Effectiveness of ICF-Based Adaptive Physical Activity Programs for High School Students with Intellectual Disabilities in China：a randomized controlled trial

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Abstract

The insufficient effectiveness of physical education curriculum for Chinese high school students with intellectual disabilities (ID) arises from a deficiency in customized frameworks. This study aims to evaluate the impact of adaptive physical activity (APA) programs designed according to the International Classification of Functioning, Disability and Health (ICF) framework on the health-related physical fitness (HRPF) and fundamental movement skills (FMS) of high school students with intellectual disabilities (ID). A total of 28 students with ID (mean age = 16.2 years) were randomly assigned to an intervention group (IG) participating in APA programs, or a control group (CG) following traditional physical education. The APA sessions lasted 45 minutes, three times a week, for 16 weeks. Pre- and post-intervention HRPF and FMS were assessed. The results show that significant improvements were observed in HRPF and FMS in the IG compared to the CG. Specifically, handgrip strength, sit-to-stand performance, and PACER test results improved significantly. The APA program, based on the ICF theory, is a valuable addition to the current physical education curriculum for students with ID, offering a more inclusive and effective approach to their physical education.

1. Introduction

Students with intellectual disabilities (ID) exhibit significant limitations in intellectual functioning and adaptive behaviors, affecting their conceptual, social, and practical skills[1]. These individuals often face multiple impairments, including motor, sensory, communication, and congenital heart issues, alongside delayed physical and mental development[2]. Consequently, they are at elevated health risks, such as hypertension, hyperglycemia, and high cholesterol[3, 4]. Childhood obesity is notably prevalent among children with ID[5, 6], with obesity rates between 5–6% and approximately a quarter being overweight or obese[7, 8]. This heightens the risk of chronic conditions like type 2 diabetes and cardiovascular diseases in adulthood[9]. These health challenges underscore the necessity for tailored interventions, such as moderate exercise, to promote healthy weight management[10]. Moreover, individuals with ID often exhibit significantly poorer physical coordination and health-related physical fitness (HRPF) compared to their peers without disabilities[11]. Deficiencies in running speed, explosive strength, grip strength, and cardiorespiratory endurance are pervasive across different age groups[12, 13]. Addressing these challenges requires specially designed exercise interventions to improve physical health and overall well-being among individuals with ID[14].

APA meticulously considers individual differences and challenges, offering a spectrum of tailored physical activities for ID students[15]. By addressing specialized needs across various dimensions, including physical, cognitive, communicative, social, and emotional aspects[16], APA aims to ensure inclusive and equitable access to physical education[15]. Humanistic education theory, focusing on student-centered pedagogy, and education fairness, emphasizing equitable access to educational opportunities, form the foundation for the development of APA[17, 18].

The ICF offers a robust and comprehensive framework for assessing an individual's functional status by categorizing functioning and dysfunction[19]. This system integrates health and environmental factors to identify rehabilitation needs and intervention goals. Based on ICF theory, individuals with ID may experience impairments in cognitive, perceptual, motor, and communication functions, affecting their motor skills development[20]. Our study aims to compare the effectiveness of adaptive physical activities based on ICF theory versus traditional physical education programs, using HRPF and FMS as evaluation metrics. This comparison will not only illuminate the benefits of ICF-based interventions but also provide a robust framework for future curriculum development in physical education for students with ID.

2. Methods

2.1. Participants and Intervention Program

At the onset of the experiment, 30 high school students with ID (15 males and 15 females) were recruited from a school for students with ID in China, with a mean age of 16.2 years (range: 15–17 years). Participants were randomly assigned to either the intervention group (IG) or the control group (CG) using a computer-generated random number sequence, maintaining a 1:1 allocation ratio. Participants provided informed consent with the approval of their parents or guardians and were allowed to withdraw at any point if they experienced discomfort during the study. The study was approved by the Ethics Committee of the Hunan Normal University (Approval NO.301 08/05/2023) in accordance with the Declaration of Helsinki. Trial Registration Clinicaltrials.gov identifier: NCT06444659 (05/06/2024).

All subjects recruited for this study abstained from any extracurricular sports activities outside of the intervention program during the intervention period. During the pre-assessment phase, the researcher conferred with the teachers to ensure their comprehensive understanding of the entire exercise intervention process and their adherence to the prescribed implementation of each exercise. The exercise process was overseen by professional personnel to prevent subjects from exhibiting negative responses, failing to complete the exercises as per the required mode, intensity, and duration, or sustaining injuries during the exercise. Exercise intensity was set at 40–80% of HRmax, in accordance with the American College of Sports Medicine (ACSM) recommendations for exercise prescription for individuals with ID. The Gym-smart (pro X) device was employed to monitor the subjects' exercise intensity in real time, providing immediate reminders to stay within the prescribed heart rate range. Participants were randomly assigned to two groups in a 1:1 ratio: the IG, which received a 16-week APA intervention, and the CG, which continued with their regular physical education program and maintained their original lifestyle habits for the same duration.

2.2. Development of Goals for APA

Incorporating APA into the structural framework of the ICF establishes the theoretical foundation for research in rehabilitative sports and identifies exercise goals for people with disabilities[15] (Fig. 1). According to ICF theory, students with ID experience impairments in body structures and functions

primarily involving damage to the structures of the nervous system (s1), mental functions (b1), sensory functions and pain (b2), functions of the cardiovascular, haematological, immunological, and respiratory systems (b4), and neuromusculoskeletal and movement-related functions (b7). In the realm of activities and participation, these individuals face obstacles in learning and applying knowledge (d1), general tasks and demands (d2), communication (d3), mobility (d4), self-care (d5), interpersonal interactions and relationships (d7), major life areas (d8), and community, social, and civic life (d9). Therefore, as shown in Fig. 2, the rehabilitation objectives of the APA program are twofold: to enhance Exercise capacity (FMS and HRPF), while concurrently promoting improvements in Mental Health, Social Adaptation, and Sports Engagement among students with ID.

2.3. Deliberations on the Selection of APA Content

Based on the ICF framework, involved first selecting activities feasible for students with ID, ensuring their capability and willingness to participate. Guided by the physiological attributes and participation needs of these students, the focus was on enhancing FMS and HRPF to support daily routines and address unique requirements. Given the relatively immutable nature of their body structures, optimizing environmental and personal factors was deemed essential for achieving positive outcomes and fostering holistic development. Following the tenets of the ICF theory, environmental factors are pivotal in facilitating the participation of students with ID in physical activities. These factors, encompassing natural surroundings, social contexts, and attitudinal environments, are essential for effectively engaging students with ID in physical activities[21–24]. Hence, as shown in Table 1, the program emphasizes collaborative endeavors between families and schools, while concurrently employing targeted implementation strategies and content characteristics to achieve the objectives of the APA program (Fig. 2).

Table 1
Matching APA Course Content for Students with ID within the Structural Framework of the ICF

Direction	Objectives	Content and sports programs
Exercise capacity	Develop HRPF, fundamental movement skills (locomotor, object control), motor skills (mastery of one or two sports)	Exercises such as kneeling push-ups, crawling on all fours, balance walking, Trotting back and forth, and jumping rope
Sport participation	To appreciate the benefits of sports and foster a positive attitude towards life.	Sports Games and Sports Competitions such as Maze Crossing, Happy Stepping, Rope Jumping Fun
Mental health	Emotional control, cognitive ability, self-awareness, adaptability, interpersonal relationships, moral values, personality development	Group sports games and competitions, sensory integration training (balance, mobility, auditory, tactile, visual.)
Social adaptation	Interaction and cooperation, respect for teachers, adaptation to the natural environment, sense of responsibility and collectivism, awareness of rules	Rule-based sports games and competition team sports games and competitions

The APA program comprises four stages: preparation, practice, main activity, and conclusion. In the preparation phase, teachers foster student engagement through greetings and tailored warm-up exercises. The practice session is centered on exercises tailored for enhancing HRPF and FMS in students with ID. Interactive games or competitive events drive participation and teamwork in the main activity phase. Stretching exercises conclude the session, aiding in functional recovery. Throughout the program, use clear and concise language and instructions to avoid complexity. Consider individual differences and adjust exercise difficulty accordingly. Commend students' efforts and provide support to foster a positive learning environment. Encourage teamwork, regulate the pace of games, and ensure competitions are engaging but not overly intense, promoting the active participation of all students.

2.4. Measures

The measurement of outcomes includes components of HPRF and FMS scores. Within HPRF, Muscular strength and endurance within HPRF are assessed using the handgrip strength test[25], the 30 s sit-to-

stand test, and the 1 min sit-ups[26]. Body mass index (BMI) was computed based on measurements of weight and height. Additionally, cardiopulmonary fitness was assessed via the 20 m PACER run[13]. Flexibility was assessed using the Sit-and-Reach test.

FMS assessment: The Test of Gross Motor Development-2 (TGMD-2) was globally renowned as the premier tool for assessing children's FMS development[27], with documented reliability and validity in children with ID. It encompasses various fundamental motor skills, including running, jumping, throwing, catching, balancing, and crawling[28]. Moreover, considering the challenges faced by children and adolescents with intellectual disabilities in motor development, it may be appropriate to extend the age range for testing the relevant scales up to 18 years[29].

2.5. Statistical analyses

Descriptive statistics are reported as mean and standard deviation (M ± SD). All statistical analyses were conducted using SPSS version 23.0. Normality of data distribution was assessed using the Shapiro-Wilk test, while the Levene test was employed to evaluate homogeneity of variances. Analysis of dependent variables (HRPF, FMS) was executed employing two-factor ANOVA (2 groups: IG vs. CG) × time (pre vs. post). Repeated measures analyses were conducted to explore both between-group and within-group disparities. Post-hoc analyses were undertaken in instances of significant findings.

3. Results

Baseline characteristics

As shown in the flow chart (Fig. 3), two students were excluded from the initial screening due to accompanying physical disabilities. The study population comprised 19 students diagnosed with mild ID and 9 students with moderate ID. Additionally, the cohort included 3 students with Down syndrome and 3 students with autism spectrum disorder (Table 2).

Table 2
Descriptive characteristics of participants.

Variables	Intervention Group (n = 14)	Control Group (n = 14)	Total (N = 28)
Age(years)	16.43 ± 0.94	16.64 ± 0.84	16.53 ± 0.88
Height(cm)	165.78 ± 8.57	162 ± 5.90	164.18 ± 9.15
Weight(kg)	62.11 ± 10.43	63.17 ± 10.67	62.64 ± 10.37
IQ	53.43 ± 7.58	51.50 ± 5.75	52.46 ± 6.67
BMI	22.76 ± 4.00	23.83 ± 2.91	23.30 ± 3.47
	n(%)	n(%)	n(%)
Sex			
Boys	6(42.8%)	8(57.2%)	14(50.0%)
Girls	8(57.2%)	6(42.8%)	14(50.0%)
ID			
Mild (IQ:55–69)	10(71.4%)	9(64.3%)	19(67.8%)
Moderate (IQ:35–54)	4(28.6%)	5(36.7%)	9(32.2%)
Comorbidities			
Down Syndrome	2(14.3%)	1(7.1%)	3(10.7%)
Autism	2(14.3%)	1(7.1%)	3(10.7%)
Intellectual disability only	10(71.4%)	12(85.7%)	26(92.9%)

ID: intellectual disability. BMI: body mass index. IQ: intelligence quotient.

Effectiveness of intervention

As shown in Table 3, the study demonstrated significant main effects post-intervention in the handgrip strength test, 30 s sit-to-stand test, and 20 m PACER run. According to Fig. 4, post-intervention, the IG showed significant improvements in handgrip strength, 30 s sit-to-stand test, and 20 m PACER run scores, which were markedly better than the CG. Additionally, the Time * Group interaction effect was significant. The handgrip strength test ($F(1,52) = 4.186$, $P = 0.046$, $\eta^2 = 0.075$), 30 s sit-to-stand test ($F(1,52) = 6.224$, $P = 0.016$, $\eta^2 = 0.282$), and 20 m PACER run ($F(1,52) = 4.054$, $P = 0.049$, $\eta^2 = 0.072$) all

showed significant improvements. However, BMI, sit-and-reach, and 1 min sit-ups did not show significant improvement, post-intervention.

Table 3
Mean, standard deviation, and effect size for the HRPF and TGMD-2

Variables	Control group (n = 14)		Intervention Group (n = 14)		Time	Group	Time×Group
	Pre-test	Post-test	Pre-test	Post-test			
BMI (kg/m^2)	23.82 ± 2.91	24.45 ± 3.16	22.76 ± 4.00	22.45 ± 3.84	0.865	0.108	0.620
Handgrip strength (kg)	11.71 ± 6.98	15.63 ± 6.52	15.05 ± 7.00	26.12 ± 5.51	0.000**	0.000**	0.046
30 s sit-to-stand (n)	16.57 ± 4.18	17.14 ± 3.74	18.14 ± 4.57	24.29 ± 4.18	0.004	0.000**	0.016
20 m PACER (# laps)	16.79 ± 7.52	17.43 ± 6.84	16.86 ± 6.42	25.50 ± 8.75	0.025	0.045	0.049
Sit-and-reach (cm)	2.93 ± 11.82	2.71 ± 11.38	0.21 ± 8.74	2.04 ± 7.23	0.764	0.527	0.704
1 min sit-ups (n)	20.64 ± 8.30	20.79 ± 5.85	21.86 ± 7.63	26.28 ± 7.65	0.254	0.096	0.284
Total TGMD	54.79± 8.83	58.21± 5.89	54.57± 5.36	71.57± 3.16	0.000**	0.000**	0.000**
Locomotor	26.43± 3.94	29.07± 2.81	25.50± 3.96	34.07± 2.06	0.000**	0.025	0.001
Object control	28.21± 6.82	29.14± 4.98	28.00± 5.31	37.50± 3.32	0.000**	0.005	0.004
Note. All scores are reported as M ± SD (range).							

According to Fig. 4, post-intervention scores of the IG were significantly higher than those of the CG. The main effects for Total TGMD, Locomotor, and Object Control were significant. Time effects were significant (Total TGMD: $F(1,52) = 38.603$, $P < 0.001$, $\eta^2 = 0.426$; Locomotor: $F(1,52) = 40.670$, $P < 0.001$, $\eta^2 = 0.439$; Object Control: $F(1,52) = 13.788$, $P < 0.001$, $\eta^2 = 0.210$). Group effects were significant as well (Total TGMD: $F(1,52) = 15.978$, $P < 0.001$, $\eta^2 = 0.235$; Locomotor: $F(1,52) = 5.361$, $P < 0.001$, $\eta^2 = 0.093$; Object Control: $F(1,52) = 9.406$, $P = 0.005$, $\eta^2 = 0.139$), as shown in Fig. 4. Additionally, interaction effects were significant (Total TGMD: $F(1,52) = 17.037$, $P < 0.001$, $\eta^2 = 0.247$; Locomotor: $F(1,52) = 11.367$, $P < 0.001$, $\eta^2 = 0.179$; Object Control: $F(1,52) = 9.314$, $P = 0.004$, $\eta^2 = 0.152$) .

4. Discussion

Based on the ICF theory, this study developed an APA program to address the inadequacies in the high school PE curriculum for students with ID in Chinese schools. The objective was to systematically validate the program's effectiveness and feasibility through empirical practice. The results demonstrated that, compared to the traditional PE curricula, the program aligns more closely with the characteristics and needs of students with intellectual disabilities. Its content selection, forms, and implementation strategies more effectively motivate these students to engage in sports. Consequently, the program not only enhances the quality of life for students with ID but also fosters the development of their overall functioning and health. These findings indicate that the adaptive physical activity program is a valuable addition to the current physical education curriculum for students with intellectual disabilities, providing a more inclusive and effective approach to their physical education.

The study results indicated that a 16-week intervention of adaptive physical activity was more effective in enhancing students' HRPF and FMS compared to traditional physical education programs. Specifically, the HRPF results demonstrated significant improvements in handgrip strength, 30 s sit-to-stand, and 20 m PACER run post-intervention. These improvements align with findings from several other studies,[10, 30], suggesting that the adaptive program's targeted exercises were effective in enhancing muscle strength and cardiovascular endurance. However, BMI, sit-and-reach, and 1 min sit-ups did not show significant differences post-intervention. This lack of improvement in BMI might be due to the relatively short intervention period, which may not have been sufficient to observe significant changes in body composition. The unchanged sit-and-reach and 1 minute sit-up results suggest that the program may need to incorporate more specific flexibility and core strength training exercises to see improvements in these areas.

Consistent with the findings of Harris et al.[31], physical activity may lead to more rational adjustments in body composition and a reduction in health risks for the ID population, beyond simple changes in height, weight, or BMI. Our study also found significant improvements in specific physical fitness parameters, supporting this view. However, the differing results between the 1 minute sit-up and sit-and-reach tests in our study suggest that the lack of specific training related to these activities and the short intervention period may be factors. Previous studies also highlight the importance of targeted training to see improvements in specific fitness components[32–34]. The findings from Sun[33] further support the need for longer and more comprehensive interventions to achieve significant changes in flexibility and core strength.

This insight will inform future research protocols to incorporate core strength and flexibility exercises. FMS denote the essential patterns of motor learning in humans that underpin the execution of complex physical activities and sports[35]. The results demonstrated that the implemented study protocol significantly enhanced students' FMS, particularly showing marked improvements in locomotor and object control skills. This finding aligns with multiple research studies, which indicates that basic motor skills can be significantly enhanced through strategically designed physical activities[36–38]. Regaïeg's

study demonstrated a significant improvement in object control skills following the implementation of a game-based design program, attributing these gains to environmental factors[37]. Similarly, Capio suggested that motor intervention programs should incorporate environmental factors to ensure proficiency in FMS among children with disabilities[39]. This aligns with the design philosophy of our APA program, which leverages environmental factors to enhance students' engagement and interest in physical activity. Future research should explore extending the intervention period and incorporating a more diverse range of exercises to address flexibility and core strength improvements. Additionally, examining the long-term impacts of such adaptive programs on the overall health and social integration of students with intellectual disabilities would provide valuable insights for curriculum development.

5. Study Limitations

While the study has shown promising results, several limitations should be considered. The sample size was relatively small, and the intervention period was limited to 16 weeks. Future research should consider larger sample sizes and longer intervention periods to validate these findings further. Additionally, incorporating a variety of measurement tools to assess different aspects of physical and psychological health could provide a more comprehensive understanding of the program's impact. The lack of specific training for flexibility and core strength exercises also suggests that future programs should include a more diverse range of activities to address these components.

6. Conclusion

By leveraging ICF theory-based family and school support, alongside goal-oriented, structured, and progressive guidance strategies, our program enhances students' motivation and interest in sports participation, ensuring the successful implementation of sports interventions. The observed improvements in FMS can be attributed to the ICF theory-based exercise content, implemented through game-based formats and strategic methodologies. These findings indicate that the APA program is a valuable addition to the current physical education curriculum for students with intellectual disabilities, providing a more inclusive and effective approach to their physical education. Future research should aim to refine and expand these findings, exploring additional dimensions of physical activity's impact on students with intellectual disabilities and their long-term health outcomes.

Declarations

Declaration of competing interest

The authors declare no conflict of interest.

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Author Contribution

G.Y. and L.Z. conceptualized the study. X.S., P.Y.H., and B.N. developed the study proposal. M.L.S. and D.L. implemented the project and collected data. D.L. performed the data analysis. S.X. and P.Y.H. interpreted the results and drafted the manuscript, including Figures 1 and 2. S.X., P.Y.H., Y.G., L.Z., and B.N. reviewed and revised the manuscript. All authors have read and approved the final version and agree with the author order.

Data Availability

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

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Figures

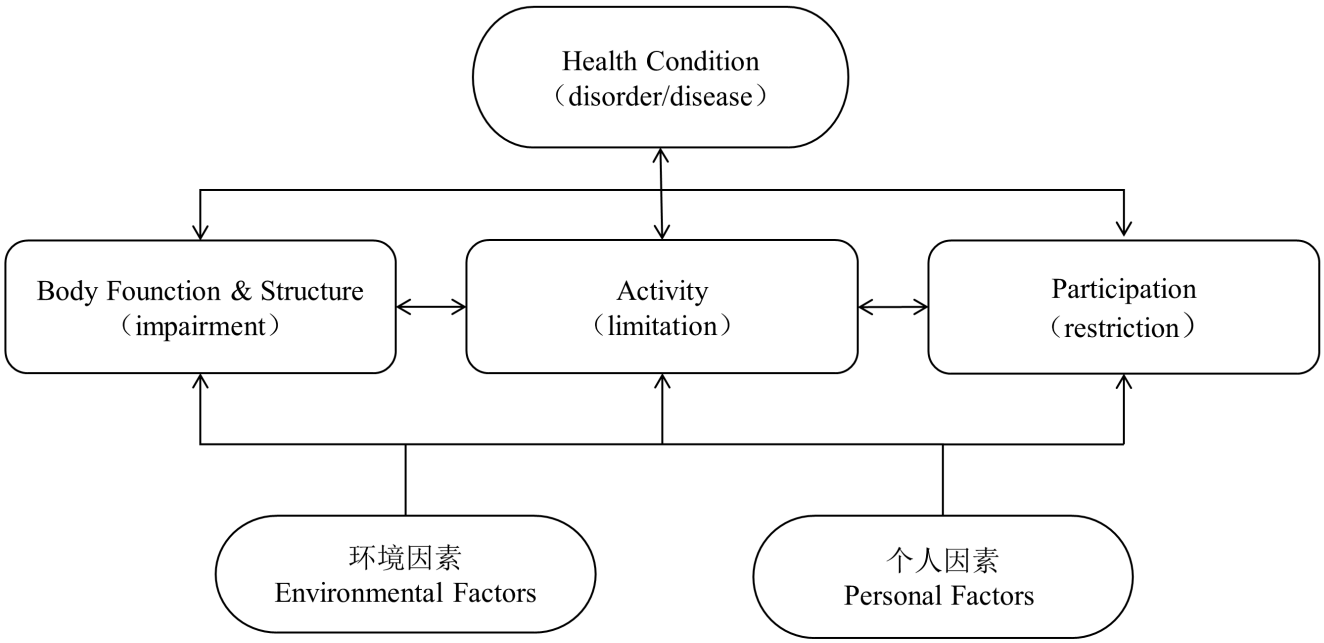

Figure 1

Construction of ICF Model Diagram

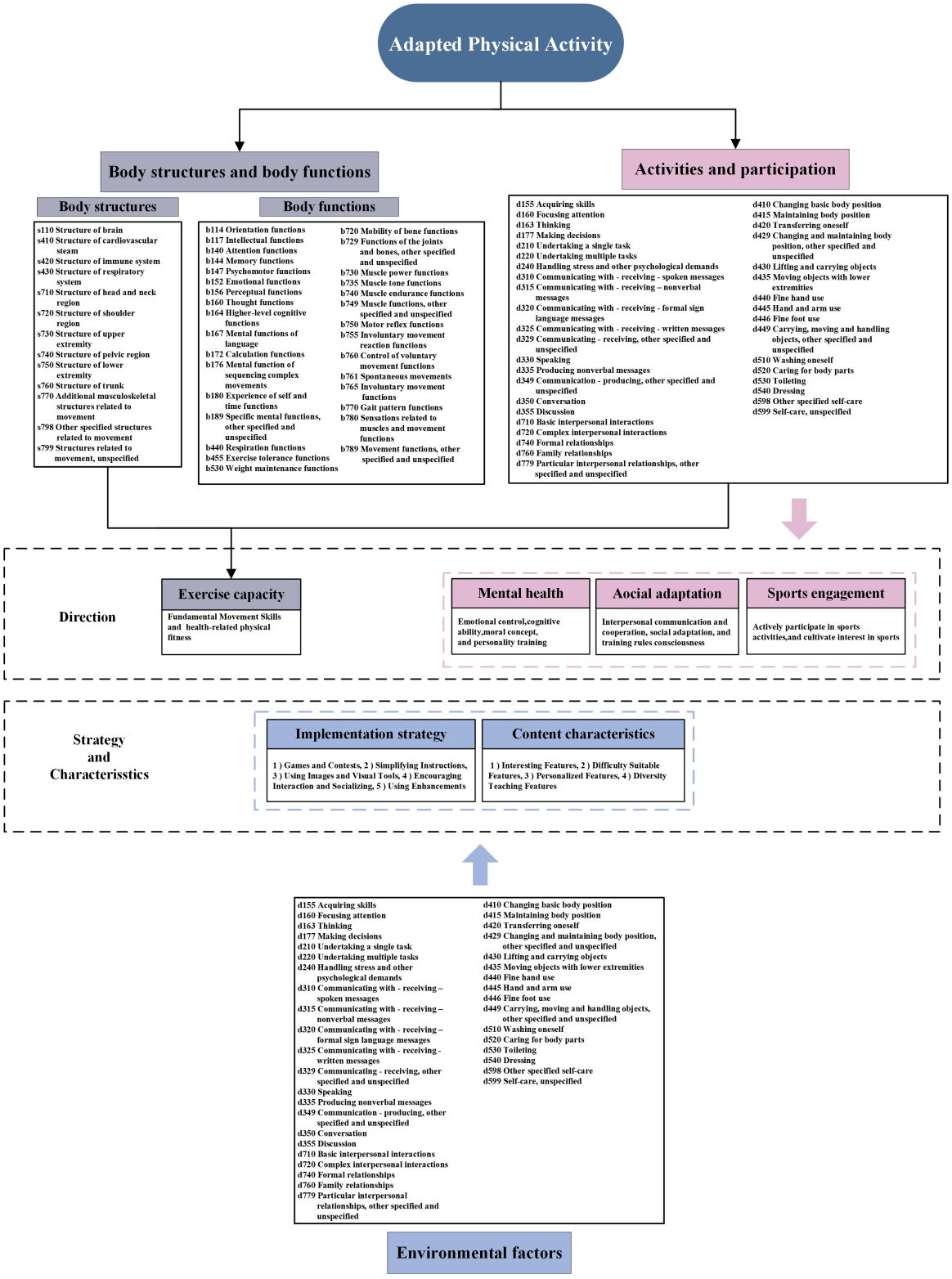

Figure 2

Matching APA Rehabilitation Goals and Implementation Strategies for Students with ID within the Structural Framework of the ICF

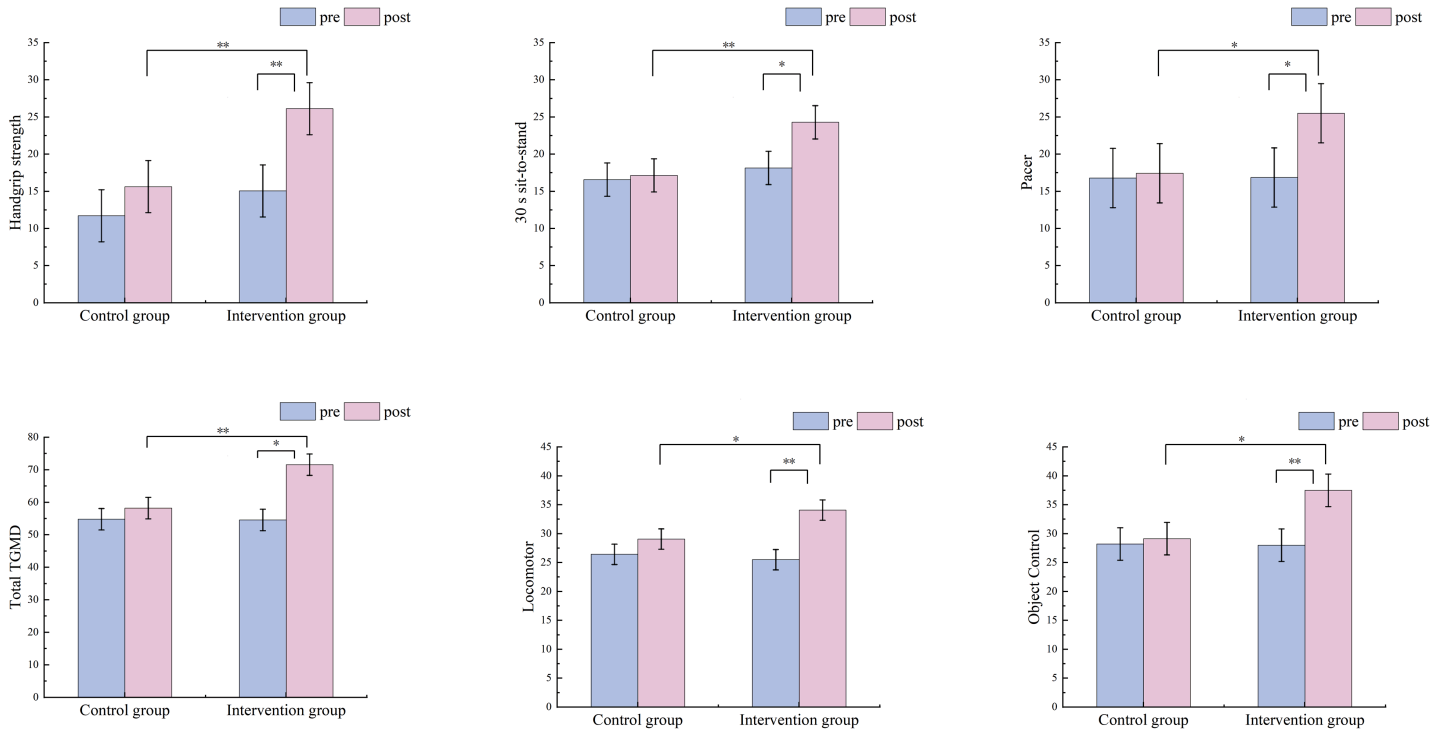

Figure 3

Study flow chart.

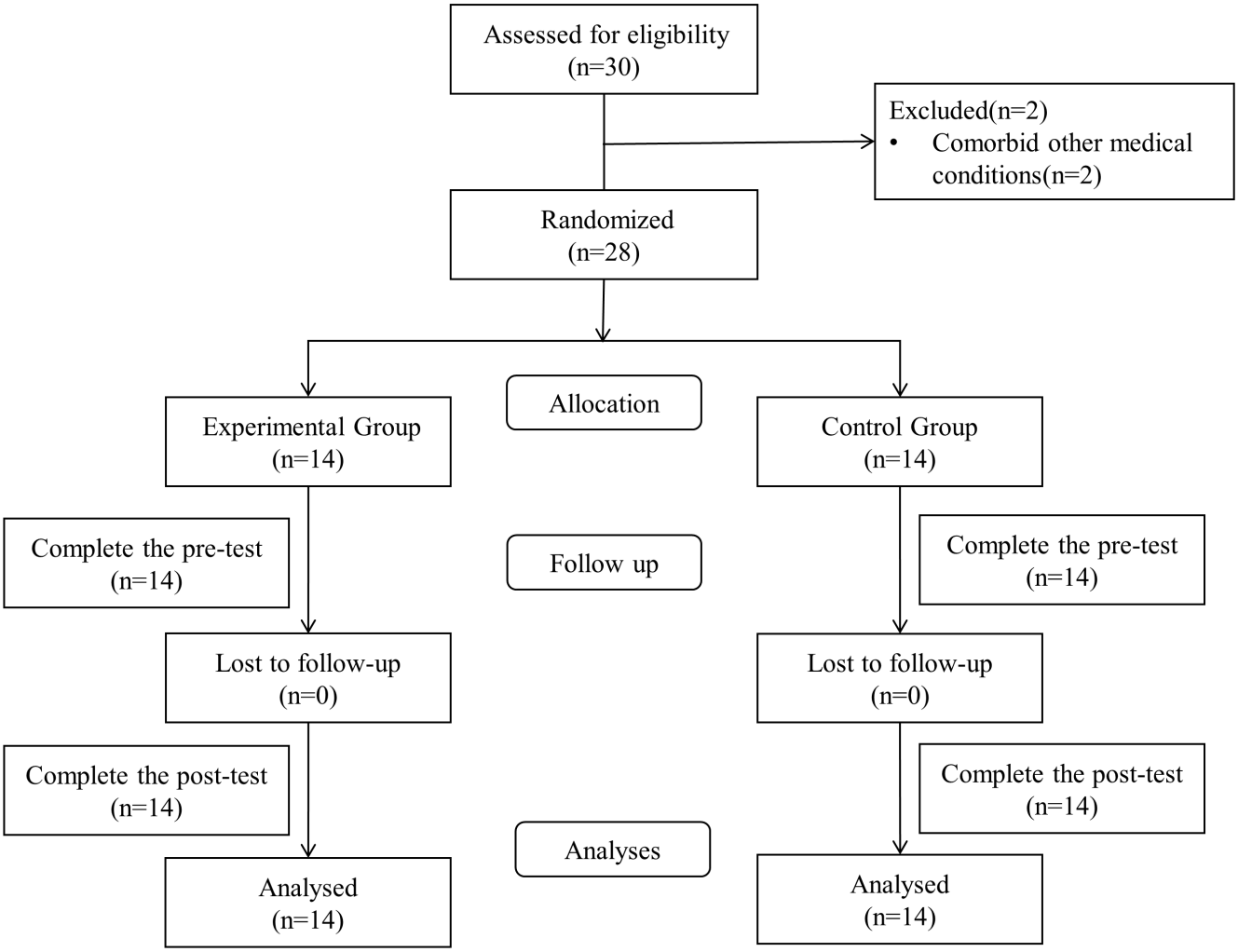

Figure 4

Mean (±SD) values of handgrip strength, 30 s sit-to-stand, 20 m pacer run ,and TGMD -2 scores in the EG and CG before and after the program. *P < 0.05; **P < 0.001.