

Effects of a Modified Play Activity Program on Balance and Motor Control in Children with Mild Intellectual Disabilities: A Randomized Controlled Trial

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Research Article

Keywords: mild intellectual disability, adapted Physical Education, play-based intervention, motor control, balance, randomized controlled trial

Posted Date: October 1st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10798254/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background and Purpose:

Children with mild intellectual disabilities commonly experience impairments in balance and motor control that restrict functional movement, participation in Physical Education, and independent daily activities. Although play-based interventions have shown potential for improving motor competence, evidence from rigorously designed randomized controlled trials conducted in school settings remains limited. This study aimed to examine the effects of a school-based Modified Play Activity Program (MPAP) on balance and motor control in children with mild intellectual disabilities.

Materials and Methods:

A two-arm parallel-group randomized controlled trial with a pretest–posttest design was conducted involving 28 children with mild intellectual disabilities (7–12 years) recruited from three special elementary schools in Yogyakarta, Indonesia. Participants were randomly allocated to either an intervention group ($n = 14$), which completed a 12-week Modified Play Activity Program, or a control group ($n = 14$), which continued conventional school-based Physical Education. Balance was assessed using the Timed Up and Go (TUG) Test, while motor control was evaluated using the School-Based Motor Control Assessment (SMCA). Data were analyzed using mixed-design analysis of variance with statistical significance set at $p < 0.05$.

Results:

Participants receiving the Modified Play Activity Program demonstrated significantly greater improvements in motor control than those in the control group ($F(1,26)=4.901$, $p=0.036$, partial $\eta^2=0.159$). No statistically significant intervention effect was observed for balance performance measured using the Timed Up and Go (TUG) Test ($F(1,26)=3.816$, $p=0.062$, partial $\eta^2=0.128$), although a moderate effect size was identified.

Conclusions:

The Modified Play Activity Program resulted in greater improvement in motor control than conventional Physical Education among participating children with mild intellectual disabilities and may represent a practical school-based adapted physical education intervention. No statistically significant improvement in TUG performance was observed, although the interaction effect was of medium magnitude. These findings provide preliminary support for structured play-based approaches to motor development while indicating the need for larger samples, longer intervention periods, and further validation of the motor control assessment.

Trial Registration: Indonesia Clinical Research Registry (INA-CRR), INA02F776F, submitted on 31 August 2026. **Retrospectively registered.**

Introduction

Intellectual disability (ID) is a neurodevelopmental disorder characterized by significant limitations in both intellectual functioning and adaptive behavior that originate during the developmental period and persist throughout the lifespan. Although impairments in cognitive functioning are the defining characteristic of ID, an increasing body of evidence suggests that deficits in motor competence constitute an equally important but frequently overlooked aspect of the disorder. Children with mild intellectual disabilities (MID), who represent the largest subgroup of the ID population, commonly experience delayed motor development, impaired postural stability, poor movement coordination, and reduced physical fitness compared with their typically developing peers [1]. These motor deficits are evident from early childhood and often persist into adolescence, limiting children's ability to participate independently in educational, recreational, and community activities. Consequently, improving motor competence has become a growing priority within adapted physical education and pediatric rehabilitation because motor proficiency underpins children's functional independence, health-related quality of life, and long-term social participation [2].

Motor impairments among children with MID represent an important functional and educational concern rather than merely a secondary consequence of cognitive disability. Epidemiological studies indicate that children with intellectual disabilities consistently exhibit lower levels of physical activity, poorer balance performance, reduced muscular fitness, and diminished motor coordination than children without disabilities [3]. These limitations contribute to a higher prevalence of sedentary behavior, obesity, cardiovascular risk factors, and musculoskeletal problems across the lifespan. Furthermore, inadequate motor competence during childhood has been associated with lower self-confidence, restricted peer interaction, decreased participation in school-based physical education, and reduced opportunities for independent living in adulthood [4]. Because motor and cognitive development are closely interconnected, interventions targeting motor competence may also support broader developmental processes beyond physical performance [5].

Among the various domains of motor competence, balance and motor control represent two fundamental capacities that support virtually every functional movement performed during childhood. Balance refers to the ability to maintain postural stability while controlling the body's center of mass under both static and dynamic conditions, whereas motor control encompasses the coordinated neuromuscular processes responsible for planning, executing, and adapting purposeful movement. Successful performance of everyday activities, including walking, stair climbing, object manipulation, playground participation, and physical education tasks, requires the efficient integration of these two functions. However, children with MID frequently demonstrate impairments in sensory integration, postural regulation, movement planning, anticipatory postural adjustments, and executive control, resulting in slower movement execution and reduced movement accuracy [6]. These impairments are particularly problematic during the elementary school years, when children are expected to acquire increasingly complex motor skills that form the foundation for lifelong physical activity and participation.

Current theoretical perspectives provide a strong rationale for implementing structured motor interventions during childhood. Dynamic Systems Theory proposes that motor behavior emerges through continuous interactions among the individual, task, and environment, implying that meaningful improvements occur when children repeatedly engage in challenging yet achievable movement experiences. Likewise, Ecological Theory emphasizes that motor development is optimized when learning occurs within realistic environments that encourage exploration, adaptation, and problem solving. Complementing these perspectives, contemporary motor learning theory suggests that repeated task-specific practice accompanied by meaningful feedback facilitates improvements in movement coordination and postural regulation through continuous motor adaptation and skill acquisition [7]. Together, these frameworks suggest that interventions should extend beyond isolated exercise drills and instead provide enriched movement experiences that promote postural control, movement coordination, and functional motor performance through meaningful practice within authentic contexts.

Play-based physical activity aligns closely with these theoretical principles because it naturally combines repetition, variability, intrinsic motivation, and social interaction within meaningful movement experiences. Unlike conventional exercise programs, structured play encourages children to practice functional motor skills while maintaining enjoyment and sustained engagement, thereby increasing adherence and reducing performance anxiety. Previous research has demonstrated that adapted play activities can improve locomotor skills, coordination, postural stability, muscular endurance, and psychosocial outcomes among children with developmental disabilities [8]. Furthermore, school-based play interventions provide ecological validity because they are implemented within children's natural learning environments, allowing motor skills acquired during intervention sessions to be more readily transferred into daily educational and recreational activities. Consequently, play-based interventions have become an increasingly attractive strategy for promoting motor development in children with intellectual disabilities.

Despite these promising findings, the existing literature remains fragmented and methodologically inconsistent. Recent intervention studies have employed a wide range of exercise modalities, including balance training, adapted physical activity, fundamental movement skill programs, exergaming, aquatic exercise, and traditional recreational games. Although many of these interventions have reported positive effects on selected motor outcomes, considerable variability exists regarding intervention duration, training intensity, participant characteristics, outcome measures, and statistical approaches, making direct comparison across studies difficult. Notably, many investigations have evaluated balance, coordination, or gross motor skills as independent constructs rather than recognizing the integrated nature of motor competence. As a result, it remains unclear whether interventions targeting multiple sensorimotor domains simultaneously produce greater functional improvements than programs focusing on isolated motor components [9].

Several methodological limitations further constrain the current evidence base. Many previous studies have been conducted using quasi-experimental designs, convenience sampling, relatively small sample sizes, inadequate randomization procedures, or insufficient reporting of intervention fidelity. Blinding of

outcome assessors is often absent, while follow-up assessments examining the sustainability of intervention effects remain uncommon. In addition, considerable heterogeneity exists in the selection of outcome measures, reducing comparability across studies and limiting opportunities for evidence synthesis through meta-analysis. These limitations collectively reduce confidence in the generalizability of existing findings and highlight the need for rigorously designed randomized controlled trials using standardized intervention protocols and clearly defined motor assessment procedures [10].

Another important research gap concerns the contextual applicability of existing interventions. Much of the available evidence on motor interventions for children with intellectual disabilities has been generated in diverse international settings, while evidence from Indonesian special-school contexts remains limited. Within Indonesia, particularly in special elementary schools (Sekolah Dasar Luar Biasa; SDLB), Physical Education frequently emphasizes participation and recreational enjoyment rather than systematic motor learning progression. While traditional games remain culturally valuable, they are rarely modified to target specific components of postural control, bilateral coordination, motor planning, agility, and movement sequencing. Consequently, there is limited empirical evidence regarding culturally relevant, school-based intervention models that integrate evidence-based motor learning principles with enjoyable play activities suitable for children with MID in Indonesian educational settings [11].

To address these limitations, the present study introduces a school-based Modified Play Activity Program (MPAP), a structured intervention designed according to contemporary principles of motor learning, ecological task design, and adapted physical activity. Unlike conventional play sessions that primarily emphasize recreational participation, MPAP systematically integrates progressive balance challenges, locomotor tasks, object-control activities, bilateral coordination exercises, agility drills, motor planning tasks, and cooperative games within a structured progression framework. The intervention encourages repeated exposure to increasingly complex movement tasks while maintaining high levels of intrinsic motivation through play. Such an approach is expected to facilitate improvements in postural regulation, movement coordination, and functional motor performance through repeated task-oriented play activities, thereby improving balance and motor control compared with conventional school-based physical education. Furthermore, because MPAP requires only simple equipment and can be delivered by physical education teachers within existing school schedules, it offers substantial potential for sustainable implementation in special education settings.

Given the limited availability of high-quality randomized controlled trials evaluating comprehensive play-based motor interventions among children with mild intellectual disabilities, further investigation is warranted. In particular, evidence is needed to determine whether an integrated play program can simultaneously examine balance and motor control within authentic school environments while overcoming the methodological limitations identified in previous research. Therefore, the present randomized controlled trial aimed to examine the effects of the school-based Modified Play Activity Program (MPAP) on balance and motor control among elementary school children with mild intellectual disabilities attending special schools in Yogyakarta, Indonesia. It was hypothesized that children receiving MPAP would demonstrate greater improvements in balance and motor control than those

participating in conventional school-based physical education. By providing rigorous evidence from a culturally relevant educational context, this study seeks to contribute to the growing body of literature supporting evidence-based adapted physical education and to inform the development of effective, scalable motor intervention programs for children with mild intellectual disabilities.

Materials and Methods

Research Design

This study employed a two-arm parallel-group randomized controlled trial (RCT) with a pretest–posttest design and a 1:1 allocation ratio to investigate the effects of the Modified Play Activity Program (MPAP) on balance and motor control in children with mild intellectual disabilities. The study was designed and reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT 2010) guidelines to enhance methodological transparency and reproducibility. Participants were randomly assigned to either the experimental group, which received the Modified Play Activity Program (MPAP), or the control group, which continued the standard school-based physical education program. This design enabled a direct comparison of intervention effects while minimizing selection bias and maintaining methodological rigor throughout the study. No important changes to the study protocol, eligibility criteria, intervention procedures, or outcome assessment procedures were made after trial commencement.

The research was conducted over a 12-week period from June to August 2025 in three public special elementary schools (Sekolah Dasar Luar Biasa/SDLB) located in Yogyakarta, Indonesia, namely SDLB Negeri 1 Yogyakarta, SDLB Negeri 2 Yogyakarta, and SDLB Pembina Yogyakarta. Baseline measurements (pretest) were performed during the first week before intervention, whereas post-intervention assessments (posttest) were completed immediately after the final intervention session.

Participants were randomly allocated into either an experimental group receiving the Modified Play Activity Program (MPAP) or a control group participating in conventional school physical education activities using a 1:1 allocation ratio. The intervention consisted of 36 supervised sessions conducted three times per week over 12 consecutive weeks, with each session lasting approximately 45–60 minutes. All intervention sessions were implemented within each school's outdoor sports area to preserve ecological validity, minimize environmental variability, and provide participants with a familiar learning environment that reflected routine physical education practice.

The study protocol was approved by the Research Ethics Committee of the Directorate of Research and Community Service, Universitas Negeri Yogyakarta (Komisi Etik Penelitian, Direktorat Riset dan Pengabdian kepada Masyarakat, Universitas Negeri Yogyakarta), under approval number 264.3/DST/UN34.9/T/PT.01.04/2025. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants, and verbal assent was obtained from the participating children before data collection.

Participants

Participants were recruited using a total sampling technique from three public special elementary schools (Sekolah Dasar Luar Biasa/SDLB) in Yogyakarta, Indonesia, namely SDLB Negeri 1 Yogyakarta, SDLB Negeri 2 Yogyakarta, and SDLB Pembina Yogyakarta. During the recruitment period, 28 children met the eligibility criteria and were assessed for participation. All 28 eligible children were invited to participate, and written informed consent was obtained from the parents or legal guardians of all participants. Therefore, no eligible participants were excluded from the study, and all 28 children were enrolled and subsequently randomized.

The diagnosis of mild intellectual disability had been established prior to participant recruitment and was confirmed through official school psychological records prepared by certified educational psychologists in accordance with the Indonesian special education assessment system. Diagnostic status was not reassessed as part of the present study. Eligible participants were between 7 and 12 years of age, enrolled in elementary-level special education, able to understand simple verbal instructions, medically fit to participate in moderate physical activity, and had written informed consent provided by their parents or legal guardians. Children with severe musculoskeletal disorders, uncontrolled neurological diseases, severe visual or hearing impairments, or concurrent participation in other structured motor rehabilitation or intervention programs during the study period were excluded to minimize potential confounding factors affecting motor performance.

Following completion of the baseline assessments, participants were randomly assigned to either the intervention group ($n = 14$) or control group ($n = 14$) using a computer-generated simple randomization sequence with a 1:1 allocation ratio. The research team enrolled eligible participants after parental consent was obtained, whereas an independent researcher, who was not involved in participant recruitment, intervention delivery, outcome assessment, or statistical analysis, generated and maintained the randomization sequence and disclosed the group assignments after completion of the baseline assessments. To maintain allocation concealment, the group assignments were not disclosed to the research team or outcome assessors until all baseline assessments had been completed. The outcome assessor remained unaware of participants' group allocation throughout the pretest and posttest assessments.

Participant recruitment was based on the total number of eligible students available at the participating schools during the recruitment period. Because only 28 children met the eligibility criteria across the three participating schools and all eligible children received parental consent to participate, a total sampling strategy was adopted. A post hoc statistical power analysis was subsequently performed using G*Power version 3.1 for a repeated-measures ANOVA (within-between interaction), using an effect size of $f = 0.28$, $\alpha = 0.05$, two groups, two measurement occasions, and a total sample size of 28 participants. The resulting estimated power was 0.814 and is reported descriptively to characterize the statistical information associated with the achieved sample size rather than as the basis for participant recruitment.

Participant attendance was monitored throughout the intervention period. Attendance below 80% of the scheduled intervention sessions was predefined as a protocol deviation; however, all participants met the attendance requirement and completed the intervention protocol. No participants withdrew from the study or experienced intervention-related adverse events during the research period.

Intervention

Participants allocated to the experimental group completed a Modified Play Activity Program (MPAP) specifically developed to improve balance, postural control, locomotor coordination, object-control skills, and overall motor control through structured play-based learning. The intervention was designed according to principles of motor learning, Dynamic Systems Theory, and developmentally appropriate physical activity, emphasizing repetitive practice, task variability, active engagement, and progressively increasing task demands appropriate for children with mild intellectual disabilities.

The intervention was delivered over 12 consecutive weeks, comprising 36 supervised sessions conducted three times per week, with each session lasting approximately 45–60 minutes. Every session followed a standardized structure consisting of a 10-minute warm-up, 30–40 minutes of structured play activities, and a 5–10-minute cool-down involving stretching and relaxation exercises.

The MPAP incorporated five modified educational games designed to stimulate different components of motor performance, including the Ball Transfer Game, Sundial Game, Letter Arrangement Game, Tunnel to the Airplane Game, and additional cooperative movement tasks emphasizing multidirectional movement, obstacle negotiation, object manipulation, balance maintenance, and movement planning. Each activity required children to perform coordinated movements while responding to simple movement-related task demands, thereby integrating multiple components of functional motor performance within an enjoyable play environment.

Task difficulty was progressively increased throughout the intervention by systematically modifying movement complexity, travel distance, task combinations, movement speed, balance challenges, and coordination demands according to participants' motor development and performance. This graded progression of task complexity was designed to continuously challenge participants while maintaining task feasibility, promoting motor skill acquisition, minimizing excessive fatigue, and sustaining motivation throughout the intervention period.

All intervention sessions were supervised by trained Physical Education teachers assisted by classroom teachers familiar with participants' behavioral characteristics. Before study implementation, instructors participated in standardized training sessions covering intervention objectives, activity demonstrations, safety procedures, instructional strategies, participant supervision, and session documentation. Attendance was recorded during every session, and intervention fidelity was periodically monitored using standardized observation checklists to ensure consistent implementation across participating schools.

Participants assigned to the control group continued participating in their routine school Physical Education curriculum consisting of conventional recreational games and regular movement activities delivered by classroom teachers without exposure to the Modified Play Activity Program. The frequency and duration of physical education sessions were comparable to those of the experimental group to minimize differences in exercise exposure while isolating the effect of the intervention program.

No intervention-related injuries or adverse events requiring medical treatment were reported during the study.

Table 1 Weekly Progression of the Modified Play Activity Program (MPAP)

Week	Session Focus	Modified Play Activities	Training Progression	Primary Outcomes Targeted
1–2	Familiarization	Ball Transfer Game, Sundial Game	Introduction to movement patterns, low intensity	Static balance, movement confidence
3–4	Fundamental locomotor skills	Ball Transfer, Letter Arrangement	Increased movement repetitions and travel distance	Dynamic balance, locomotor coordination
5–6	Object control	Letter Arrangement, Tunnel to the Airplane	Dual-task activities and multidirectional movement	Motor control, hand-eye coordination
7–8	Balance integration	Combined game circuits	Reduced external assistance, greater postural demands	Functional balance, movement accuracy
9–10	Complex motor coordination	Integrated MPAP circuit	Increased movement speed and task complexity	Dynamic stability, coordination
11–12	Functional movement mastery	Combined cooperative games	Full game integration under standardized conditions	Balance, motor control, functional mobility

Intervention Standardization

To maximize intervention reproducibility, the following procedures were standardized across all participating schools:

- Session duration (45–60 minutes).
- Training frequency (three sessions/week).
- Instructor-to-participant supervision ratio.
- Equipment specifications and game layout.
- Standardized verbal instructions and demonstrations.

- Warm-up and cool-down protocols.
- Attendance monitoring.
- Safety monitoring procedures.
- Weekly progression criteria.
- Intervention fidelity checklist completed periodically by the research team.

These procedures were implemented to ensure that the Modified Play Activity Program could be consistently replicated in future school-based intervention studies involving children with mild intellectual disabilities.

Instruments and Measurements

Outcome assessments were conducted twice for all participants: one week before the intervention (pretest) and immediately after completion of the 12-week intervention (posttest). To minimize measurement error and ensure reproducibility, all assessments were administered by the same trained assessor under identical testing conditions, including the same testing environment, equipment, assessment sequence, and standardized verbal instructions. Participants completed one familiarization trial before formal testing to ensure comprehension of each assessment procedure. No changes were made to the prespecified outcome measures, assessment procedures, or assessment time points after trial commencement.

Balance Assessment

Functional balance was assessed using the Timed Up and Go (TUG) Test, a standardized clinical instrument widely used to assess functional mobility and dynamic balance. Participants were instructed to stand up from a standard chair, walk three meters toward a designated marker at their fastest safe speed, turn around the marker, return to the chair, and sit down. Performance time was recorded using a calibrated digital stopwatch and expressed in seconds. Each participant performed one practice trial followed by two recorded trials separated by sufficient recovery time to minimize fatigue. The shortest completion time was used for statistical analysis, with lower values indicating better functional balance and mobility. The shortest value was selected to minimize the influence of occasional performance errors, hesitation, or attentional fluctuations that are commonly observed among children with mild intellectual disabilities during repeated functional mobility testing.

The TUG Test demonstrates excellent psychometric properties, including high construct validity and excellent test–retest reliability (ICC ranging from 0.85 to 0.99 across pediatric and clinical populations, depending on participant characteristics and testing protocols), as well as strong inter-rater reliability. Its sensitivity to functional changes and ease of administration make it an appropriate instrument for evaluating intervention-related improvements in children with mild intellectual disabilities.

Motor Control Assessment

Motor control was assessed using the School-Based Motor Control Assessment (SMCA), an observational assessment instrument developed specifically for this study to evaluate functional motor performance among children with mild intellectual disabilities during adapted physical education activities. The instrument was developed based on core movement competencies emphasized in adapted physical education, including locomotor coordination, postural control, object manipulation, bilateral coordination, movement sequencing, and motor planning. The content and scoring framework were developed through expert consultation with specialists in adapted physical education and pediatric motor development to assess the relevance and clarity of the domains for the study population. The SMCA was designed to capture multiple dimensions of functional motor performance considered essential for successful participation in school-based physical activities. Eight motor domains were evaluated: locomotor coordination (LC), dynamic balance (DB), postural control (PC), object control (OC), hand coordination (HC), movement sequencing (MS), bilateral coordination (BC), and motor planning (MP).

Each domain was assessed individually using standardized movement tasks administered under identical testing conditions. Performance was evaluated through criterion-referenced observational scoring using a four-point ordinal scale ranging from 0 to 3, where 0 indicated inability to perform the movement task, 1 indicated performance with major movement errors and/or physical assistance, 2 indicated successful task completion with minor movement errors or verbal cueing, and 3 indicated independent task completion using an appropriate movement pattern. Scores obtained across the eight domains were summed to produce a composite motor control score ranging from 0 to 24, with higher scores indicating better overall motor control. For descriptive purposes, composite scores were categorized as Very Poor (0–8), Poor (9–12), Moderate (13–16), Good (17–20), and Very Good (21–24). These categories were used only to describe participants' motor performance levels, whereas continuous composite scores were used in all statistical analyses to preserve statistical precision.

To ensure measurement consistency, all assessments were administered individually by the same trained evaluator, who remained blinded to participant group allocation throughout the study. Before data collection, assessor calibration sessions were conducted using standardized scoring criteria to minimize subjective judgment and improve scoring consistency. Standardized verbal instructions, identical equipment, a fixed assessment sequence, and consistent environmental conditions were maintained during both pretest and posttest assessments to maximize measurement reliability and reproducibility. Prior to data collection, the preliminary version of the SMCA underwent content review by three university academics with expertise in adapted physical education and motor development for children with disabilities. Their feedback was used to refine the assessment tasks, scoring criteria, and operational definitions of each domain before implementation in the study. Because the SMCA was developed specifically for this trial, it was intended as a study-specific observational outcome measure rather than a standardized diagnostic instrument.

Table 2 Components and Scoring Criteria of the School-Based Motor Control Assessment (SMCA)

Domain	Abbreviation	Description
Locomotor Coordination	LC	Ability to coordinate fundamental locomotor movements such as walking, running, and changing direction during functional activities.
Dynamic Balance	DB	Ability to maintain postural stability while performing dynamic movement tasks.
Postural Control	PC	Ability to maintain appropriate body alignment and trunk stability during movement execution.
Object Control	OC	Ability to manipulate and control objects accurately during functional movement tasks.
Hand Coordination	HC	Ability to coordinate upper-limb movements during object manipulation and functional activities.
Movement Sequencing	MS	Ability to perform a sequence of movements in the correct order with appropriate timing.
Bilateral Coordination	BC	Ability to coordinate simultaneous and alternating movements between both sides of the body.
Motor Planning	MP	Ability to organize, initiate, and execute purposeful movements according to task demands.

Scoring Criteria (Applied to All Domains)

Score	Operational Definition
0	Unable to perform the movement task.
1	Performs the movement with major errors and/or requires physical assistance.
2	Completes the movement task with minor errors or verbal cueing.
3	Completes the movement task independently using the correct movement pattern.

Interpretation of Composite Scores

Total Score	Performance Category
21–24	Very Good
17–20	Good
13–16	Moderate
9–12	Poor
0–8	Very Poor

Note. Scores from the eight domains were summed to obtain a composite motor control score ranging from **0 to 24**, with higher scores indicating better motor control. Performance categories were used only

for descriptive purposes, whereas continuous composite scores were used in all statistical analyses.

Table 3 Summary of Primary Outcome Measures

Outcome Variable	Instrument	Measurement Procedure	Outcome Measure	Measurement Standardization
Balance	Timed Up and Go (TUG) Test	Participants stood from a standard chair, walked 3 m, turned around a marker, returned to the chair, and sat down. One familiarization trial followed by two recorded trials. The shortest completion time was analyzed.	Completion time (seconds); lower values indicate better functional balance and mobility.	Standardized testing protocol, identical equipment, same assessor, standardized verbal instructions, familiarization trial, and identical testing environment.
Motor Control	School-Based Motor Control Assessment (SMCA)	Eight domains (LC, DB, PC, OC, HC, MS, BC, and MP) were evaluated using standardized movement tasks. Each domain was scored from 0 to 3 and summed to produce a composite score ranging from 0 to 24.	Composite motor control score (0–24); higher scores indicate better motor control.	Standardized observation form, criterion-referenced scoring rubric, assessor calibration, identical equipment, standardized verbal instructions, fixed assessment sequence, and consistent testing conditions.

Intervention Fidelity

Intervention fidelity was implemented to ensure consistent delivery of the Modified Play Activity Program (MPAP) across all participating schools. Prior to study commencement, all instructors participated in a standardized training workshop covering intervention objectives, instructional strategies, activity demonstrations, progression criteria, participant supervision, and safety procedures. A detailed intervention manual describing each session, activity sequence, progression strategy, and implementation guidelines was used throughout the study.

Attendance was recorded at every intervention session, and participant adherence was continuously monitored. Members of the research team periodically observed intervention sessions using standardized fidelity checklists to verify compliance with the intervention protocol, including session duration, activity sequence, instructional consistency, participant engagement, and safety procedures. Any protocol deviations were documented and immediately addressed to maintain implementation consistency.

To minimize procedural variability, intervention sessions were conducted using standardized equipment, identical activity layouts, and comparable environmental conditions across all participating schools.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Prior to inferential analyses, datasets were screened for completeness, missing values, outliers, and potential data-entry errors. Descriptive statistics were calculated and reported as mean ± standard deviation (SD) for all outcome variables.

Data normality was assessed using the Shapiro–Wilk test, while homogeneity of variance was evaluated using Levene's test. Baseline equivalence between the experimental and control groups was examined before intervention analyses.

The primary analysis was conducted using a two-way mixed-design analysis of variance (Mixed ANOVA) with Time (pretest and posttest) as the within-subject factor and Group (experimental and control) as the between-subject factor. The principal outcome of interest was the Time × Group interaction, which tested whether changes over time differed between participants receiving the Modified Play Activity Program and those receiving conventional physical education. Because statistically significant baseline differences were observed between groups, the primary interpretation focused on the Time × Group interaction, while acknowledging that baseline imbalance may influence the magnitude and interpretation of the observed effects. The between-group main effect was therefore not interpreted as evidence of an intervention effect because it may partly reflect pre-existing differences between groups.

When significant interaction effects were observed, Bonferroni-adjusted pairwise comparisons were performed to identify specific differences between measurement occasions and study groups while controlling for Type I error. No interim analyses were performed, and no formal stopping rules were applied during the study.

To determine the practical significance of the intervention, partial eta squared (η^2p) was calculated for the mixed-design ANOVA and interpreted according to conventional criteria, with values of 0.01, 0.06, and 0.14 representing small, medium, and large effects, respectively. Mean between-group differences in change scores were reported with corresponding 95% confidence intervals to quantify the precision of the estimated intervention effects.

Table 4 Statistical Analysis Plan

Research Objective	Outcome Variable	Statistical Analysis	Effect Size
Examine baseline comparability	Balance, Motor Control	Independent samples t-test	—
Compare baseline categorical characteristics	Sex	Chi-square test	Cramér's V
Test normality	All variables	Shapiro–Wilk	—
Test homogeneity	All variables	Levene's test	—
Evaluate intervention effects	Balance	Mixed-design ANOVA	Partial η^2
Evaluate intervention effects	Motor Control	Mixed-design ANOVA	Partial η^2
Identify specific differences	Significant interaction effects	Bonferroni-adjusted pairwise comparisons	—

Results

Participant Characteristics and Baseline Comparability

A total of 28 eligible children were assessed for participation and enrolled in the study, with no exclusions after eligibility assessment. All 28 participants were subsequently randomized equally to the intervention group ($n = 14$) and control group ($n = 14$). No participants were lost to follow-up or discontinued the assigned condition, and all randomized participants were included in the final analysis ($n = 14$ per group). The trial ended as planned after completion of the 12-week intervention and the immediate post-intervention assessment.

Figure 1 CONSORT flow diagram of participant recruitment, allocation, follow-up, and analysis.

Baseline descriptive statistics and between-group comparisons are presented in Table 5. Before the intervention, statistically significant between-group differences were observed for both balance and motor control outcomes. The intervention group had a lower mean TUG completion time than the control group (9.86 ± 1.70 vs. 13.71 ± 3.91 seconds, $p = 0.002$), indicating better baseline functional mobility, whereas the intervention group had a higher mean motor control score than the control group (14.14 ± 1.70 vs. 11.93 ± 2.40 , $p = 0.009$).

Table 5 Baseline Outcome Measures

Variable	Control ($n = 14$) Mean $\pm$ SD	Intervention ($n = 14$) Mean $\pm$ SD	t	p
Balance (Pretest)	13.71 ± 3.91	9.86 ± 1.70	3.383	0.002
Motor Control (Pretest)	11.93 ± 2.40	14.14 ± 1.70	-2.815	0.009

Assumption Testing

Prior to inferential analyses, the assumptions underlying the mixed-design ANOVA were evaluated using the Shapiro–Wilk test for normality and Levene's test for homogeneity of variance. Because each group consisted of fewer than 50 participants, the Shapiro–Wilk statistic was used as the primary indicator of normality.

Table 6 Assumption Testing

Variable	Group	Shapiro–Wilk (W)	<i>p</i>	Levene's <i>p</i>
Balance_Pre	Control	0.836	0.014	<0.001
	Intervention	0.960	0.728	
Balance_Post	Control	0.886	0.071	0.151
	Intervention	0.893	0.088	
Motor_Pre	Control	0.746	0.001	0.013
	Intervention	0.960	0.728	
Motor_Post	Control	0.894	0.091	0.312
	Intervention	0.946	0.496	

The Shapiro–Wilk test indicated that posttest balance and motor control scores were normally distributed in both groups ($p > 0.05$). Significant departures from normality were observed for the control group's pretest balance and pretest motor control scores. Homogeneity of variance was satisfied for both posttest variables, whereas unequal variances were observed at baseline. Considering the balanced sample sizes and the robustness of mixed-design ANOVA to moderate violations of normality, the planned analyses were retained.

Effects of the Modified Play Activity Program on Balance

Descriptive statistics for balance performance before and after the intervention are presented in Table 7. Changes in mean TUG completion time were observed in both groups across the intervention period.

Table 7 Changes in Balance Performance Following the Intervention

Group	Pretest Mean $\pm$ SD	Posttest Mean $\pm$ SD
Control	13.71 $\pm$ 3.91	13.07 $\pm$ 3.87
Intervention	9.86 $\pm$ 1.70	11.29 $\pm$ 3.22

Results of the mixed-design ANOVA showed no significant main effect of time, $F(1,26) = 0.549$, $p = 0.465$, partial $\eta^2 = 0.021$. Likewise, the Time $\times$ Group interaction was not statistically significant, $F(1,26) = 3.816$, $p = 0.062$, partial $\eta^2 = 0.128$, with a mean between-group difference in change of 2.07 seconds

(95% CI, -0.12 to 4.26). A significant main effect of Group was observed across measurement occasions, $F(1,26) = 6.244$, $p = 0.019$, partial $\eta^2 = 0.194$; however, this between-group difference was not interpreted as an intervention effect because the groups differed significantly at baseline.

Overall, although TUG completion time changed across the intervention period, the Mixed ANOVA demonstrated that the Modified Play Activity Program did not produce statistically significant improvements in functional balance compared with conventional school-based physical education.

Effects of the Modified Play Activity Program on Motor Control

Descriptive statistics for motor control are presented in Table 8. Participants in the intervention group demonstrated higher posttest motor control scores than those observed before the intervention, whereas only minimal changes were evident in the control group.

Table 8 Changes in Motor Control Performance Following the Intervention

Group	Pretest Mean ± SD	Posttest Mean ± SD
Control	11.93 ± 2.40	11.86 ± 2.14
Intervention	14.14 ± 1.70	14.93 ± 1.94

Mixed-design ANOVA revealed no significant main effect of time, $F(1,26) = 3.403$, $p = 0.076$, partial $\eta^2 = 0.116$. In contrast, the Time × Group interaction was statistically significant, $F(1,26) = 4.901$, $p = 0.036$, partial $\eta^2 = 0.159$, with a mean between-group difference in change of 0.86 points (95% CI, 0.06 to 1.65). A significant main effect of Group was also observed, $F(1,26) = 12.244$, $p = 0.002$, partial $\eta^2 = 0.320$; however, this between-group difference was not interpreted as an intervention effect because the intervention group had a significantly higher motor control score at baseline. These findings indicate that the magnitude of change in motor control differed significantly between the intervention and control groups across the study period.

Discussion

The present randomized controlled trial examined the effects of a 12-week Modified Play Activity Program (MPAP) on balance and motor control in children with mild intellectual disabilities attending special elementary schools in Yogyakarta, Indonesia. The principal finding was that participation in the MPAP resulted in a significantly greater improvement in motor control than conventional school-based physical education, as demonstrated by a significant Time × Group interaction. In contrast, no statistically significant improvement in functional balance, as measured by the Timed Up and Go (TUG) Test, was observed following the intervention, although the interaction effect approached statistical significance and demonstrated a moderate effect size (partial $\eta^2 = 0.128$). Collectively, these findings suggest that a structured play-based intervention may support improvements in multidimensional motor control, although the absence of a statistically significant effect on TUG performance indicates that the effects of MPAP may vary across motor domains. These findings are consistent with the growing

consensus that motor competence in children with intellectual disabilities can be enhanced through structured, task-oriented interventions that integrate meaningful movement experiences into everyday educational settings rather than relying solely on conventional physical education activities [12].

The interpretation of these findings should also consider the significant baseline differences observed between the intervention and control groups for both balance and motor control despite random allocation. Although randomization was implemented to minimize selection bias, baseline imbalance may occur in randomized controlled trials with relatively small sample sizes due to chance variation. Consequently, the intervention effects reported in this study should be interpreted with appropriate caution, particularly for balance performance, where the intervention group demonstrated better initial performance before the intervention.

The significant improvement in motor control observed in the intervention group is likely attributable to the design characteristics of the Modified Play Activity Program itself. Unlike conventional physical education, which often emphasizes general participation and recreational engagement, the MPAP systematically incorporated locomotor activities, dynamic balance tasks, bilateral coordination, object manipulation, movement sequencing, and motor planning within progressively more challenging play situations. This combination of movement variability and repeated task practice is consistent with contemporary motor learning principles, which propose that repeated exposure to functional, goal-directed movement tasks facilitates the refinement of movement coordination through continuous error detection, movement adaptation, and sensorimotor integration. Because children repeatedly encountered similar movement challenges in varied contexts, they were required to continuously adjust postural strategies, coordinate upper- and lower-limb movements, and modify motor responses according to changing environmental demands. Such repeated adaptations may explain the greater improvements in overall motor control observed after the intervention [13].

Another plausible explanation relates to the multidimensional nature of the intervention. Rather than targeting a single motor component, MPAP simultaneously engaged several domains of functional motor performance, including locomotor coordination, postural regulation, object control, bilateral coordination, and movement planning. These components rarely operate independently during everyday activities. Instead, successful functional movement depends on the coordinated interaction of multiple sensorimotor processes occurring simultaneously. Consequently, an intervention that integrates these components within meaningful play activities may provide broader opportunities for motor learning than isolated exercise programs targeting only one physical capacity. The present findings therefore support the perspective that comprehensive play-based interventions can facilitate more generalized improvements in motor competence by encouraging children to coordinate multiple movement systems within realistic school-based environments. This interpretation is consistent with recent systematic reviews reporting that interventions incorporating functional and task-oriented movement activities tend to produce broader improvements in motor performance than narrowly focused exercise protocols [13]. The absence of a statistically significant improvement in TUG performance should be interpreted cautiously. Although the Modified Play Activity Program incorporated activities challenging postural

control and movement coordination, the intervention may not have provided sufficient task-specific practice to substantially improve functional mobility as assessed by the TUG test. Moreover, the moderate interaction effect (partial $\eta^2 = 0.128$) suggests that the intervention may have practical relevance despite the absence of statistical significance. Future studies involving larger sample sizes, longer intervention periods, or more intensive balance-specific training are warranted to clarify the potential effects of the program on functional balance.

The educational context in which the intervention was delivered may also have contributed to the observed improvements in motor control. All MPAP sessions were implemented during routine school activities using simple equipment and familiar outdoor environments, allowing children to practice movement skills under conditions closely resembling their everyday physical education experiences. Ecologically relevant practice is considered particularly important for children with intellectual disabilities because learning is often facilitated when motor tasks are embedded within familiar, meaningful, and socially engaging environments. Furthermore, the game-based format of MPAP may have enhanced intrinsic motivation, sustained participation, and reduced performance anxiety, thereby increasing children's willingness to engage repeatedly in increasingly complex movement tasks throughout the intervention period. Previous evidence has shown that enjoyable play experiences can improve intervention adherence while simultaneously promoting motor learning and participation among children with disabilities, particularly when activities emphasize active exploration and cooperative interaction rather than repetitive exercise alone [14].

The present findings also contribute to the growing body of literature supporting play-based interventions within adapted physical education. Recent evidence indicates that children with intellectual disabilities consistently demonstrate lower levels of motor competence than their typically developing peers, particularly in balance, locomotor performance, and object manipulation skills, highlighting the need for interventions specifically tailored to their motor learning needs. While previous studies have reported improvements following adapted physical activity, perceptual-motor training, and balance-oriented exercise programs, considerable methodological heterogeneity has limited direct comparison across interventions. The current randomized controlled trial extends this evidence by demonstrating that a structured, school-based play program delivered within routine educational settings can improve motor control under practical conditions that are readily applicable in special schools. Because the intervention required only inexpensive equipment and teacher supervision, its implementation may be feasible in educational systems with limited rehabilitation resources, thereby increasing its potential for wider dissemination [15], [16].

Although the Modified Play Activity Program did not produce statistically significant improvements in TUG performance, the observed moderate interaction effect (partial $\eta^2 = 0.128$) suggests that the intervention may still have practical relevance. Functional balance is a complex motor capacity that typically requires prolonged, task-specific practice to achieve measurable improvements. Therefore, the absence of statistical significance should be interpreted cautiously and may reflect the relatively short

intervention period, baseline variability between groups, and the multidimensional focus of the program rather than a lack of intervention effectiveness [17], [18].

The present balance findings should also be interpreted in light of the intervention objectives. The Modified Play Activity Program was intentionally designed to improve overall functional motor competence rather than to isolate postural stability as its primary outcome. Most intervention activities simultaneously required locomotor coordination, object manipulation, bilateral coordination, motor planning, and dynamic postural adjustments during play. While these integrated tasks undoubtedly challenged balance, they distributed training demands across multiple motor domains instead of providing repeated exposure to isolated balance exercises. Previous meta-analytic evidence has demonstrated that interventions specifically emphasizing strength-oriented balance training or targeted postural control exercises often produce larger improvements in balance performance than multidimensional activity programs. Therefore, it is plausible that the integrated nature of MPAP preferentially enhanced global motor control while producing more gradual changes in balance performance that may become more evident following longer intervention periods or additional task-specific progression [19].

Overall, the findings of this study are broadly consistent with recent evidence supporting the benefits of structured physical activity for individuals with intellectual disabilities while also highlighting the importance of intervention specificity. Systematic reviews and meta-analyses have consistently shown that exercise-based interventions improve overall motor competence, gross motor skills, coordination, and functional movement performance in this population. At the same time, considerable heterogeneity remains regarding intervention content, duration, outcome measures, and participant characteristics, making direct comparisons across studies difficult. The present study contributes to this literature by evaluating a culturally adapted, school-based play program delivered under authentic educational conditions rather than within clinical rehabilitation settings. This ecological approach increases the practical relevance of the findings and demonstrates that meaningful improvements in motor control can be achieved using simple equipment and activities that are feasible for routine implementation in special education schools [20].

From a practical perspective, the findings suggest that integrating structured play into adapted Physical Education may represent an effective strategy for improving functional motor competence among children with mild intellectual disabilities. Because the intervention relied on inexpensive materials, familiar school environments, and teacher-led activities, its implementation does not require specialized rehabilitation facilities or advanced technological resources. This characteristic is particularly relevant for special schools in low- and middle-income countries, where access to multidisciplinary rehabilitation services may be limited. Embedding evidence-informed play activities within existing physical education curricula may therefore provide a sustainable and scalable approach to enhancing children's movement competence while preserving the motivational and social benefits inherent in play-based learning [21].

Several strengths of the present study should be acknowledged. The randomized controlled design, standardized intervention protocol, supervised implementation, and complete participant retention strengthened the internal validity of the findings. Furthermore, conducting the intervention within routine school settings increased ecological validity and enhanced the potential applicability of the program in real-world educational practice. Nevertheless, several limitations should also be considered when interpreting the results. First, statistically significant baseline differences were observed between the intervention and control groups despite random allocation, most likely because of the relatively small sample size. Although the mixed-design ANOVA evaluates changes over time and differences in those changes between groups, it does not eliminate the potential influence of baseline imbalance. Therefore, these baseline differences should be considered when interpreting the magnitude of the intervention effects. Second, the sample was recruited exclusively from three special elementary schools within a single geographical region, which may limit the generalizability of the findings to other educational settings or populations. Third, the intervention lasted only 12 weeks, and no follow-up assessment was conducted; therefore, the long-term maintenance of the observed improvements remains unknown. Finally, although the School-Based Motor Control Assessment was administered using standardized procedures, assessor calibration, and a predefined scoring rubric, it was developed specifically for this trial and has not undergone comprehensive psychometric validation. Further studies examining its validity and reliability in larger and more diverse populations are warranted to establish its broader applicability [20].

Future studies should build upon the present findings by examining the effects of different combinations of task-specific balance training and multidimensional play activities on postural stability and overall motor competence. Longitudinal follow-up assessments are warranted to determine whether intervention-related improvements are maintained over time. In addition, future multicenter randomized controlled trials involving more diverse educational settings should investigate dose–response relationships, individual differences in intervention responsiveness, and the transfer of motor improvements to daily functional performance, school participation, and health-related quality of life. Such evidence would strengthen the external validity of the Modified Play Activity Program and contribute to the development of increasingly effective, evidence-based adapted physical education programs for children with mild intellectual disabilities [22].

Conclusions

This randomized controlled trial demonstrated that a 12-week school-based Modified Play Activity Program (MPAP) resulted in greater improvement in motor control than conventional Physical Education among participating children with mild intellectual disabilities. Although changes in functional balance, as measured by the Timed Up and Go (TUG) Test, were observed following the intervention, these changes were not statistically greater than those observed in the control group. These findings suggest that structured play activities integrating locomotor tasks, object manipulation, coordination, and progressively challenging movement experiences may be particularly effective for enhancing multidimensional motor competence in special education settings.

The study further highlights the feasibility of implementing a structured play-based intervention within routine school physical education using simple equipment and teacher-led instruction. Accordingly, MPAP may represent a practical school-based adapted physical education strategy for supporting motor development in children with mild intellectual disabilities, particularly in resource-constrained educational environments where access to specialized rehabilitation services may be limited.

Nevertheless, the findings should be interpreted in light of several methodological considerations, including baseline differences between groups, the relatively small sample size, and the absence of long-term follow-up. Future multicenter randomized controlled trials incorporating extended intervention periods, longitudinal follow-up assessments, and task-specific balance training are warranted to confirm the effectiveness and generalizability of the Modified Play Activity Program across diverse educational settings.

Overall, the present study provides preliminary evidence that a structured, school-based Modified Play Activity Program may support improvements in motor control among children with mild intellectual disabilities and provides a practical basis for further evaluation of play-based motor interventions in special education.

Abbreviations

MID: Mild Intellectual Disabilities; MPAP: Modified Play Activity Program; RCT: Randomized Controlled Trial; TUG: Timed Up and Go; SMCA: School-Based Motor Control Assessment; SDLB: Sekolah Dasar Luar Biasa; CONSORT: Consolidated Standards of Reporting Trials.

Declarations

Ethics approval and consent to participate

This study was approved by the Research Ethics Committee of the Directorate of Research and Community Service, Universitas Negeri Yogyakarta (Komisi Etik Penelitian, Direktorat Riset dan Pengabdian kepada Masyarakat, Universitas Negeri Yogyakarta), under approval number 264.3/DST/UN34.9/T/PT.01.04/2025. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants, and verbal assent was obtained from the participating children before data collection.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Protocol availability

The full study protocol is not publicly available. Detailed descriptions of the intervention procedures, assessment methods, and statistical analysis are provided in this manuscript.

Funding

The authors received no specific funding for this study.

Author Contribution

****Author Contributions****H.A.H. conceived and designed the study, coordinated the research, contributed to data collection, conducted the statistical analysis, and prepared the initial manuscript. W.I.R. contributed to the study design, data collection, intervention implementation, and manuscript revision. D.K.C. contributed to data collection, intervention implementation, and critical revision of the manuscript. J.V.G.-J. contributed to the methodological development, interpretation of the findings, and critical revision of the manuscript. Z.A.R. contributed to the study design, interpretation of the findings, and critical revision of the manuscript. All authors reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work.

Acknowledgements

Not applicable.

Data Availability

Data availability statement: The dataset generated and analyzed during the current study is not publicly available because it contains individual-level data from children with mild intellectual disabilities and is subject to ethical and institutional restrictions regarding participant privacy and confidentiality. The de-identified dataset may be available from the corresponding author on reasonable request and subject to approval by the relevant institutional ethics committee.

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Figures

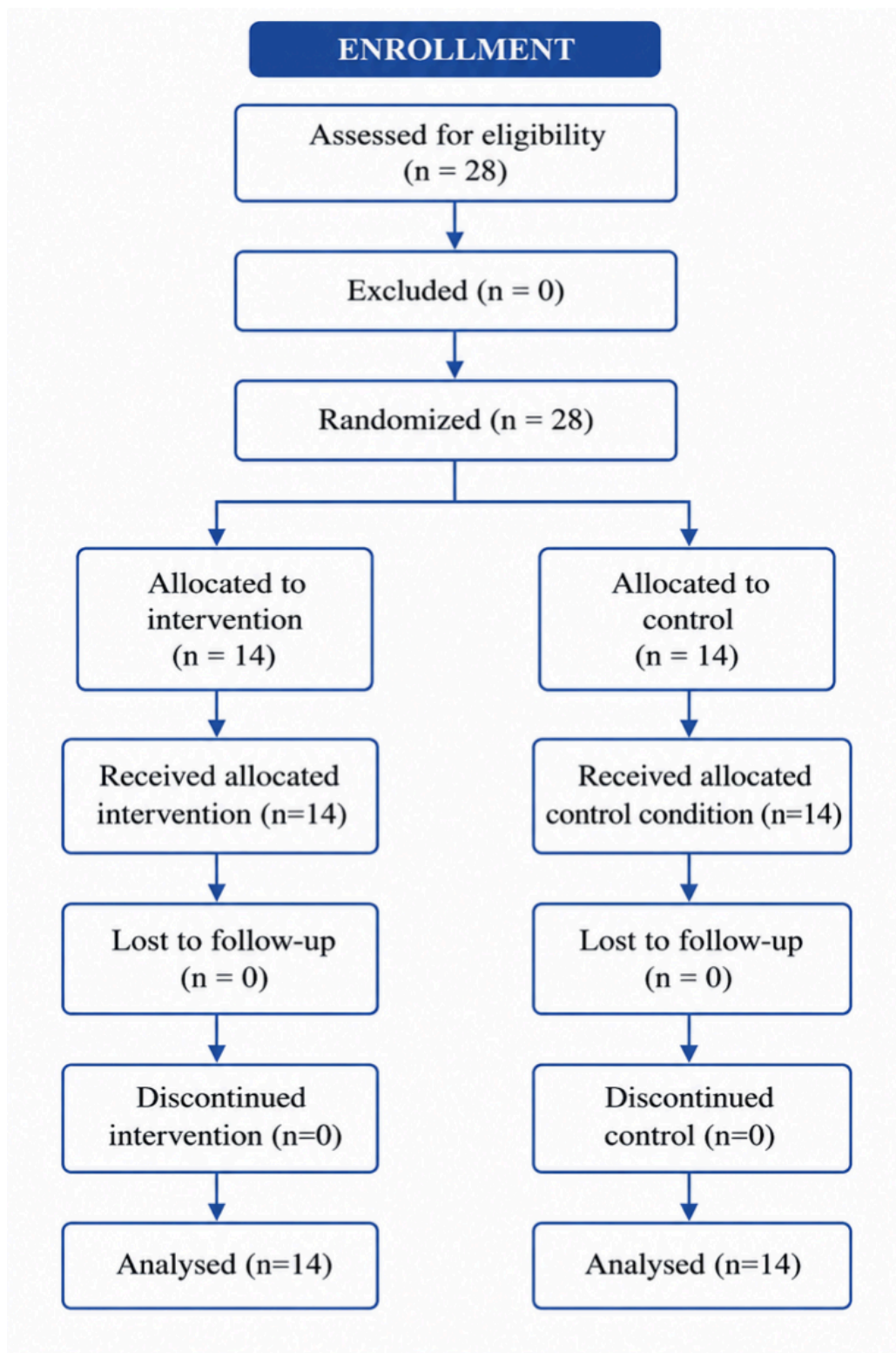


Figure 1

CONSORT flow diagram of participant recruitment, allocation, follow-up, and analysis.

Supplementary Files

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