de I+D en dos fases: (1) validación de contenido por expertos (n = 3) mediante el índice V de Aiken en los componentes del modelo; y (2) prueba piloto en campo con 20 estudiantes con DI (7–12 años) en una escuela especial de Makassar, Indonesia. La intervención aplicó cinco fases (Activación Sensorial, Señalización de Patrones, Práctica Guiada Multisensorial, Refuerzo Cinestésico, Retroalimentación Multimodal Reflexiva) en siete módulos (un módulo por sesión; ~40–45 minutos). Se monitoreó fidelidad/factibilidad y los cambios pre–post en el Rendimiento Motor Fundamental (FMP) se analizaron con t de muestras relacionadas, tamaño de efecto (dz) e IC 95%..
Resultados: La validez de contenido fue alta (V de Aiken = 0.853). La fidelidad aumentó de 2.38 (Módulo 1) a 3.63 (Módulo 7). El FMP compuesto mejoró significativamente (+5.80; dz = 1.67; p < .001; IC 95% [4.17, 7.43]), con mayores incrementos en Independencia (+2.45) y Motor (+2.20).
Discusión: Las mejoras se relacionaron con repetición estructurada, claves multisensoriales y rutinas que favorecen la autonomía; las ayudas didácticas (p. ej., tarjetas con iconos y marcadores) facilitaron la consistencia.
Conclusiones: El modelo es válido, factible y se asocia con mejoras relevantes del rendimiento motor fundamental en niños con DI; se sugiere ampliar su aplicación y evaluar efectos a largo plazo.

Palabras clave

Instrucción multisensorial; gimnasia adaptada; discapacidades intelectuales; desempeño motor fundamental; Educación Física inclusiva; desarrollo de modelos instruccionales.

Introduction

Inclusive education has become a global priority under the framework of Sustainable Development Goal 4 (SDG 4), which emphasizes equal access to quality education for all learners, including those with disabilities (Baena-Morales & González-Víllora, 2023). In this agenda, adapted physical education (APE) serves as a strategic entry point for advancing physical, cognitive, social, and emotional development in children with intellectual disabilities (ID) (Syahruddin et al., 2025). Indonesia, through national strategies such as Asta Cita 3 and RPJMN 2025–2029, places strong emphasis on inclusive human-resource development and expanding access to sport and physical activity among people with disabilities (Mira et al., 2023) The country currently supports 2,366 special schools (SLB) with a total enrollment of 162,806 students, of which approximately 52.8% have intellectual disabilities—85,900 nationally and 1,009 in South Sulawesi alone (Indonesian SLB Statistics 2024/2025).

Despite its strategic potential, APE remains underdeveloped in addressing the specific needs of learners with ID. Data from Makassar reveal that nearly 40% of students with ID exhibit very poor motor coordination (Maritska et al., 2025), a condition strongly linked to decreased physical activity participation and increased risk for non-communicable diseases (NCDs) such as obesity, diabetes, and hypertension (Cleven et al., 2020; MacEachern et al., 2022; Schroeder et al., 2020). Current physical education (PE) practices frequently fail to account for the diverse sensory profiles of students with ID, resulting in instruction that is non-responsive to sensory integration needs and inadequate for fostering meaningful engagement, comprehension, and task execution (Arroyo-Rojas & Hodge, 2024; Holland & Haegele, 2021; Mawena & Sorkpor, 2024).

The literature strongly supports the effectiveness of gymnastics-based programs in improving fundamental movement skills (FMS), physical fitness, balance, coordination, and psychosocial outcomes among children with ID ((Kurtoğlu et al., 2022; McGuire et al., 2019; Özkan & Kale, 2023; Shuttleworth et al., 2024; Xu, Ming-yan, et al., 2020). Rhythmic gymnastics and other structured motor activities have been shown to enhance speed, strength, endurance, and self-efficacy while promoting participation and quality of life (Di Concilio et al., 2019; Puce et al., 2023; Yemiscigil & Vlaev, 2021). However, the integration of multisensory instructional strategies—visual, auditory, tactile, proprioceptive, and vestibular—into adaptive gymnastics programs remains underexplored and insufficiently structured (Block et al., 2021; Camarata et al., 2020; Case et al., 2025).

Emerging pedagogical frameworks such as the OPTIMAL theory and external focus of attention highlight the critical role of motivation and attentional focus in motor learning, particularly when paired with multisensory cueing (Chua et al., 2021; Ghorbani et al., 2020; Pradipta et al., 2023). When learners with ID receive multisensory support aligned with external focus strategies—such as rhythmic auditory cues, visual prompts, and tactile guidance—improvements in motor acquisition and engagement are consistently observed. This interaction of sensory integration with cognitive-motivational frameworks provides a promising foundation for instructional design.

Moreover, syntheses of rhythmic gymnastics interventions affirm their potential to generate significant motor and fitness gains among children with developmental conditions, including ID (Duan et al., 2022; Theroux et al., 2025; Xu, Yao, et al., 2020). Structured, playful, and rhythmic components of gymnastics enhance task engagement and skill acquisition through embodied, multimodal learning experiences (Barzyk & Grüber, 2024; Duan et al., 2022; Dafun et al., 2024). These findings call for the development and validation of instructional models that translate such evidence into classroom-implementable formats. However, current studies rarely specify a teachable phase-based syntax, implementation supports (e.g., job aids, cue hierarchies), or fidelity-monitorable routines that enable APE teachers to deliver multisensory gymnastics instruction consistently in school settings.

This study aims to design, validate, and field-test a five-phase multisensory instructional model for adaptive gymnastics targeting children with ID aged 7–12. The model integrates sensory activation, pattern cueing, guided practice, kinesthetic reinforcement, and reflective multimodal feedback into a structured sequence that is teachable, observable, and responsive to learners' motor and sensory needs. Consistent with these identified theoretical and practical gaps, we hypothesized that (H1) the model would demonstrate strong content validity (Aiken's V ≥ .80), (H2) implementation fidelity would improve across modules as teachers became familiar with the phase-based routines, and (H3) students' composite FMP would increase significantly from pre- to post-intervention, with larger gains expected in Motor and Independence than in Cognitive and Social–Emotional domains.

Method

Study Design

This study employed an early-stage Research and Development (R&D) design in education, organized into two sequential phases. Phase 1 involved the development of a preliminary instructional model—a five-phase multisensory-based instructional framework for adaptive gymnastics targeting children with intellectual disabilities (ID). Phase 2 consisted of a preliminary field test conducted at a special school in Makassar, Indonesia, aimed at examining the model's feasibility, implementation fidelity, and initial effectiveness on Fundamental Motor Performance (FMP). The preliminary field test was implemented across seven modules delivered over seven instructional sessions (one module per session), with each session lasting approximately 40–45 minutes.

This developmental sequence aligns with recommended practices in PE/APE instructional design, which emphasize theoretical grounding and feasibility testing before large-scale validation (Alarifi et al., 2024; Zhang et al., 2024). The model was conceptually anchored in multisensory learning principles and model-based instruction traditions in physical education (Sousa et al., 2024).

Participants

Three groups were involved in this study: (1) a panel of three experts for content validity assessment, including a school-based APE teacher, a university lecturer in APE, and a practitioner experienced in teaching children with ID aged 7–12; (2) a sample of 20 students formally diagnosed with ID (aged 7–12) enrolled in a special school in Makassar; and (3) teachers and trained observers. Students were included based on readiness for light-to-moderate PE activities, written parental/guardian consent, and de-identified records. Two PE teachers (guru PJOK) implemented the intervention, while trained observers monitored fidelity. Teachers were included based on active assignment to PJOK instruction at the participating school and willingness to deliver the seven-module program. Prior to the field test, teachers completed a brief orientation (approximately 90 minutes) covering the five-phase lesson syntax, use of visual job aids and floor/equipment markers, spotting and supervision checklists, and fidelity checklist procedures; teachers also practiced one micro-teaching trial using the module guide. A subset of observations was double-coded to estimate inter-rater reliability using intraclass correlation coefficients (ICC).

Intervention: Five-Phase Multisensory Instructional Model

The intervention consisted of a structured sequence of five instructional phases:

1. Sensory Activation: Prepared learners using targeted visual, auditory, tactile–proprioceptive, and vestibular inputs.
2. Pattern Cueing: Employed short verbal and visual rhythmic prompts to scaffold movement sequences.
3. Multisensory Guided Practice: Used task decomposition, assisted spotting, and progressive stations to guide practice.
4. Kinesthetic Reinforcement: Provided repetitions incorporating proprioceptive and vestibular variations.
5. Reflective Multimodal Feedback: Offered teacher, peer, and self-feedback via visual rubrics and brief cues.

Each session delivered the complete five-phase sequence; module content progressed from basic shapes and locomotor patterns to simple rolls, supports, and balance sequences using differentiated stations. Support tools included icon- and color-coded visual aids, concise verbal instructions (≤6 words), floor and equipment markers, a four-domain formative rubric (motor, cognitive, social–emotional, independence), and safety checklists for spotting/supervision. To standardize implementation, teachers received (a) a printed module guide with time allocations per phase (Sensory Activation 3–5 min; Pattern Cueing 2–3 min; Guided Practice 20–25 min; Kinesthetic Reinforcement 8–10 min; Reflective Feedback 3–5 min), (b) a digital orientation module, and (c) a brief coaching checklist used by observers during early sessions.

Instruments

- Content Validity: Expert judgments on 25 items across seven components (objectives, steps, reaction principles, social system, support system, instructional and accompanying impacts) were rated on a 1–4 scale. Aiken's V was computed per item and by component, with V ≥ 0.80 interpreted as strong agreement (Alarifi et al., 2024).
- Implementation Fidelity: A checklist was used to assess presence (0/1) and quality (1–4 scale) of each instructional phase. A subset was double-rated for ICC.
- Feasibility and Acceptability: Teachers rated practicality, instructional impact, innovation, and relevance using a 4-point Likert scale.
- Fundamental Motor Performance (FMP): An 18-item tool measured four domains—motor, cognitive, social–emotional, and independence—adapted from validated FMS/FMP frameworks (Barnett et al., 2023; Colombo-Dougovito et al., 2019).

Data Analysis

Descriptive statistics summarized feasibility and fidelity indicators. Aiken's V was calculated to assess content validity. Changes in FMP were analyzed using paired-sample t-tests, with effect sizes reported as Cohen's dz (thresholds: 0.20 = small, 0.50 = medium, 0.80 = large), and 95% confidence intervals (CI). ICC estimates assessed inter-rater reliability for fidelity scores.

Ethical Considerations

The study received ethical clearance from the Institutional Review Board of Universitas Negeri Makassar. Procedures adhered to ethical standards for human-participant research in special and inclusive education. Written informed consent was obtained from all parents or guardians, and data were anonymized to ensure participant confidentiality.

Results

Content Validity of the Instructional Model

Expert evaluation of the five-phase multisensory instructional model produced an overall Aiken's V of 0.853, with item-level values ranging from 0.667 to 1.000, exceeding the commonly accepted threshold of 0.80 for strong content validity (Pradipta et al., 2023). The highest average Aiken's V scores were reported for the components "Instructional Impact," "Reaction Principles," and "Social System" (each M = 0.889), while "Support System" scored the lowest (M = 0.815), suggesting a need for further detailing on safety logistics and equipment protocols. Across all items, 56.0% exceeded V ≥ .80 and 96.0% exceeded V ≥ .75, supporting the theoretical soundness and practical relevance of the model.

Table 1. Expert content validity of the five-phase instructional model (Aiken's V by component)

Component	k (items)	Aiken's V (M)	Aiken's V (min)	Aiken's V (max)	% items V ≥ .80	% items V ≥ .75
Instructional Impact	2	0.889	0.889	0.889	100.0	100.0
Accompanying Impact	3	0.852	0.778	0.889	66.7	100.0
Instructional Steps (Syntax)	6	0.852	0.778	1.000	50.0	100.0
Reaction Principles	3	0.889	0.778	1.000	66.7	100.0
Support System	3	0.815	0.778	0.889	33.3	100.0
Social System	2	0.889	0.778	1.000	50.0	100.0
Learning Objectives	6	0.833	0.667	1.000	50.0	83.3
Overall	25	0.853	0.667	1.000	56.0	96.0

Note. V = Aiken's V; k = number of items; M = mean; min = minimum; max = maximum.

Fidelity and Feasibility of Implementation

Implementation fidelity across seven modules demonstrated consistent improvement, with mean scores rising from 2.38 in Module 1 to 3.63 in Module 7 (scale 1–4), indicating approximately 91% of the maximum by the final module. Sensory Activation yielded the largest gain (+1.75), reflecting successful integration of multisensory priming routines. Guided Practice had the highest overall mean (M = 3.32), highlighting the strength of task decomposition and station-based delivery. Increases in other components, such as Kinesthetic Reinforcement (+1.25) and Reflective Feedback (+1.00), suggest internalization of the structured instructional phases over time (Gitimoghaddam et al., 2021; YU et al., 2025). Teacher training and the use of standardized job aids (module guide, cue cards, floor markers) were incorporated to support consistent delivery across sessions.

Changes in Fundamental Motor Performance by Domain

Significant pre–post improvements were observed in all four measured domains (N = 20). The largest gains were recorded in Independence (+2.45) and Motor (+2.20), reflecting the model's emphasis on autonomy and kinesthetic engagement. Cognitive and Social–Emotional gains were more modest (+0.70 and +0.45, respectively), likely due to the brief seven-session intervention duration. These results align with literature reporting high responsiveness of motor and independence domains to multisensory interventions (Iborra et al., 2023).

Table 2. FMP by domain: pre- and post-intervention descriptive statistics

Domain	Pre M	Pre SD	Post M	Post SD	Δ (Post–Pre)
Motor	16.50	4.26	18.70	3.95	+2.20
Cognitive	10.75	1.37	11.45	1.39	+0.70
Social-Emotional	11.25	1.65	11.70	1.49	+0.45
Independence	8.70	1.49	11.15	1.18	+2.45

Note. FMP = Fundamental Motor Performance; M = mean; SD = standard deviation; Δ = Post–Pre difference.

Composite FMP and Statistical Significance

The composite FMP score increased significantly from 47.20 (SD = 6.45) to 53.00 (SD = 5.49), a gain of +5.80. A paired-sample t-test yielded $t(19) = 7.468$, $p < .001$, with a large effect size (dz = 1.67) and 95% CI [4.17, 7.43]. The strong pre–post correlation ($r = 0.843$) indicates stable individual response to the intervention. These results exceed typical effect sizes reported in similar small-sample pilot studies, supporting practical relevance and robustness (Aliriad et al., 2024).

Table 3. Paired-sample t-test for composite FMP

Measure	Pre M	Pre SD	Post M	Post SD	Δ	t(df)	p	dz	95% CI Δ	r
FMP (Composite)	47.20	6.45	53.00	5.49	+5.80	7.468(19)	< .001	1.67	[4.17, 7.43]	0.843

Note. FMP = Fundamental Motor Performance; Δ = Post–Pre difference; dz = Cohen's dz; CI = confidence interval; r = pre–post correlation.

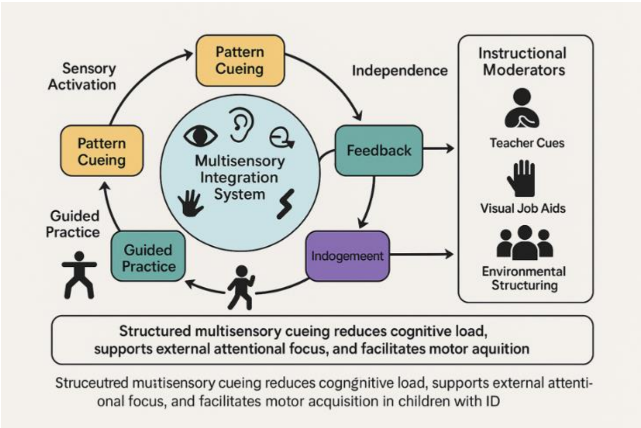
Ancillary Observations

Teachers rated feasibility domains (practicality, relevance, innovation, impact) positively, and observational fidelity metrics rose throughout implementation. Areas for refinement include enhancing feedback routines, fading instructional prompts, and clarifying equipment/safety SOPs to strengthen the support system. Qualitative impressions highlighted increased student motivation and enjoyment, attributed to rhythmic and sensory-rich activities (Xu, Ming-yan, et al., 2020). Safety practices and logistical planning (e.g., room layout, matting, equipment access) were noted as critical enablers for sustained implementation (Colombo-Dougovito et al., 2019; Zhao et al., 2024). Teachers also reported that the pre-implementation orientation and ongoing use of the module guide improved confidence in delivering spotting procedures and maintaining consistent phase timing across sessions. These results support the instructional model's feasibility and impact, warranting larger-scale trials and further integration into inclusive physical education practice.

Discussion

This study demonstrated that the five-phase multisensory instructional model for adaptive gymnastics was valid, feasible, and effective in supporting motor performance outcomes for children with intellectual disabilities (ID) (Alarifi et al., 2024; Pradipta et al., 2023). The overall content validity score (Aiken's V = 0.853) confirmed that the model's components—ranging from learning objectives to support systems—aligned well with the learning needs of students with ID. Components with the highest expert agreement, such as Reaction Principles, Instructional Impact, and Social System, reinforce the model's strength in promoting interactive learning, feedback responsiveness, and socially supportive environments. Although the Support System scored slightly lower (V = 0.815), its acceptable rating signals the need for clearer safety protocols, equipment logistics, and consistent implementation tools (Zhang et al., 2024). Practically, this finding underscores that teacher-facing supports (e.g., standardized matting/layout guidance, spotting SOPs, and module-specific equipment checklists) should be specified as part of the model package to improve implementability across settings.

Figure 1. Conceptual mechanism of change illustrating how multisensory cueing, structured instructional phases, and feedback routines collectively enhance motor performance, independence, and engagement in children with intellectual disabilities.



Note. The figure is presented to synthesize the proposed mechanism linking multisensory cueing, phase-based instruction, and feedback routines to observed changes in motor performance and independence.

This figure visualizes the mechanistic pathways through which the five-phase multisensory instructional model generates functional learning outcomes. At the center is the *Multisensory Integration System*, composed of visual, auditory, tactile–proprioceptive, and vestibular channels that jointly support motor representation and cognitive readiness for movement tasks. These sensory channels connect directly to a circular sequence of instructional phases—Sensory Activation, Pattern Cueing, Guided Practice, Kinesthetic Reinforcement, and Reflective Feedback—depicted as an iterative learning loop to emphasize repeated, structured exposure. From these phases, directional pathways lead to three major learner outcomes: Motor Coordination, Independence, and Engagement, consistent with improvements documented in the study. A parallel panel labeled *Instructional Moderators* highlights contextual teacher-mediated supports—teacher cues, visual job aids, and environmental structuring—that strengthen phase delivery and influence fidelity. At the bottom, the conceptual statement summarizes the mechanism: structured multisensory cueing lowers cognitive load, enhances external attentional focus, and accelerates motor acquisition in children with intellectual disabilities. This figure integrates the theoretical, pedagogical, and empirical elements discussed in the manuscript, offering a visual synthesis of how multisensory instruction transforms learning processes into measurable performance gains.

Fidelity outcomes reflected a strong learning curve, with implementation quality increasing steadily across seven instructional modules (M1 = 2.38 to M7 = 3.63). The most substantial gain occurred in the Sensory Activation phase, suggesting that priming sensory readiness is both essential and trainable.

Guided Practice had the highest average score across modules, highlighting the value of structured, scaffolded, and station-based motor learning for children with ID. Furthermore, the observed gains in contextual indicators—such as Social System and Reaction Principles—indicate that support mechanisms like cue cards, visual markers, and concise instructions (≤6 words) were instrumental in shaping classroom routines. Teachers' feasibility ratings also improved, confirming that prolonged exposure to the model enhanced perceived practicality, innovation, and relevance, consistent with findings in previous PE model-based interventions (Barnett et al., 2023). Importantly, these fidelity gains are consistent with the inclusion of teacher preparation procedures (orientation to the five-phase syntax, safety/spotting checklists, and job-aid use), suggesting that brief, targeted training can accelerate implementation quality in APE settings.

Outcome-wise, the largest improvements were found in Independence (Δ = +2.45) and Motor (Δ = +2.20) domains, followed by smaller yet positive gains in Cognitive (Δ = +0.70) and Social–Emotional (Δ = +0.45) areas. These results align with the instructional focus of the model, particularly phases emphasizing kinesthetic reinforcement and guided practice. The consistently high pre–post correlation ($r = 0.843$) supports the inference that change was driven by systematic instruction rather than isolated outliers. The overall composite FMP improvement (Δ = +5.80), with a large effect size ($dz = 1.67$), positions this intervention well within the effect range typically reported in single-group pilot studies with focused dosage and multisensory support (Aliriad et al., 2024). Given the seven-session dosage, the smaller gains in Cognitive and Social–Emotional domains are plausible and suggest that longer exposure may be needed for broader transfer beyond motor–independence outcomes.

The effectiveness of the intervention is best understood through its mechanistic underpinnings. Layered cueing strategies—spanning visual models, auditory rhythms, tactile–proprioceptive feedback, and vestibular engagement—stimulate multiple sensory channels simultaneously, reinforcing motor representations and reducing cognitive load. The phase-based syntax enables learners to internalize routines in a predictable and structured manner, while visual rubrics and feedback routines facilitate autonomy. These mechanisms echo prior findings in related populations, such as children with autism and Down syndrome, where similar multisensory strategies led to gains in balance, coordination, and fitness (Colombo-Dougovito et al., 2019; Ruffino et al., 2025; Ferawati et al., 2026).

In practical terms, several key adaptations are suggested for schools implementing inclusive PE programs. These include incorporating 2–4 minute sensory activation protocols at the start of lessons, using icon-based cue cards and floor markers for clarity, and applying tiered station designs to accommodate different skill levels. Teachers should also employ visual rubrics for fast feedback and gradually fade prompts to support independence. Aligning teacher coaching cycles with fidelity data may further optimize implementation. These strategies, collectively, offer a practical roadmap for operationalizing inclusive, multisensory teaching in special schools (Chu et al., 2021; Gitimoghaddam et al., 2021). To enhance feasibility, we recommend bundling the model with a brief teacher-training package (≤2 hours) and a low-cost multisensory kit (cue cards, floor tape, marker cones, and a one-page safety checklist) to support consistent delivery.

From a policy and programming perspective, this model resonates with inclusive education goals and adaptive sports participation targets. It can serve as a modular curriculum element supported by short teacher training sessions, job-aid packages, and fidelity monitoring tools. Education and sports departments may consider scaling the model through regional teacher workshops, rubric standardization, and integration into SLB curriculum policy. Such institutionalization could foster more equitable PE access for students with ID (Elipe-Lorenzo et al., 2025; Xu & Wang, 2023).

Nonetheless, several limitations constrain the study's generalizability. The single-group pre–post design limits causal inference, and the sample size ($N = 20$) drawn from a single site restricts demographic variability. The relatively short intervention duration may have underpowered cognitive and social–emotional domains. The 18-item FMP instrument, although adapted from valid frameworks, warrants further validation across broader ID populations. Additionally, without a control group, threats such as regression to the mean and expectancy effects cannot be ruled out, even though fidelity ratings and ICC procedures were used to mitigate implementer bias (Trabelsi et al., 2025).

To strengthen causal claims, future research should involve randomized controlled trials or multi-site quasi-experiments. These should extend program duration to enable deeper development of cognitive and socio-emotional outcomes. Component and dose–response analyses would identify critical phases or minimum effective exposure. Broader psychometric validation of the FMP tool, including invariance testing and inter-rater reliability, is also recommended. Lastly, future work should explore the integration of technology-enhanced cueing—such as video modeling, metronomic guidance, or augmented reality—to further enrich multisensory instruction and expand scalability (Zhou & Qi, 2022).

Ensuring equitable, safe, and sustainable implementation requires several practical safeguards. Instruction should be tailored to individual sensory profiles, with access to safe, low-cost equipment. Clear safety SOPs, adequate supervision ratios, and differentiated task design are non-negotiable. Schools should be supported with basic multisensory kits (e.g., icon cards, floor tape, visual panels), minimal training modules, and lightweight fidelity monitoring systems. These considerations are essential for embedding the model within everyday practice and sustaining its benefits over time (Zhao et al., 2024).

Conclusions

The five-phase multisensory instructional model for adaptive gymnastics demonstrated strong content validity, high implementation fidelity, and statistically significant improvements in fundamental motor performance among children with intellectual disabilities. The model's layered sensory cues and structured instructional phases contributed to gains in motor coordination, independence, and classroom engagement. These findings underscore the importance of integrating sensory-responsive strategies into adapted physical education to promote inclusive participation and motor development. Given the model's feasibility and instructional clarity, it holds promise as a scalable tool for special schools and inclusive programs. Future studies should pursue experimental validation, cross-setting implementation, and incorporation of technology-enhanced cueing to strengthen generalizability and instructional impact.

References

Alarifi, S. T., Denne, L., Alatifi, N. M., & Hastings, R. P. (2024). Interventions Addressing Challenging Behaviours in Arab Children and Adults With Intellectual Disabilities and/or Autism: A Systematic Review. *Journal of Applied Research in Intellectual Disabilities*, *37*(2). https://doi.org/10.1111/jar.13205

Aliriad, H., S, A., Manullang, J. G., Endrawan, I. B., & Satria, M. H. (2024). Improvement of Motor Skills and Motivation to Learn Physical Education Through the Use of Traditional Games. *Teorìâ Ta Metodika Fìzičnogo Vihovannâ*, *24*(1), 32–40. https://doi.org/10.17309/tmfv.2024.1.04

Arroyo-Rojas, F., & Hodge, S. R. (2024). Phenomenological Research Involving Students with Disabilities in Physical Education: A Systematic Literature Review. *Quest*, *76*(2), 135–153. https://doi.org/10.1080/00336297.2023.2206579

Baena-Morales, S., & González-Víllora, S. (2023). Physical education for sustainable development goals: reflections and comments for contribution in the educational framework. *Sport, Education and Society*, *28*(6), 697–713. https://doi.org/10.1080/13573322.2022.2045483

Barnett, L. M., Jerebine, A., Keegan, R., Watson-Mackie, K., Arundell, L., Ridgers, N. D., Salmon, J., & Dudley, D. (2023). Validity, Reliability, and Feasibility of Physical Literacy Assessments Designed for School Children: A Systematic Review. *Sports Medicine*, *53*(10), 1905–1929. https://doi.org/10.1007/s40279-023-01867-4

Barzyk, P., & Grüber, M. (2024). Motor Learning in Golf—a Systematic Review. *Frontiers in Sports and Active Living*, *6*. https://doi.org/10.3389/fspor.2024.1324615

Block, M. E., Haegele, J., Kelly, L., & Obrusnikova, I. (2021). Exploring Future Research in Adapted Physical Education. *Research Quarterly for Exercise and Sport*, *92*(3), 429–442. https://doi.org/10.1080/02701367.2020.1741500

Camarata, S., Miller, L. J., & Wallace, M. T. (2020). Evaluating Sensory Integration/Sensory Processing Treatment: Issues and Analysis. *Frontiers in Integrative Neuroscience*, *14*. https://doi.org/10.3389/fnint.2020.556660

Case, L., Kirk, T. N., Stribing, A., & Blagrave, A. J. (2025). A Document Analysis of Disability-Focused Articles Published in Practitioner-Oriented Physical Education Journals From 2013 to 2022. *Kinesiology Review*, *14*(3), 329–339. https://doi.org/10.1123/kr.2024-0038

Chu, H.-Y., Chan, H., & Chen, M. (2021). Effects of Horticultural Activities on Attitudes Toward Aging, Sense of Hope and Hand–Eye Coordination in Older Adults in Residential Care Facilities. *International Journal of Environmental Research and Public Health*, *18*(12), 6555. https://doi.org/10.3390/ijerph18126555

Chua, L.-K., Jiménez-Díaz, J., Lewthwaite, R., Kim, T., & Wulf, G. (2021). Superiority of External Attentional Focus for Motor Performance and Learning: Systematic Reviews and Meta-Analyses. *Psychological Bulletin*, *147*(6), 618–645. https://doi.org/10.1037/bul0000335

Cleven, L., Krell-Roesch, J., Nigg, C. R., & Woll, A. (2020). The association between physical activity with incident obesity, coronary heart disease, diabetes and hypertension in adults: a systematic review of longitudinal studies published after 2012. *BMC Public Health*, *20*(1), 726. https://doi.org/10.1186/s12889-020-08715-4

Colombo-Dougovito, A. M., Block, M. E., Zhang, X., & Strehli, I. (2019). A Multiple-Method Review of Accommodations to Gross Motor Assessments Commonly Used With Children and Adolescents on the Autism Spectrum. *Autism*, *24*(3), 693–706. https://doi.org/10.1177/1362361319884400

Dafun, P. B., Nurhasan, N., Muhammad, H. N., Padmasari, D. F., & Ayubi, N. (2024). An Investigation of the Flipped Learning Method to Physical Education Classes in the University: Systematic Review. *Retos*, *52*, 384–389. https://doi.org/10.47197/retos.v52.102148

Di Concilio, S. , Forte, D. , & Senatore, B. (2019). Artistic gymnastics and down's syndrome. *Journal of Physical Education and Sport*, *19*(5).

Duan, G., Han, Q., Ming-yan, Y., & Li, R. (2022). Effects of Rhythmic Gymnastics on Joint Attention and Emotional Problems of Autistic Children: A Preliminary Investigation. *Computational Intelligence and Neuroscience*, *2022*, 1–10. https://doi.org/10.1155/2022/2596095

Elipe-Lorenzo, P., Díez-Fernández, P., Ruibal-Lista, B., & López-García, S. (2025). Barriers Faced by People With Disabilities in Mainstream Sports: A Systematic Review. *Frontiers in Sports and Active Living*, *7*. https://doi.org/10.3389/fspor.2025.1520962

Ferawati, F., Syahruddin, S., Jamaluddin, J., Suarlin, S., & Ramadan, G. (2026). Multimedia-based 7E instructional model to enhance student engagement and floor-gymnastics skills in elementary Physical Education. *Retos*, *77*, 56–69. https://doi.org/10.47197/retos.v77.118186

Ghorbani, S., Dana, A., & Christodoulides, E. (2020). Effects of External Focus of Attention on Learning Static Balance Among Girls With ADHD. *Biomedical Human Kinetics*, *12*(1), 69–74. https://doi.org/10.2478/bhk-2020-0009

Gitimoghaddam, M., Vanderloo, L. M., Hung, R., Ryce, A., McKellin, W. H., Miller, A. R., & Collet, J. (2021). Impacts of Participation in Community-Based Physical Activity Programs on Cognitive Functions of Children and Youth With Neurodevelopmental Disabilities: A Scoping Review. *Brain Sciences*, *11*(2), 195. https://doi.org/10.3390/brainsci11020195

Holland, K., & Haegele, J. A. (2021). Perspectives of Students With Disabilities Toward Physical Education: A Review Update 2014–2019. *Kinesiology Review*, *10*(1), 78–87. https://doi.org/10.1123/kr.2020-0002

Iborra, A. T., Más, J. R. L., & Suelves, D. M. (2023). Effects of Physical Education on Students With Intellectual Disabilities. A Systematic Review Autores/As. *Cultura Ciencia Y Deporte*, *18*(58). https://doi.org/10.12800/ccd.v18i58.2021

Kurtoğlu, A., Çar, B., & Konar, N. (2022). The effect of 8 weeks plyometric exercise on physical and motoric features of mental disabled. *Pedagogy of Physical Culture and Sports*, *26*(4), 228–232. https://doi.org/10.15561/26649837.2022.0402

MacEachern, S., Forkert, N. D., Lemay, J.-F., & Dewey, D. (2022). Physical Activity Participation and Barriers for Children and Adolescents with Disabilities. *International Journal of Disability, Development and Education*, *69*(1), 204–216. https://doi.org/10.1080/1034912X.2021.1952939

Maritska, *Ziske Maritska, Prananjaya, B. A., Parisa, N. P., Suryani, P. R., & Hartati, M. D. (2025). AN INSIGHT INTO GENETIC CONDITIONS ASSOCIATED WITH INTELLECTUAL DISABILITY IN INDONESIAN POPULATION. *International Journal of Neuropsychopharmacology*, *28*(Supplement_1), i186–i187. https://doi.org/10.1093/ijnp/pyae059.323

Mawena, J., & Sorkpor, R. S. (2024). Enhancing inclusive physical activity for students with disabilities: Patterns and opportunities. *Aquademia*, *8*(1), ep24002. https://doi.org/10.29333/aquademia/14430

McGuire, M., Long, J., Esbensen, A. J., & Bailes, A. F. (2019). Adapted Dance Improves Motor Abilities and Participation in Children With Down Syndrome: A Pilot Study. *Pediatric Physical Therapy*, *31*(1), 76–82. https://doi.org/10.1097/PEP.0000000000000559

Mira, T., Costa, A. M., Jacinto, M., Diz, S., Monteiro, D., Rodrigues, F., Matos, R., & Antunes, R. (2023). Well-Being, Resilience and Social Support of Athletes with Disabilities: A Systematic Review. *Behavioral Sciences*, *13*(5), 389. https://doi.org/10.3390/bs13050389

Özkan, Z., & Kale, R. (2023). Investigation of the effects of physical education activities on motor skills and quality of life in children with intellectual disability. *International Journal of Developmental Disabilities*, *69*(4), 578–592. https://doi.org/10.1080/20473869.2021.1978267

Pradipta, G. D., Suherman, W. S., Suhartini, B., Maliki, O., Widiyatmoko, F. A., Hudah, M., Yudhistira, D., Virama, L. O. A., Akhiruyanto, A., Hidayah, T., Paryadi, P., Pratama, E., Putranto, D. S. C., Oktarina, O., & Naviri, S. (2023). Development of Si Buyung Gymnastics-Based Motion Learning Model to Improve Students' Basic Motion Skills: Aiken Validity. *International Journal of Human Movement and Sports Sciences*, *11*(2), 388–397. https://doi.org/10.13189/saj.2023.110216

Puce, L., Okwen, P. M., Yuh, M. N., Akah Ndum Okwen, G., Pambe Miong, R. H., Kong, J. D., & Bragazzi, N. L. (2023). Well-being and quality of life in people with disabilities practicing sports, athletes with disabilities, and para-athletes: Insights from a critical review of the literature. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1071656

Ruffino, C., Gueugneau, N., & Grosprêtre, S. (2025). Barriers and Facilitators to Sports Participation in Autistic Europeans: Insights From a Large-Scale Questionnaire Survey. *Frontiers in Sports and Active Living*, *7*. https://doi.org/10.3389/fspor.2025.1580462

Schroeder, E. C., DuBois, L., Sadowsky, M., & Hilgenkamp, T. I. M. (2020). Hypertension in Adults With Intellectual Disability: Prevalence and Risk Factors. *American Journal of Preventive Medicine*, *58*(5), 630–637. https://doi.org/10.1016/j.amepre.2019.12.011

Shuttleworth, H., Hickey, L., & Toovey, R. (2024). Pathways to participation in gymnastics for children with disability. *Disability and Rehabilitation*, *46*(11), 2365–2373. https://doi.org/10.1080/09638288.2023.2221460

Sousa, R. R. d., Sousa, A. B., Lima, A. F. B. de, Santos-Rehder, R. d. B., Simão, C. R., Fischer, G., Camargos, A. C. R., Clutterbuck, G. L., & Leite, H. R. (2024). Modified Sports Interventions for Children and Adolescents With Disabilities: A Scoping Review. *Developmental Medicine & Child Neurology*, *66*(11), 1432–1445. https://doi.org/10.1111/dmcn.15952

Syahruddin, S., Saleh, M. Sahib, Mailizar, M., Saleh, Muhammad Syahrul, Habibi, A., & Alqahtani, T. M. (2025). Responsible AI in Indonesian higher education: A survey in sports education and public health programs. *Social Sciences & Humanities Open*, *11*, 101445. https://doi.org/10.1016/j.ssaho.2025.101445

Theroux, B. M., Eggins, E., Paynter, J., Dawe, S., & Williams, K. (2025). A Systematic Review and Evidence Gap Map Evaluation of Rhythmic and/or Complex Movement Interventions and Child Cognitive Outcomes. *Clinical Child and Family Psychology Review*. https://doi.org/10.1007/s10567-025-00547-1

Trabelsi, O, Romdhani, A., Ghorbel, A., Bouchiba, M., Trabelsi, Omar, Scharenberg, S., & Gharbi, A. (2025). A Review of Best Practices in Video Modeling for Sport Pedagogues. *International Journal of Sports Science & Coaching*. https://doi.org/10.1177/17479541251335611

Xu, C., Ming-yan, Y., Kang, M., & Duan, G. (2020). Improving Physical Fitness of Children With Intellectual and Developmental Disabilities Through an Adapted Rhythmic Gymnastics Program in China. *Biomed Research International*, *2020*(1). https://doi.org/10.1155/2020/2345607

Xu, C., Yao, M., Kang, M., & Duan, G. (2020). Improving Physical Fitness of Children with Intellectual and Developmental Disabilities through an Adapted Rhythmic Gymnastics Program in China. *BioMed Research International*, *2020*(1). https://doi.org/10.1155/2020/2345607

Xu, W., & Wang, L. (2023). Adherence to 24-h Movement Guidelines Among Chinese Children and Adolescents With Intellectual Disabilities. *Journal of Intellectual Disability Research*, *67*(7), 668–678. https://doi.org/10.1111/jir.13035

Yemiscigil, A., & Vlaev, I. (2021). The bidirectional relationship between sense of purpose in life and physical activity: a longitudinal study. *Journal of Behavioral Medicine*, *44*(5), 715–725. https://doi.org/10.1007/s10865-021-00220-2

YU, Q., Pan, X., Liu, Z., & Deng, C. (2025). Effect of Gymnastics on Balance Ability in Children Aged Three to Six Years. *Frontiers in Psychology*, *16*. https://doi.org/10.3389/fpsyg.2025.1549741

Zhang, J., Lu, J., Sun, Y., & Li, J. (2024). Recreational Gymnastics Exercise of Moderate Intensity Enhances Executive Function in Chinese Preschoolers: A Randomized Controlled Trial. *Psych Journal*, *13*(6), 954–965. https://doi.org/10.1002/pchj.786

Zhao, P., Zhu, G., Chen, S., Pan, Y., Chen, K., Huang, L., & Li-ya, G. (2024). Effects of Aquatic Exercise and Floor Curling on Balance Ability and Lower Limb Muscle Strength in Children With Intellectual Disabilities: A Pilot Study in China. *Children*, *11*(1), 85. https://doi.org/10.3390/children11010085

Zhou, X., & Qi, Y. (2022). Development of Creativity in Physical Education Teachers Using Interactive Technologies: Involvement and Collaboration. *Education and Information Technologies*, *28*(5), 5763–5777. https://doi.org/10.1007/s10639-022-11422-9

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