DOCTORAL (PHD) DISSERTATION

ANGÉLICA LISETH MERO PIEDRA

EFFECTS OF AN ENRICHED PHYSICAL EDUCATION PROGRAM ON COGNITIVE AND MOTOR PERFORMANCE IN CHILDREN WITH MILD INTELLECTUAL DISABILITIES

2023

EÖTVÖS LORÁND UNIVERSITY

FACULTY OF EDUCATION AND PSYCHOLOGY

Angélica Liseth Mero Piedra

Effects of an Enriched Physical Education Program on Cognitive and Motor Performance in Children with Mild Intellectual Disabilities

DOI ID: 10.15476/ELTE.2023.199

Doctoral School of Education

Head of the Doctoral School: Anikó Zsolnai, Ph.D., Professor

Special Education Programme

Head of the Doctoral Programme: Dr. Klára Marton, Ph.D., Professor

Topic supervisor: Dr. Klára Marton, Ph.D., Professor

Budapest, 2023

Declaration

I confirm that the work presented in this dissertation is my own, and that all the assistance received, and information derived from other sources have been acknowledged. This study is registered in the ISRCTN primary clinical trial database as ISRCTN17079009.

Angélica Liseth Mero Piedra

August 2023

Funding

My Ph.D. studies would not have been possible without the Stipendium Hungaricum Scholarship from the Hungarian Government. Furthermore, this research was partially supported by a Doctoral Student Research Grant from the Faculty of Education and Psychology of Eötvös Loránd University, Hungary, to obtain independent statistical analysis consulting.

The Manabí zonal coordinator of the Ministry of Education donated the paintings for renovating the school's multipurpose court where this study took place, and the material to replace gymnastics bars on the sides of the court. The initial proposal was to donate sports caps and water bottles for the participants of this research, but the coordination opted for this donation so that all the children of the school benefit.

Conflict of Interest

The author declares no conflict of interests.

Acknowledgements

Many wonderful people helped me through this Ph.D. journey. Firstly, I would like to thank my father Roque Mero, my mother Carmen Piedra, my sister Carmin Mero, and my brother David Mero for their unconditional love, consistent support, and encouragement to follow my goals without any second thoughts throughout my life. Without them, all my achievements have simply been impossible. Furthermore, I am forever indebted to my husband László Nikházy; his careful advice and untiring academic and personal support over the past years have shown me that life has given me the best partner I could have asked for. They all have inspired me to do my best and be my best; they have been my "biggest fans," and a piece of each of them takes part in these pages.

I want to express my deep appreciation to my supervisor, Prof. Klára Marton, for what I have learned from her and all she has done for me. Many thanks for always reading my lengthy emails and answering even small questions. For her continuous and thoughtful insight, her commitment to my development as a researcher, and for letting me find my own way in the study. I would also like to thank Orsolya Pesthy for her support in theoretical and applied statistics, an area in which I still have a lot to learn, and for all her patience in explaining what I did not understand with a big smile.

Finally, I would like to acknowledge my endless gratitude to the protagonists of this study and source of motivation when facing difficult periods: the children with intellectual disabilities. Their active participation, constant hugs and smiles, and immense desire to play wildly justify all the work done during these years. A huge thanks to the teachers and parents for receiving me from the beginning with open arms, helping me with everything I needed to carry out my study, and for their constant curiosity about my work.

CONTENTS

List of Tables

List of Figures

1 INTRODUCTION

As a physical education teacher and as a sports project manager for people with disabilities in different Ecuadorian institutions throughout my career, my main motivations to conduct this research were driven by the following pronounced reasons*:*

Firstly, Ecuador has been considered a referent in Latin America in the protection and vindication of the rights of persons with disabilities; that is why countries such as Peru and Uruguay replicated elements of the Ecuadorian model with our governmental support (Camacho Vásconez et al., 2013; Camacho Vásconez et al., 2018; Unuzungo & Carvajal, 2018). In the last two decades, substantial changes towards inclusion in education have been made with government policies and programs (e.g., Constitution of the Republic of Ecuador, 2008; inclusive education programs for teachers by the Ministry of Education, 2011) in an attempt to prevent the multiple limitations concerning to the learning processes and participation for students with typical and atypical developmental trajectories. Changes included organizational and curricular adjustments at all educational levels by the Ecuadorian Ministry of Education (e.g., Physical Education curriculum, 2016a, Curriculum for compulsory education levels 2016b), and promoting flexibility as one of the key new features in the process of teaching in the sense of allowing accommodations and modifications to favor successful experiences in students.

Despite these attempts, I have been able to observe, together with my close colleagues in the area, that the processes toward a real inclusive education in practice are advancing at a very slow pace. In some aspects, education continues to operate with an individualized approach to the children with disabilities, highlighting their learning difficulties attributed to individual variables and often obviating the considerable influence that the educational, familiar, and social environments have on development and learning. We need more efforts to focus on the development of these children's skills to empower their minds, bodies, and lives and enhance their abilities with an appropriate education. This research proposal was born from the desire for integrated and inclusive education for children and young people with disabilities, starting from the conception that to achieve a fundamental change, a profound transformation in the culture of the teachers is necessary. The nature of the profession requires interaction with students with different types and levels of disability, which is why teachers should replicate positive and reflective disposition to modifications and adaptations of curriculum, methods, and teaching strategies of all kinds, with that sense of flexibility that is already reflected in the government guidelines but that in practice is not always observed. Embracing the notion that inclusive practices are very complex and of a multifactorial nature (Fournidou et al., 2011).

Second, physical activity has become a public health priority in modern societies. As a result, many strategies and interventions have been used to promote physical activity in schools, and the scientific interest in this area increased considerably. Although the role of physical activity in managing physical health and reducing obesity is clear and widely accepted, it is also accepted that it has multiple benefits in other domains of the human being, such as cognitive or social (Diamond, 2012; Kohl & Cook, 2013). However, the specific role it plays in developing some of these domains is still not well understood.

The scientific research on the relationship between physical activity and cognitive performance in children and adolescents has received pronounced attention in the last decade, with evidence suggesting a positive association between the two (e.g., Afshari, 2012; Chirosa et al., 2016; Halperin et al., 2013; Hillman et al., 2014; Kamijo et al., 2011; Pesce et al., 2016; Razza et al., 2015). However, experimental studies that focus on the causal effects of these variables in typical and atypical young populations are still limited. In the literary review made for this dissertation, only scare studies on this relationship in children and adolescents with intellectual disability (ID) were found (Fotiadou et al., 2020; Hartman et al., 2010; Javan et al., 2014; Wuang et al., 2008; Yılmaz & Soyer, 2018). This reflects a significant gap in the field due to the fact that the association has not yet been clarified and, therefore, no firm conclusions have been drawn about it. More research in this regard is needed towards programs and interventions that respond to the needs of children with ID, taking into consideration the following:

1) The prevalence of people with disabilities is around 15% of the world's population (World Health Organization, [WHO], 2011). In Ecuador, where this research was conducted, the prevalence of people with disabilities is 2.67%, and the persons with ID represent 23,12% of that total. Further, about 27.3% of people with ID are school-aged between 5 and 18 years old (Consejo Nacional para la Igualdad de Discapacidades, 2021).

   Persons with ID have significant difficulties in general mental abilities that affect their intellectual functioning (American Psychiatric Association, [APA], 2013) compared to typically developed populations. Mental ability describes abilities and aptitudes manifested through tests designed to measure a person's behavior in different areas, such as verbal, numerical, or spatial (APA Dictionary of Psychology, n.d.; Schmidt & Hunter, 2004). On the other hand, intellectual functioning embraces individual intelligence, which is why it is also known as intellectual operation and is defined as "any of the mental functions involved in acquiring, developing, and relating ideas, concepts, and hypotheses. Memory, imagination, and judgment can also be considered intellectual functions" (APA Dictionary of Psychology, n.d.). In this sense, persons with ID exhibit difficulties perceiving and processing new information, learning rapidly and efficiently, thinking creatively and flexibly, and solving novel problems (Henry et al., 2011). Moreover, they also demonstrate significant challenges in underlying cognitive control functions (e.g., Danielsson et al., 2012; Menghini et al., 2010; Palmqvist et al., 2020; Traverso et al., 2018) that refer to the capacity to pursue goal-directed behavior instead of choosing more habitual or persuasive responses (Cohen, 2017). Cognitive control plays a central role in human autonomous functioning (Medaglia, 2019), and it has been associated with different aspects of life, such as academic, social, mental, and physical health, which highlights its importance as human beings (Diamond, 2013).

2) In addition, children with ID may also be characterized by a delay in reaching motor milestones and difficulties in sensorimotor function; this, therefore, may affect the neuro-musculoskeletal and motor systems (Hogan et al., 2000; Pellegrino, 2007). For example, studies reported difficulties in gross motor skills (GMS) when compared to typically developed populations (e.g., Hartman et al., 2010; Rintala & Loovis, 2013; Vuijk et al., 2010; Westendorp et al., 2011; Wuang et al., 2008). GMS are goal-focused movement patterns employing large muscles of our body (Haywood & Getchell, 2009) and are the basic building blocks for more complex motor skills (Stodden et al., 2008) and all physical activity throughout our lives.

3) Nowadays, children of preschool age already do not engage in sufficient physical activity (Tucker, 2008), and the physical condition of young populations has significantly decreased over the past years compared to youths three decades ago (Runhaar et al., 2010). Besides, factors such as the barriers to participation that individuals with ID encounter contribute to sedentary lifestyles, including staff (e.g., teachers, volunteers, and program coordinators) interest, constraints, and lack of expertise in physical activity, limited options for physical activity programs, and lack

of inclusion and financial support (Bossink et al., 2017). Therefore, personas with ID are at relatively high risk for the development of secondary consequences of physical inactivity, such as high rates of obesity, which also leads to other trends, such as higher consumption of medications associated with weight gain (Hsieh et al., 2014; Lotan et al., 2006; Slevin et al., 2014).

Secondary consequences are preventable because they originate from the environment and not from the ID itself, which is why the literature supports the need to re-examine the circumstances and experiences children are exposed to in our society. In general, research indicates that people with ID have poorer health and more unsatisfied health needs compared to the typical populations. Therefore, strategies to promote physical activity in the young populations with ID, such as easily accessible programs for children and adolescents with ID, are highly needed (Lotan et al., 2006).

With this background, after positioning this study in the theoretical framework through a deep literary review and by understanding the current international discussion in the field, my research interest was aimed at analyzing the effects of an enriched physical education program on cognitive and motor performance in children with mild ID, in order to provide a much more comprehensive understanding of this underexplored field.

2 THEORETICAL BACKGROUND

The following sections present the theoretical approach on which this study has been built, with a review of relevant literature to support the recognition of the gap in the field and the relevance of the study.

In the first section (2.1), we present a comprehensive overview of intellectual disabilities, highlighting the significant heterogeneity within this population with atypical developmental trajectories. Furthermore, we explore the learning characteristics and special education needs of students with ID.

The second section (2.2) addresses key terminology of physical education, its importance in our society, and some bases for broadly understanding typical human motor development. Then, in the third section (2.3.) there is a focus on the specific motor skills contemplated in the present study, taking into consideration the motor development of children with ID.

In the fourth section (2.4.) we are presenting definitions of cognitive control and its components: cognitive flexibility, inhibitory control, and attention, explaining their relevance in the human autonomous functioning and addressing research in populations with ID. Finally, the last section (2.5) offers the unifications of the variables through an overview of the association between cognitive and motor performance with correlational and experimental studies in young populations with ID and other atypical developmental trajectories.

2.1 AN OVERVIEW OF INTELLECTUAL DISABILITIES

The American Psychiatric Association (APA, 2013) describes ID as a neurodevelopmental disorder characterized by difficulties in both intellectual functioning and adaptive behavior typically displayed in one's age group that is evidenced from childhood. In intellectual functioning, individuals with ID show significant challenges in general mental abilities such as learning, abstract thinking, and planning. Regarding adaptative functioning, persons with ID show substantial difficulties in performing daily real-life activities at home, school, and the community, concerning conceptual (e.g., reading, mathematics), social (e.g., communication, empathy), and practical (e.g., money management, self-care) areas (APA, 2013; Boat & Wu, 2015).

All of these characteristics are translated into atypical developmental trajectories, which Davies et al. (2010) defined as inconsistencies in accomplishing milestones related to different domains such as cognition, language, motor coordination, social interaction, and adaptive development. Although each person has different abilities and skills that develop at various rates depending on genetics and experience, most children typically show similar and predictable developmental patterns (Papalia & Duskin, 2012).

However, in the case of persons with ID, there is a great variability in their developmental profile due to the varied etiologies (Giaouri et al., 2010) with an estimated prevalence within the general population between 1% and 3% (Tan et al., 2016). For instance, the typical developmental process may be affected by prenatal, perinatal, or postnatal causes that include genetic factors (e.g., Down syndrome, Fragile X syndrome) or environmental factors (e.g., exposure to toxic substances, nutritional deficiencies, brain radiation) (Boat & Wu, 2015), or interactions between these two (Davies et al., 2010). Nevertheless, many cases are of unknown origin (Boat & Wu, 2015).

In addition, the population's heterogeneity increases when considering the large individual variations in the severity of the diagnosis of ID (mild, moderate, severe, and profound). In this sense, the different severities are characterized by criteria detailed in the Diagnostic and Statistical Manuals of Mental Disorders (DSM). The DSM-5 criteria are centered on the difficulties of the person with ID in daily life skills, and the DSM-IV criteria are based on the intelligence quotient derived from standardized measurements (Boat & Wu, 2015):

- In general, persons with mild ID are able to live independently with minimum levels of support. Their IQ falls within the range of 50–69 and represent 85% of the population with ID.
- Persons with moderate ID may independently live with moderate levels of support (e.g., the support provided by group homes). They have IQs ranging between 36–49 and represent 10% of the population with ID.
- Persons with severe ID need daily assistance that involves safety supervision and self-care activities. They have IQs ranging between 20–35 and represent 3.5% of the population with ID.
- Persons with profound ID require complete daily support and care (24 hours per day). They have an IQ <20 and represent 1.5% of the population with ID.

Although it is characteristic of people with ID to have an IQ score below 70, the scientific literature also acknowledges a population with milder difficulties in overall intellectual functioning, referred to as borderline intellectual functioning or borderline ID. This category encompasses individuals with IQ scores ranging from 71 to 84, representing approximately 13.6% of the population between 1-2 standard deviations below the mean IQ on the statistical curve of normal distribution (Fernell & Gillberg, 2020; Meral & Yalnizoğlu, 2013; Wieland & Zitman, 2016). Individuals with borderline intellectual functioning typically are able to live independently, although they often face challenges in academic or occupational performance as well as social functioning (Fernell & Gillberg, 2020; Wieland & Zitman, 2016). It is important to note that the current edition of the DSM does not define borderline intellectual functioning as a separate diagnostic criterion since it is not classified as a disorder. However, the DSM does recognize that may be an area of clinical concern and highlight its significance in relation to an individual's mental well-being (Fernell & Gillberg, 2020; Georgiopoulos, 2008; Wieland & Zitman, 2016).

2.1.1 Learning characteristics and special education needs

In the realm of education, it is recognized in the literature that students with ID often exhibit challenges in learning processes compared to their typically developing peers of the same age (e.g., Antequera Maldonado et al., 2008; Ministry of Education of Ecuador, 2013). This can be exemplified by the acquisition of speech and locomotion, where children with ID generally require more time to achieve these milestones. While some may eventually catch up with their peers, others may not reach the same level of development (González Serrano & Ubilla Navarro, 2007).

Acknowledging the significant variability in learning characteristics within the population with ID is crucial. Each child is unique, and this individuality is further influenced by specific individual factors like the etiology and severity of ID, as mentioned in the previous section, as well as the interactions with external elements such as the environment and barriers to participation (Antequera Maldonado et al., 2008). In this sense, it is essential to emphasize that disability cannot be solely defined through an individualized approach, focusing solely on individuals' mental and physical health characteristics. Instead, disability should be understood as an interaction between these individual attributes and environmental and contextual factors, including negative attitudes or limited access to education (WHO, 2023). Therefore, in educational inclusion for students with ID, critical goals revolve around fostering conditions that support educational processes and identifying barriers that hinder learning and participation (González Serrano & Ubilla Navarro, 2007).

The special education needs of students with ID are derived from their learning characteristics, strengths, and support requirements. Focusing specifically on students with mild ID for the purposes of this research, various aspects of their learning characteristics derived from intellectual functioning, communication, autonomy, and motor and social domains pointed out by Antequera Maldonado et al. (2008) work can be highlighted. In the learning characteristics derived from intellectual functioning, the authors mentioned that students with mild ID experience difficulties in focus (attention), information retention, and self-regulation. Abstract thinking, problem-solving, processing relevant information, and applying learned concepts across different situations are also challenging. Communication-wise, while oral language development generally follows typical patterns, delays in acquisition and slower progression in advanced conversational skills are common. Antequera Maldonado et al. (2008) also pointed out that autonomy reveals the gradual attainment of independence in personal care and handling daily activities (e.g., managing clothing and household chores). Students with mild ID might also encounter challenges in social interactions, identifying emotions, and regulating behavior in social contexts. In terms of motor skills, students with mild ID encounter difficulties in motor skills performance compared to their peers, necessitating additional time for lateral dominance establishment and showing slower progress in balance and postural control development (Antequera Maldonado et al., 2008; González Serrano & Ubilla Navarro, 2007; Pellegrino, 2007; Peredo Videa, 2016).

Based on the learning characteristics and educational requirements of students with mild ID, teachers can implement general pedagogical considerations to foster a supportive and inclusive learning environment, such as curricular adaptations, including adaptations in objectives, methodology, resources, activities, and evaluation (Ministry of Education of Ecuador, 2013) and also selecting additional objectives based on their significance and functionality in the student's current development stage (Seifert & Sutton, 2009; Troncoso & Del Cerro, 1999). Enhancing learning supports to achieving learning goals with additional time and sufficient practice (Troncoso & Del Cerro, 1999), regularly providing constructive and encouraging feedback (Seifert & Sutton, 2009), and utilizing level-appropriate verbal and non-verbal communication resources to promote better understanding among students (Mero Piedra, 2020b; Payne et al., 2010) are important factors to consider.

Besides, the educators' attitudes in learning situations play an essential role as either a facilitator or a barrier to the participation and learning of students with ID. A positive and supportive attitude enhances the development of effective educational strategies, leading to a more successful teaching-learning process (Gonzalez-Gil et al., 2019). Conversely, negative attitudes toward inclusion and perpetuating societal stereotypes can be significant barriers (Shields & Synnot, 2016). Recognizing the profound impact of educators' attitudes promoting a culture of inclusivity within educational institutions' staff is imperative.

Overall, this theoretical background section provides an overview of intellectual disabilities as neurodevelopmental disorders characterized by challenges in intellectual functioning and adaptive behavior from early ages (APA, 2013). These atypical developmental trajectories stem from diverse causes, including genetic and environmental factors (Boat & Wu, 2015). In the realm of education, students with mild ID may exhibit slower learning processes compared to their typically developing peers. Curricular adaptations are vital to ensure inclusivity and academic progress, embracing each learner's unique strengths and challenges (Ministry of Education of Ecuador, 2013). Their special education needs may extend beyond the standard curriculum, focusing on socio-emotional needs, autonomy, and daily life activities (Seifert & Sutton, 2009; Troncoso & Del Cerro, 1999). Teachers can foster a supportive learning environment by offering for example, sufficient practice and providing constructive feedback (Seifert & Sutton, 2009; Troncoso & Del Cerro, 1999). Moreover, positive and inclusive attitudes among educators play a pivotal role in promoting effective educational strategies and achieving successful teaching-learning outcomes (Gonzalez-Gil et al., 2019).

2.2 PHYSICAL EDUCATION AND CHILDREN'S DEVELOPMENT

Physical education is a fundamental right (United Nations Educational, Scientific and Cultural Organization, [UNESCO], 1981) and is an essential part of every childhood educational project reflected in the curriculum. Physical education is the entry point towards practicing physical activity throughout life. Besides, it is the only subject that combines physical competence with communication, general human values and life skill-based learning (e.g., self-discipline, respect, teamwork, fairness, and tolerance) (McLennan & Thompson, 2015, p. 6).

Physical education is a school subject that comprises pedagogically thematized knowledge about subjective perceptions of the body and bodily practices with contextual meaning (e.g., gymnastics, games, sports) (Bracht, 1996; Ministry of Education of Ecuador, 2016a, p. 45). Its mission in the educational system distinguishes it from other more general concepts commonly taken as synonyms, such as physical activity and physical exercise. Physical education must guarantee the right of students to find the best ways to solve the challenges that bodily practices imply in the motor, cognitive and emotional domains, building their body identity and confidence in the process (Ministry of Education of Ecuador, 2016a, p. 47).

It is important to clarify at this point that the World Health Organization defines physical activity as "any bodily movement produced by skeletal muscles that requires energy expenditure". Therefore, it refers to all bodily movement, such as walking in the park, taking the stairs, the Sunday soccer game with friends, and going to the gym regularly. On the other hand, physical exercise is a physical activity aimed at improving or maintaining physical fitness and overall health components, based on a plan, structure, and repetition (Caspersen et al., 1985). Thus, both physical exercise and physical education are physical activities, but physical education is also a pedagogical discipline that might include physical exercise within the curricular framework.

Regular physical activity has become a public health priority in modern societies because of its positive effects on health, risk reduction of chronic diseases, among other benefits (Biddle et al., 2019; Jakicic et al., 2018; Marques et al., 2018). In this sense, school physical education programs offer a remarkable opportunity to provide physical activity to all children in an effort to decrease the high sedentarism level in society from young ages. Children at preschool age already do not engage in sufficient physical activity (Tucker, 2008). It has also been demonstrated that the physical condition of youths has significantly decreased over the past years in comparison to youths of three decades ago (Runhaar et al., 2010). Therefore, governments and development actors have gradually recognized the overall value of quality physical education (McLennan & Thompson, 2015, p. 12).

In 2014 the Ministry of Education of Ecuador increased the amount of compulsory physical education hours from two to five hours per week, from the first to tenth year of general basic education (children between 5 to 15 years old) (Ministry of Education of Ecuador, 2014). In addition, in 2016 the physical education curriculum was reformed, giving the teachers the possibility of selecting content, prioritizing the most significant cultural values and interests for their students in each context. The new curricular design contains the following blocks: 1) playful practices: games and play, 2) gymnastic practices, 3) expressive-communicative bodily practices, 4) sports practices, 5) construction of body identity, and 6) relationships between bodily practices and health. The last two blocks should be considered transversal together with the other four since the knowledge they emphasize must be taken into account constantly (Ministry of Education of Ecuador, 2016a).

The new curriculum update allows for a unique integration of skills from different content blocks. While there are formally two blocks of transversal content, the principles of interdisciplinarity and transdisciplinarity are pervasive throughout all content blocks to achieve meaningful learning. For example, the realm of sports practices may involve the incorporation of gymnastics and playful practices and also promote a holistic approach to health and well-being. This approach is particularly significant during the early years of schooling, as the focus is on general skills, knowledge, and evaluation criteria. As students progress through high school, they will have the opportunity to specialize and delve deeper into specific methodologies, activities, and evaluation approaches.

The present study focused on the first block because playing is an essential human function, and its importance has been studied for decades. For instance, Huizinga (1972) denominates humans as *homo ludens*: the man who plays. He also defined (1949) play as “a voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted but absolutely binding, having its aim in itself and accompanied by a feeling of tension, joy and the consciousness that it is “different” from “ordinary life” (p. 28). Thus, playing as an inherent practice can be a great facilitator in all ages' teaching and learning processes (Mero Piedra, 2020b). Furthermore, play is a source of joy and pleasure, and its pedagogical value relies on being an agent of global development (i.e., motor, social, cognitive, and affective areas) (Juan & Montes, 2001). The "playful practices: games and play" curriculum block is based on individual or collective playful learning through guided games, with different pedagogical objectives such as encouraging creativity, cooperation, and collaboration. Games can be of different categories, including but not limited to traditional, popular, expressive, with elements, in between nature, persecution, and cooperation games (Ministry of Education of Ecuador, 2016a, p. 59; Nakayama, 2018).

Components of pedagogical practices such as frequency, effectiveness, and quality are among the current challenges of physical education because the benefits may not necessarily occur spontaneously (McLennan & Thompson, 2015). Even though children's physical competence and health improvements are typically considered major advantages of physical education, Bailey et al. (2009) suggest that these improvements may not be automatically guaranteed. Further, the authors pointed out that the significance of the impact of physical education in enhancing social, cognitive, and emotional domains is arguable in different contexts.

For instance, systematic reviews and meta-analysis studies have examined the effects of the quantity and quality components of school-based physical activity on children's and adolescents' development, providing a broader understanding of the key aspects for effective practices to generate benefits in various areas such as motor and cognitive development and academic performance (Alvarez-Bueno et al., 2017; Garcia-Hermoso et al., 2020; Rasberry et al., 2011).

García-Hermoso et al. (2020) study found that quality-based physical education was more effective in improving health-related physical fitness (e.g., Body Mass Index, cardiorespiratory fitness, muscular strength) and fundamental motor skills (for more information about fundamental motor skills, see section 2.3) than quantity-based physical education. These outcomes contradict the notion that more leads to better results. Instead, high-quality physical education, characterized by well-structured classes, effective teaching strategies, and highly qualified teachers, is essential for more positive outcomes regardless of the frequency or duration of the classes. An explanation for these results could be that the quantity-based programs did not reach the appropriate physical and motor skills engagement to promote significant enhancements.

Programs focused on both quality and quantity components could possibly generate even greater benefits in population development. This notion could be aligned with the conclusions including quantity-based physical activity for cognitive development and academic performance from Alvarez-Bueno et al. (2017) and Rasberry et al. (2011) studies. Alvarez-Bueno et al. (2017) found that curricular physical education focused on increasing the daily amount of exercise carried out by specialists was the most effective in generating a positive impact on several cognitive functions in children and adolescents, such as working memory, inhibition, reasoning, problem-solving, perception, spatial aptitudes, and cognitive life skills (e.g., self-awareness of goal setting). These results highlighted how both parameters are important for cognitive development. (For more information about cognitive functions, see section 2.4; for more information about physical activity interventions and their effects on cognition, see section 2.5).

In any case, Rasberry et al. (2011) highlighted that increasing the quantity or quality of physical activity is recommended when talking about the academic performance of young populations. Their study outcomes have shown that different types of school-based physical activity (physical education class, recess, classroom-based, and extracurricular physical activity) have either a positive or no relationship with academic performance, pointing out that educational institutions can meet physical activity recommendations without concern for an unfavorable impact on student's academic success.

In conclusion, pedagogical and contextual factors heavily influence many of the benefits of physical education and school sport in different domains (physical, social, affective, and cognitive) (Bailey et al., 2009, p. 1). However, there is sufficient evidence to support that it can positively impact the development of various domains in children and adolescents. Effective physical education requires complex coordination of various aspects of education, such as content knowledge, curriculum, teaching, and assessment strategies, in addition to supportive aspects, such as venues, and inclusion policy, among others (Ho et al., 2018, p. 362). The above-mentioned is consistent with the UNESCO (2023) framework for Quality Physical Education, which defines it as a comprehensive approach to physical education promoting quality components such as value content, peer-led learning, inclusivity, and holistic well-being development (physical, psychological, and social). Moreover, the UNESCO framework acknowledges the significance of quantity components such as frequency in order to address the worldwide issue of physical inactivity. More studies are recommended to explore the best practices in physical education to generate physical, social, affective, and cognitive benefits.

Finally, due to physical education, and in general, all physical activities, are characterized by practices that require bodily movements, it is imperative to understand and explore the development of human motor skills in more detail. Therefore, based on relevant literature on the matter, the next section will broadly address the typical human motor development, and then, there will be a focus on the specifics motor skills involved in the present study taking into consideration the atypical motor developmental characteristics of its participants: persons with ID.

2.3 Human Motor Development: Gross Motor Skills

Motor development has been defined as a process of internal change that occurs in the individual during the course of life (Payne & Isaacs, 2012; Pérez et al., 2008). It is a continuous sequential process related to age by which a person progresses from simple to complex motor skills and finally to the adjustment of those skills to aging (Haywood

& Getchell, 2005). Schmidt and Wrisberg (2000) point out that all human beings are born with some innate skills that, thanks to natural maturation and the acquired experience, can be performed almost in complete form as walking and balancing. Although to achieve proficiency in other more complex skills, we need a lot more practice, "our lives as human beings are characterized by the performance of skills and the learning of skills" (pp. 4-5).

Literature’s concept of "motor skills" depends essentially on its classification (Schmidt & Wrisberg, 2000). For example, a recognized classification is basic motor skills and specific motor skills, which gives the guidelines for its conceptualization. The first one is the foundation of our motor skills; they are a series of motor actions that emerge phylogenetically in human evolution and find support for their development in perceptual abilities (Falcón & Rivero, 2010). Sensory perceptual abilities allow us to learn about ourselves and the environment by generating a two-way connection between perception and action that can be observed from birth (Papalia & Duskin, 2012). For instance, visual perception and motor skill coordination can be observed when an infant first can reach stationary objects only and then can adapt his stretching to objects that move (Wentworth et al., 2000). The above denotes development in visual skills such as focus and following a moving target with the eyes to guide the adjustment of hand placement motor movements (Wentworth et al., 2000).

Thanks to the basic motor skills, we can build richer, more complex, and adapted motor responses called specific motor skills. For instance, "running" is a basic motor skill because it is broad, general, and not specialized, but if we consider the "running" skill of a sprinter, with a stride technique, acceleration phase, maximum speed, and deceleration phase with particular characteristics, and taking place in the athletic track, we are talking about a specific motor skill.

This study takes a perspective that emphasizes motor skills as skills where the critical factor impacting performance is the quality of the individual’s deliberate movement (Schmidt & Wrisberg, 2000, p. 6) since it is widely used in the literature, especially in physical education and other sports sciences. We execute motor skills in our daily life to solve situations that require an intentional and directed movement for their resolution. Therefore, it involves movements of the muscles of our body to perform a specific task. This perspective guides the classification in which the present study is framed, based on the amount of muscular involvement required to differentiate them into "fine motor skills" and "gross motor skills." Although indeed, movements are often classified, it is also correct to indicate that most movements require both types of motor skills; the categorization lies in the most significant muscle affectation that is required, whether with significant participation of large or small muscles or muscle groups (Payne & Isaacs, 2012).

This research centers on gross motor skills (GMS), also called fundamental movement skills, because they are the basic building blocks for movement competence throughout our lives (Stodden et al., 2008). GMS are purposeful movements patterns involving the activation of large muscle groups that enable us to control our bodies, move independently in our environment and respond to stimuli effectively, starting from a young age (Haywood & Getchell, 2009; Pangrazi & Beighle, 2012).

Typically, motor development in children follows a sequential progression and predictable pattern. In this sense, the large muscles develop before the small ones, promoting mastery of fundamental GMS before more complex motor skills (Papalia & Duskin, 2012; Payne & Isaacs, 2012). Other examples of predictable patterns are the proximodistal and cephalocaudal principles. The proximodistal principle is based on the development from the inside out; the body parts near the body axis develop before the extremities. The cephalocaudal principle is based in that the development proceeds in the direction of the head to the extremities; the upper parts of the body develop before the lower parts of the trunk (e.g., Papalia & Duskin, 2012; Payne & Isaacs, 2012). In practice, we can see how these principles are related to the execution of movements; for example, children first acquire the ability to intentionally move the arm (containing the large muscles of the upper limb) to perform a task and later the skill to move the fingers intentionally (proximodistal principle, use of smaller muscles). In turn, we also observe that they can first learn to do many things with their hands long before crawling or walking (cephalocaudal principle). Nevertheless, the development of the GMS may vary between individuals, influenced by the interaction of factors such as age and natural maturation, experience, instruction, environment, and individual characteristics (Clark & Metcalfe, 2002; Haywood & Getchell, 2014).

The GMS are divided into two main groups of motor skills. The first groups are the Locomotor skills, which include skills for moving the body through space, and the second are the Object control skills, which involve skills for manipulating and projecting objects (Haywood & Getchell, 2005). The above is relevant to the present study as qualitative aspects of the following locomotor skills were evaluated: running, galloping, leaping (one foot), sliding, jumping (two feet), and hopping. Besides, the following object control skills were assessed: catching, kicking, throwing, rolling, dribbling, and striking. For more details on the performance criteria of each GMS evaluated, see Appendix 5

Studies have indicated that a considerable proportion of children do not have a proficiency level in GMS according to their age (Goodway & Branta, 2003; Hardy et al., 2012) showing decreases in their physical condition compared to previous generations (Runhaar et al., 2010). The reduced physical activity levels experienced during childhood (Tucker, 2008) may be an important factor for the above and have a lasting impact on an individual's ability to engage in physical activity later in life. The decline in physical activity levels among children during early childhood has been linked to decreased motor proficiency during adolescence and adulthood (e.g., Malina, 1996; Stodden et al., 2008). Furthermore, the likelihood of having difficulties in GMS when compared to the typically developed population is significantly higher in children with ID. Children with ID tend to display delayed attainment of motor milestones, which can be observed at early ages (Hogan et al., 2000; Pellegrino, 2007; APA, 2013). Although there is no known neurological or physical impediment to their ability to develop typical motor patterns, numerous studies have reported these delays (e.g., Gkotzia et al., 2017; Hartman et al., 2010; Westendorp et al., 2011; Wuang et al., 2008).

The following section presents an overview of the motor delays mentioned before in individuals with mild ID and the possible reasons that could cause or influence them. Second, the subsequent section focuses on physical activity intervention studies and their effects on GMS in young populations with ID.

2.3.1 Fundamental Motor Skills and Intellectual Disabilities

Children with ID tend to be behind in their motor development compared to the standards of typically developing children (Hogan et al., 2000; Pellegrino, 2007). Studies in this regard reported difficulties in reaching motor milestones at predictable rates having 1) quantitative (e.g., Wuang et al., 2008; Zhang & Chen, 2004) and 2) qualitative delays (e.g., DiRocco et al.,1987; Westendorp et al., 2011). Payne and Isaacs (2012) defined *motor delay* in children as “following a normal course of motor development but at a level that is below expectations for the child’s age” (p. 449). Burton and Miller (1998) pointed out that the qualitative descriptors of motor performance refer to the components of the skill (e.g., movement form or pattern) and quantitative focus in the products (e.g., distance or time). For example, running and moving the arms in opposition to the legs is a qualitative component, and the time someone runs 400 meters is a quantitative product.

Existing research indicates a correlation between GMS delays and the degree of ID severity (e.g., Vuijk et al., 2010; Westendorp et al., 2011; Wuang et al., 2008). Individuals with a more severe ID level exhibit more significant motor delays than those with a lower ID level. This is attributed to cognitive and perceptual difficulties (e.g., attention, obtaining and processing environment information, planning and selecting a movement) in executing accurate and/or fast motor function responses compared to the quantitative and qualitative standards of typically developing children (Kurtz, 2007; Payne & Isaacs, 2012; Pellegrino, 2007; Schmidt & Wrisberg, 2008).

For a better illustration of the GMS difficulties in this population and its relationship with ID severity, and according to the interests of the present research, will be shown below studies that consider GMS of children with mild ID with non-specific etiology (non-syndromic, without atypical neurological development) (For more details of the participants, see section 4.2.1). The motor proficiency of children with ID is typically assessed with standardized motor assessment tools as a reliable and valid first step in identifying motor differences according to the age norms. The limited studies in this population have used tools that differ - among other things - in their items to evaluate (in GMS or both fine and gross). These are some of the most used movement assessment tools that will be cited in the studies below:

1) Test of Gross Motor Development (TGMD, TGMD-2) (Ulrich, 1985, 2000). Includes two sub-tests: locomotion skills (running, leaping, horizontal jumping, galloping, hopping, and sliding) and object control skills (striking a stationary ball, kicking, stationary dribbling, catching, overhand throwing, and underhand rolling).
2) Bruininks-Oseretsky Test of Motor Proficiency (BOTMP; BOT-2) (Bruininks, 1978; Bruininks & Bruininks, 2005). Includes two composites: A gross motor composite (balance, running speed and agility, strength and bilateral coordination) and a fine motor composite (response speed and upper-limb speed, visual-motor control and dexterity) (Wuang et al., 2008).

3) Movement Assessment Battery for Children (MABC; MABC-2) (Henderson & Sugden, 1992; Henderson et al., 2007). Include three categories: manual dexterity skills, ball skills, and balance skills.

4) Peabody developmental motor scales (PDMS, PDMS-2) (Folio & Fewell, 1983, 2000). Includes four gross motor performance subtests (reflexes, locomotion, stationary performances, object manipulation) and two fine motor performance subtests (visual-motor integration, grasping) (Cools et al., 2009).

Using the MABC, Vuijk et al. (2010) compared the motor skills performance in children with mild and borderline ID with typically developing children. The results showed that 81.8% of the children with mild ID and 60.0% with borderline ID performed below the total score compared to their peers with typical development. In the specific gross motor elements, children with mild ID (n: 55; 7-12 years old) showed borderline or definite motor problems in the ball skills (catching a moving object and aiming at a goal) and balance subscales (static balance, dynamic balance while moving fast and slowly) compared to normative standardized scores. The authors pointed out a relationship between the degree of ID and motor performance. Similar results were obtained by Wuang et al. (2008) with 233 children with mild ID aged between 7 and 8 years of age, in which they compared the motor performance results between BOTMP and PDMS-2 tests. The IQ was significantly associated with overall motor performance in both tests. In the gross motor composite, outcomes reflected an impaired range significantly higher on the BOTMP than in the PDMS-2 (52% and 4%, respectively).

The TGMD-2 is one of the most often tests used to evaluate gross motor performances in a population with ID. Besides, it was the GMS test used in this study because it is frequently utilized in sports sciences, has standardized and criterion-referenced movement patterns, and has been proven to be an appropriate tool for assessing children with mild ID (Simons et al., 2008). For instance, Frey and Chow (2006) studied the GMS of 244 youths with mild ID aged between 6 and 18 years old using the TGMD-2. The motor outcomes placed the sample of children with mild ID in the very poor performance category. Westendorp et al. (2011) made a comparison between the gross motor performance of children with mild ID (n: 68), with borderline ID (n:88), and with typically developing children (n:255) ages between 7–12 years. Children with ID scored significantly lower than the typically developing children on almost all TGMD-2 gross motor skill items. Besides, the children with mild ID had significantly lower scores than those with borderline ID in the locomotor subtest (particularly in leap, horizontal jump, and slide).

Moreover, using the same measurement tool, Rintala and Loovis (2013) examined differences in GMS of 20 children with mild ID and 20 typically developing children aged 7-11. The results showed that children with mild ID performed significantly lower than the control group achieving 0% mastery (achievement of all criteria) on five items (locomotor: hop, leap, and horizontal jump; object control: striking a stationary ball and underhand roll). The highest mastery percentage was shown by 20% of the children in three items (locomotor: running, sliding; object control: catching). Overall, in the literature review made for this research (Mero Piedra, 2020a), all the groups with young populations with mild ID with non-specific etiology scored below the average in comparison with the normative standardized tool scores of the TGMD-2 or typically developing group (Frey & Chow, 2006; Hartman et al., 2010; Rintala & Loovis, 2013; Simons et al., 2008; Westendorp et al., 2011). The effect sizes for locomotion and object control subtests were medium to large.

The findings presented indicate that children with mild ID encounter significant difficulties in the development of their fundamental motor skills, as compared to typical standards, irrespective of the movement assessment tool employed. Furthermore, outcomes indicate that when a cohort of participants with borderline ID was also examined, there was a notably lower performance among both groups in ID in comparison to typically developing children. However, the disparities between children with milder forms of ID and typical standards were comparatively smaller. These observations underscore the role of cognitive functioning in children's motor skills development, revealing a correlation between the degree of ID severity and motor performance.

In this sense, Payne and Issacs (2012) highlighted that cognition plays an important role when performing a voluntary movement because different cognitive processes are needed for learning, planning, decision-making, performing, and adjusting motor movements. In addition, the authors point out that the perceptual abilities to sensory perceive and process information from the environment are also essential for motor performance. Let us not forget that it was previously mentioned that motor skills find support for their development in perceptual abilities such as visual perception

(Falcón & Rivero, 2010). The above are essential factors to understanding the overall difficulty in reaching the GMS performance of the population with ID compared to typical standards due to challenges in these areas that characterize the persons with ID such as limitations in general mental abilities such as learning rapidly, planning, perceiving and processing new information and problem-solving.

Aligned with these results are the findings suggesting that although the motor delays in children with ID can already be seen at the age of two (APA, 2021), there is a tendency of further increases with age (Zhang & Chen, 2004). This means that with chronological age the differences in performance between children with ID and typical development increase. The increment in the complexity of the cognitive demand for the execution of motor movements over the years could explain this phenomenon (Wall, 2004). For example, the motor movements promoted in physical education classes for high school youth often require greater coordination and/or strategy compared to elementary school classes. This makes the gap between both groups, the young population with ID and those with typical development, become more pronounced with age.

Regarding the motor delays, it is worth emphasizing that Payne and Isaacs (2012) point out that despite the differences between children with and without ID in their motor performance, children with mild ID may eventually catch up to peers with development and therapy. Basically, because these children do not present an apparent neurological or physical disability and the differences are attributed to a delay in motor development and not to a deficit. This motor delay may also be associated with other disabilities such as autistic spectrum disorder (ASD) or attention deficit hyperactivity disorder (ADHD). Unlike motor delays, a motor deficit indicates a specific developmental pattern deviation from the typical standard (Staples & Reid, 2010, p. 210). In contrast to children with motor delays, children with motor deficits will not be able to catch up to their peers, and in many cases, as a measure of compensation for its deficit, they will possess different movement patterns (Pellegrino, 2007). Motor deficits are associated with disorders such as cerebral palsy or physical disability (e.g., limb amputations) (Payne & Isaacs, 2012).

Cerebral palsy, for example, is a group of neurological disorders caused by a non-progressive lesion or abnormal development of the motor-control areas of the brain (Sadowska et al., 2020). The above is translated into deficits in controlling and coordinating the movements and muscles, maintaining balance and posture, among others (Patel et al., 2020; Sadowska et al., 2020). Additionally, ID is a frequently observed coexisting condition in individuals with cerebral palsy (40-65% of the population with Cerebral palsy) (Sadowska et al., 2020). However, when we consider the group of people with mild ID with non-specific etiology (non-syndromic), there is no damage or abnormal development in the brain nor physical/muscular problems. Instead, it is believed that the delay in their motor development is best attributed to the typical cognitive and perceptual difficulties of the population with ID, as mentioned above (Payne & Issacs, 2012).

2.3.2 Physical Activity Programs on GMS in Young Populations with Intellectual Disabilities

Taking into account the importance of the development of GMS for its role in general movement competence and the acquisition of more complex motor skills (Stodden et al., 2008), and considering the difficulties of children with ID in reaching the GMS milestones at predictable rates in comparison with the typically developed population (e.g., DiRocco et al.,1987; Westendorp et al., 2011; Wuang et al., 2008; Zhang & Chen, 2004), the quality research on physical activity programs analyzing the effectiveness on GMS are surprisingly limited.

Maïano et al. (2019) and St. John et al. (2020) conducted systematic reviews on the effectiveness of motor skill interventions on populations with ID, but with slightly different focuses. Maïano et al. (2019) reviewed 14 studies that examined the effects of motor skill interventions on fundamental motor skills in young populations with ID (mainly mild severity of the ID), finding that regular physical activity lasting from 6 weeks to 1 ½ years can promote robust enhancements in balance skills and overall fundamental motor skills. Whereas St. John et al. (2020) aimed to study the effectiveness of physical activity interventions in populations with ID on physical and mental outcomes, including 18 studies mainly focused on balance skills and physical fitness (e.g., body composition, muscular strength, aerobic capacity, and flexibility). Results showed modest evidence of improvements in some physical fitness parameters but were inconclusive. This systematic review also included five studies with psychological outcomes detailed later in the section (see section 2.5).

Overall, both systematic reviews incorporated quality studies based on experimental designs and minimized confounding data that could negatively affect the results (e.g., assessment of the risk of bias, standardized motor assessment tools, and quality assessment). In this sense, the authors strongly emphasized the need for more and better-quality research on physical education interventions in this population. Additionally, both systematic reviews highlighted the importance of further research to understand the effects of specific GMS in populations with ID, due to none of the included studies focused on examining specific locomotor and object control motor skills in this population, leaving the effectiveness of interventions on these specific skills unclear.

Fortunately, more recent research already focuses on this need highlighted in the literature. For instance, Capio and Eguia's (2021) and Ketcheson et al. (2021) studies aimed to improve specific GMS of children with ID but had different methodologies and outcomes. Capio and Eguia's (2021) implemented an eight-week training program (once a week) for ten children with ID (from mild to moderate ID) to verify the effectiveness of the error-reduced motor learning approach. In training, the children practiced six object control skills (overhand throwing, underhand rolling, catching, kicking, dribbling, and striking), and the coach ensured that errors during practice were minimized with measures such as difficulty adaptation so that the child learns from the simplest to the most complex. Comparing results with the control group, children in the training program showed significant benefits in TGMD-3 (Ulrich, 2019) outcomes from this methodological teaching strategy for object control skills acquisition.

Another example of research on the motor learning approach in children with ID (unspecified ID severity) is the 10-week (once-a-week) intervention in Ketcheson et al. (2021) pilot study. A physical activity program with 24 participants aimed to explore the Classroom Pivotal Response Teaching methodology (Stahmer et al., 2011) designed to guide special education teachers with strategies such as enhancing children's motivation in learning. However, results showed no significant improvement in the motor skills assessed by the TGMD-3. Both studies aimed to explore the effectiveness of GMS learning approaches and methodologies. However, while Capio and Eguia's (2021) study found significant GMS benefits, Ketcheson et al.'s (2021) pilot study did not. The difference in these results may be due to a limitation in Ketcheson et al.'s (2021), which was the lack of a control group, which raises questions about the reliability of the findings. Nevertheless, these studies demonstrate the importance of further research in developing effective motor learning approaches and detecting the best techniques for teaching GMS children with ID.

Overall, these studies are encouraging evidence of the current interest in this topic; however, more research is still needed. Especially with physical activity interventions aimed at studying different physical education contents with more varied and global activities (not merely adapted direct instruction of how to perform the skill) to promote the development of GMS. The above is aligned with the current educational reality in the field of physical education, which in the case of the Ecuadorian context, encourages the integration of different blocks of content seeking an integral development of children and achieving meaningful learning.

Finally, we can summarize this part of the theoretical background by highlighting the importance of physical education as a school subject that has the potential to be an agent of general development (physical, social, affective, and cognitive areas) and provides the entry point towards practicing physical activity throughout life. This research focused on children with ID, a heterogeneous population with large individual differences that show difficulties in general mental abilities that affect their intellectual and adaptive functioning in daily life activities. Besides, studies have shown that their GMS performance is behind compared to typically developing control groups and the normative standardized tool scores. Literature with this regard attributes the cognitive development and perceptual abilities of children with ID as responsible for these motor delays suggesting that children may present motor delays because of problems with receiving and processing necessary information to carry out typical motor functioning (Payne & Issacs, 2012). However, it is suggested that some children with mild ID may catch up with their peers' motor performance through maturation and appropriate interventions. With this background, early and adapted intervention seems essential for improving motor skills. Nevertheless, physical activity intervention research focused on GMS development in children with ID is very limited and with mixed results. Therefore, the present study aimed to implement a physical education program based on playful practices for children with mild ID in an attempt to mitigate the above-mentioned motor delays and determine whether the intervention has an effect on the children's cognitive control functions. Consequently, in the next section, the cognitive control construct will be addressed in order to provide a better understanding of its implications in this study.

2.4 THE HUMAN CAPACITY FOR COGNITIVE CONTROL

Cognitive control is one of the cognitive processes essential to human healthy autonomous functioning (Medaglia, 2019). Over the years, it has been defined in different ways in diverse scientific contexts that can lead to semantic ambiguity. For instance, cognitive control is frequently called executive functions or executive control (Diamond, 2013) and refers to capacities of control processes such as attention, inhibition of impulses, and task switching (Davidson et al., 2006). Shenhav et al. (2013) defined it as the set of mental mechanisms required to pursue an individual's current goals. Below are other definitions to illustrate the variances through the years (Table 1):

Table 1. *Examples of cognitive control definitions*

Author/s	Definition
Botvinick, Braver, Barch, Carter and Cohen (2001, p. 624)	Cognitive control are the human cognitive processes behind the: "Ability to configure itself for the performance of specific tasks through appropriate adjustments in perceptual selection, response biasing, and the on-line maintenance of contextual information"
Rougier, Noelle, Braver, Cohen and O'Reilly (2005, p. 7338)	"Cognitive control: the ability to behave in accord with rules, goals, or intentions, even when this runs counter to reflexive or otherwise highly compelling competing responses (e.g., the ability to keep typing rather than scratch a mosquito bite)"
Braver (2012, p. 106)	"Cognitive control: the ability to regulate, coordinate, and sequence thoughts and actions in accordance with internally maintained behavioral goals"
Snyder, Miyake and Hankin (2015, p. 1)	Executive function "is comprised of a set of cognitive control processes, mainly supported by the prefrontal cortex (PFC), which regulate lower level processes (e.g., perception, motor responses) and thereby enable self-regulation and self-directed behavior toward a goal, allowing us to break out of habits, make decisions and evaluate risks, plan for the future, prioritize and sequence our actions, and cope with novel situations"

Botvinick and Braver (2015, p. 84)	“The set of superordinate cognitive functions that encode and maintain a representation of the current task, marshaling to the task subordinate functions including working, semantic, and episodic memory; perceptual attention; and action selection and inhibition.”
Cohen (2017, p. 3)	“Cognitive control refers to the ability to pursue goal-directed behaviour, in the face of otherwise more habitual or immediately compelling behaviours. This ability is engaged by every faculty that distinguishes human abilities from those of other species, and in virtually every domain of human function from perception to action, decision making to planning, and problem solving to language processing”

It can be observed that an important difference in the definitions of cognitive control is that some describe it as a set of processes, functions or mechanisms (e.g., Botvinick & Braver, 2015; Shenhav et al., 2013; Synder et al., 2015) and others as an ability (e.g., Braver, 2012; Cohen, 2017; Rougier et al., 2005). Considering cognitive control as an ability allows us to have the notion of a logical cognitive assembly within which there could be coordination, regulation and/or interaction among its underlying mechanisms. For its worldwide acceptance, novelty, and prestige in the field, the integrated definition of cognitive control by Cohen (2017) is considered for the current study.

Cohen's (2017) definition highlights the human cognitive control ability that enables us to behave towards a goal despite the existence of more automatic or alluring alternatives. Schneider and Shiffrin (1977) pointed out that the difference between automatic and controlled cognitive processing is that the first one is based on the activation of a learned sequence in long-term memory, and the second is a temporary activation of a sequence that can be quickly configured but involves other requirements like attention. The authors also mentioned that the automatic processes are faster than those controlled; the latter compete with automatic processes for which they can present interference and depend on a central mechanism (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). Besides, controlled processes with practice could become automatic; this denotes continuity and is based on the association between responses and stimuli. In this regard, Cohen (2017) emphasized that the distinction between controlled and automatic processing (Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977) gave the first steps to the operationalization of the cognitive control construct becoming a significant part of experimental research.

Cognitive control has been associated in the literature with several areas which highlight its importance in our life as human beings (Diamond, 2013). For instance, research has shown that cognitive control is relevant in health-related quality of life (e.g., mobility and self-care) (David et al., 2010), mental health (e.g., depression) (Tavares et al., 2007), physical health risk factors (e.g., nutrition) (Riggs et al., 2010), school readiness and success (e.g., science, math, and literacy outcomes) (Nayfeld et al., 2013), professional success (Bailey, 2007), individual and social problems (e.g., impulsive aggression) (Denson et al., 2011), and addictions (Baler & Volkow, 2006), among others. Further, it has an essential role in pursuing goal-directed motor behavior on motor skill acquisition, which is related to the present study (Fitts & Posner, 1967) (see section 2.5).

In the case of people with ID, on whom this study focuses, the research highlights that they begin to show difficulties in cognitive control from an early age (e.g., Danielsson et al., 2012; Lanfranchi et al., 2010) and their cognitive weaknesses have also been associated with challenges in social behavior (Japundza-Milisavljevic et al., 2010), academic performance (Kirk et al., 2017), independent functioning and language (Gligorović & Buha-Đurović, 2014). Furthermore, these difficulties in cognitive control are reflected in low performance in underlying cognitive abilities, such as cognitive flexibility, inhibitory control, and attention. These cognitive notions will be defined in the following sections, explaining their relevance and presenting studies in populations with ID.

2.4.1 Cognitive Flexibility in Individuals with Intellectual Disabilities

One of the main characteristics of human cognitive control is its flexibility. Cognitive flexibility is the capacity to quickly reconfigure our cognitive system in response to changing situations and internal demands and execute apparently unlimitedly different behaviors (Braver et al., 2009; Cohen, 2017; Meiran et al., 2015). Thanks to cognitive flexibility, for example, we can generate alternative responses to solve a problem, understand a situation from another person's point of view, or think outside the box (Diamond, 2013). Cognitive flexibility can be correlated with most of the concepts of cognitive control presented (Table 1) since it seems essential not only to understand what the cognitive control mechanisms are but to achieve, for instance, the appropriate cognitive adjustments and coordination according to the needs of the new situation or goal. Cognitive flexibility (also called set-shifting or mental set shifting [Diamond, 2013] in the literature) is the reason why human beings can carry out new tasks with little or even without any experience and switch between chores.

Miller and Cohen (2001) mention that throughout our lives, we are getting more and richer information from the outside world; consequently, we have a large number of behavioral options and actions that produce levels of interference and cognitive confusion. To reduce the latter, cognitive flexibility involves internal processes to achieve the goal using mechanisms such as attention and decision-making. Furthermore, Cohen (2017) points out functional requirements that cognitive flexibility capacity must satisfy in order to reconfigure our cognitive system, for instance, the a) ability to update the contents in working memory according to the contextual changes and b) the selection of relevant representations that need to be activated to perform the given task.

Among the family of tasks used to study cognitive flexibility within the cognitive control framework, the task-switching paradigm is an important tool including recurrent switches back and forth between tasks or rules (Diamond, 2013; Vandierendonck et al., 2010). One of the widely used tasks in this paradigm is probably the Dimensional Change Card Sort task (DCCS) from Zelazo (2006), in which children are required to sort a series of bivalent stimuli, switching according to different dimensions (e.g., the first color and then shape). Typically, three-year-old children can sort the stimuli based on a single dimension, and five-year-old children can sort stimuli in a first and a second dimension as well. The more challenging version may be used with seven-year-old children (Zelazo, 2006). With this background, and because this task can be used with children across a wide range of ages, a version of the computer-based adaptation of the DCCS was used in this study.

The DCCS task also allows us to analyze other factors such as switching and mixing costs. In task-switching studies, the switching cost refers to the reaction time performance difference between switch and non-switch (stay) trials within mixed blocks conditions (Rogers & Monsell, 1995; Wylie & Allport, 2000). Mixing costs, on the other hand, refers to the reaction time performance difference between non-switch (stay) trials in single blocks and mixed blocks conditions (Strobach et al., 2012; more details in section 4.3.3.2.). In task-switching circumstances, representations of defined task sets must be acquired and adequately retrieved depending on the goal (i.e., task-relevant representations) (Kessler & Oberauer, 2014).

In this sense, the literature points out there is a mensurable temporal cost underlying cognitive flexibility related to the effort needed to perform a task and associated with the person's motivation (Cohen, 2017; Miyake et al., 2000). Therefore, in other words, these parameters are inversely proportional; the greater the level of cognitive flexibility capacity, the smaller the switching and mixing costs (Monsell, 2003).

Research has shown that people with ID experience significant difficulties in cognitive flexibility abilities, although studies are limited and with very mixed results. A critical factor of the diverse outcomes is methodological differences in the studies, for example, in the inclusion and exclusion criteria of participants with ID related to the underlying cause of the ID. One approach is to study a mixed population with ID, regardless of other syndromes or diagnoses, such as autism spectrum disorder. Another involves studying individuals with ID-associated syndromes, such as Down syndrome or Williams syndrome. Besides, there is a lack of research on individuals with ID who do not have a specifically associated syndrome or atypical neurological development.

For example, evidence from Palmqvist et al. (2020) study with seventy-one adolescents with mild to moderate ID of mixed etiology and with other diagnoses (e.g., autism spectrum disorder or attention deficit hyperactivity disorder), showed that the young population with ID performed significantly lower than the typically developing chronological age-matched group, but not significantly different from the mental age-matched control group. Similar results were obtained by Danielsson et al. (2012) with a group of twenty-two children with ID (the authors did not specify the etiology). The performance levels of children with ID were significantly lower compared to a chronological age-matched group in verbal and non-verbal switching tasks, but there were no significant differences concerning the mental age group comparisons.

Based on these results, the young population with ID may experience a comparable progression of cognitive flexibility development to their typically developing peers, albeit at a lower level than expected for their chronological age, but in line with their mental age. It is also possible that these findings are due to children and adolescents with ID relying on their switching abilities more frequently than their typically developing peers because of their restricted working memory capacity, as noted by

Danielsson et al. (2012). According to Baddeley et al. (2011, p. 1393), working memory can be described as a comprehensive processes network encompassing the information temporary retention and manipulation, all in support of carrying out complex cognitive tasks. Burack et al. (2012) highlighted the importance of considering different factors, such as social abilities and life experiences, when comparing groups of persons with ID by mental age with typically developing groups. Additionally, we must consider the limitation of both studies in which participants with mixed or not specified etiology were included; this very heterogeneous population prevents us from understanding possible cognitive flexibility pattern differences.

Studies involving individuals with ID-associated syndromes have shown significant differences compared to typically developing control groups matched for mental age. In Hooper et al. (2008) study, for instance, fifty-four boys with Fragile X syndrome (7 to 13 years old) showed significant difficulties in cognitive flexibility, among other cognitive abilities, compared to a typical development mental age-matched group. Similarly, Lanfranchi et al. (2010) research outcomes from fifty-five adolescents with Down Syndrome showed significant difficulties in the set-shifting task, also among other cognitive abilities, compared with a mental age-matched typical development group.

These mixed results might be due to a distinct cognitive pattern of development and not a mere developmental delay (Hooper et al., 2008). Cognitive flexibility development may depend more on other factors in young individuals with inherited genetic syndromes associated with ID than mental age. In this sense, there is a significant association between the above-mentioned syndromes and the presence of a wide range of other prevalent traits. For instance, Fragile X syndrome is not only associated with ID but also with autism spectrum disorder (Hagerman et al., 2017). Thus, mental age could influence performance outcomes to a certain extent, beyond which other factors related to the Fragile X syndrome may also play a significant role. In addition, medication could have an impact on the results. In the study by Hooper et al. (2008), for example, the authors point out that a high number of participants with Fragile X syndrome were taking medication (e.g., stimulants, antipsychotics), a situation that was not described in the previous studies presented with participants with ID with mixed or not specified etiology. The above is in line with Memisevic’s and Sinanovic's (2014) study, in which the authors examined the difference in cognitive control functions in relation to the etiology (Down syndrome, other genetic cause or organic brain injury, and children with unknown etiology), sex (54 boys and 36 girls) and severity of the ID (mild and moderate) of a young population with ID between 7 and 15 years old. Results showed that the severity of the ID had a significant effect on cognitive control, and the only cognitive function with a statistical difference concerning the etiology of the participants was cognitive flexibility.

The literature also suggests that the shifting abilities profile depends not only on the etiology of the ID but also on the domain component of the task with distinctive syndrome-specific cognitive development. For instance, Menghini et al. (2010) studied fifteen persons with Williams syndrome (mean chronological age: 19.11, mean mental age: 6.10) and showed results not significantly different in their shifting performances when relying on verbal materials compared to mental age-matched typically developing children. However, performance was significantly lower when non-verbal stimuli had to be processed. Costanzo et al. (2013) performed a comparative study in which fifteen participants (children, adolescents, and adults) with Down Syndrome performed lower than fifteen participants with Williams Syndrome on verbal shifting. Results were not significantly different between the individuals with Williams Syndrome and mental age-matched typically developing children.

In both studies, participants with Williams syndrome had a similar performance to the mental age-matched typically developing children in tasks relying on verbal materials suggesting that the participants did not have difficulties in this task modality. Methodological differences in cognitive flexibility tasks might give us insight into specific information-processing difficulties in different populations. Results might also be related to the participant's life experiences because it is expected that children with a mean chronological age of 19.11, as in our first example (Menghini et al., 2010), have had more prolonged exposure to life situations to develop verbal skills than children with a mean chronological age of 6.10, which could facilitate the execution of tasks with verbal demands. The above findings prompt an analysis of whether the tasks utilized are at suitable difficulty levels for individuals with ID. In our examples with participants with Williams syndrome, non-verbal difficulties may have impacted the outcomes and hindered our ability to evaluate cognitive ability accurately. In another example previously mentioned, Hooper et al. (2008) detailed that only 24.9% of participants with Fragile X syndrome were able to complete the cognitive flexibility task. The aforementioned underscores the necessity to scrutinize the suitability of the assessment tools employed in research involving individuals with disabilities to ensure their appropriateness for this cohort.

The studies mentioned above evidenced the heterogeneous nature of the population with ID with different cognitive flexibility developmental trajectories, which might depend on factors such as the etiology of ID, the domain component of the tasks, type of control groups (chronological or age-matched), life experiences, among others. Overall, evidence suggests that the young population with ID has significant difficulties in cognitive flexibility that in some cases go beyond their established mental age compared with typical development mental age-matched groups. However, it is important to consider that the disparity of the findings could be due to some studies including participants with a large range of chronological ages, large range of intelligence quotient (IQ), different ID severities diagnoses or tasks that may not be appropriate for participants with ID. More quality studies are needed to a better understanding of these outcomes, particularly with persons with ID with non-specific etiology (non-syndromic, without atypical neurological development nor syndrome).

Although cognitive flexibility is separated by definition from other cognitive control constructs, it is important to highlight that it is built on and requires other cognitive abilities that are acquired and improved during child development and that. decline during aging (Diamond, 2013; Miyake et al., 2000). For instance, in the DCCS task, inhibitory control and attentional processes are necessary to suppress irrelevant/unnecessary information in switching between sorting tasks according to the different dimensions (e.g., color or shape).

2.4.2 Inhibitory Control Functions in Individuals with Intellectual Disabilities

Inhibitory control is the essential cognitive ability to suppress responses no longer relevant to pursuing the goal. It implies the ability of an individual to override an intrinsic predisposition or extrinsic distraction with the control of their own behavior, attention, emotions, and thoughts (Diamond, 2013). Inhibition allows us to maintain focused selective attention (Malagoli & Usai, 2015) and allows us to change and choose by willfully suppressing or countermanding responses that are unimportant to pursuing our goal and selecting more appropriate and consistent ones without being merely creatures whose actions and thoughts are only the result of impulses, habits, or stimuli of the environment, which are called conditioned responses (Diamond, 2013). For example, a young student in the classroom may need to inhibit attending distractions of another classmate while he attends to the teacher, control a habitual response of scratching a wound when the doctor has recommended it (itchiness is a normal part of the healing), or wait for his turn to play on the swing. All these actions show inhibitory control and are difficult to master at an early age (Diamond, 2013).

Inhibitory control has an influence on the general intellectual functioning (Cassotti et al., 2016; Dempster, 1991; Mason & Zaccoletti, 2021) and also in the adaptive behavior in daily life activities in children (Eisenberg et al., 2007); both parameters are essential when defining the characteristics of ID (APA, 2013). For instance, Gligorović and Buha Đurović (2014) studied the relationship between inhibitory control and adaptive behavior in fifty-three children with mild ID between 10-14 years old (without neurological impairment or genetic problems). Results showed a significant relationship between inhibitory control and adaptive behavior domains related to conceptual and practical adaptive skills. Inhibitory control abilities predicted speech and language development outcomes, economic activity, independent functioning, and number and times domains. Inhibitory control ability is crucial in modifying and adjusting our behavior in various daily life scenarios by restraining inappropriate or unwanted behavior (Gligorović & Buha Đurović, 2014). As an illustration, independent functioning is closely linked to autonomy and means making our own life choices and controlling our daily routines (Ioanna, 2020). One essential aspect of promoting healthy independent living is maintaining good hygiene, nutrition, and personal care. Adaptive eating habits, for instance, rely on the interplay of motivational factors, such as experiencing hunger, and the inhibitory ability to control our eating behaviors to resist daily the allure of high-calorie, easily available unhealthy foods (Bartholdy et al., 2016).

Therefore, it is not so surprising that previous studies aimed to investigate inhibitory control in individuals with ID reported significant difficulties compared to the control groups. However, they also showed some inconsistent results that are difficult to compare, probably because of the different types of inhibitory tasks used. In this regard, it is crucial to consider that inhibitory control is not currently postulated as a unitary construct. Instead, it is a family of functions that include different dimensions that can also be performed in different types of tasks (Friedman & Miyake, 2004; Nigg, 2000). Therefore, this study is aligned with the theoretical frame from Friedman and Miyake's work (2004), in which three primary inhibition-related functions are distinguished:

prepotent response inhibition, resistance to distractor interference, and resistance to proactive interference.

Inhibition of a prepotent response, also called response inhibition, is the ability defined as the capacity to actively suppress an ongoing, habitual, or dominant behavior that is no longer relevant to pursue the goal (Friedman & Miyake, 2004, p. 104). This type of inhibitory control is often measured using tasks such as the Stroop (Stroop, 1935) or the Go/no-go. The first one is a verbal task in which participants are required to suppress the habitual tendency of reading words and verbally state as quickly as possible the color in which those words are written or printed; these include color and neutral words. The Go/no-go task includes both verbal and nonverbal versions, where participants are required to respond to "go" stimuli and make no response to "no-go" stimuli. Most studies focused on examining the inhibitory control ability in persons with ID are carried out with participants with common associated genetic syndromes, such as Down and William Syndromes. Costanzo et al. (2013), for example, performed a comparison study between individuals with Williams syndrome (n:15), Down syndrome (n:15), and mental-age matched typically developing individuals (n:16). A difference between groups occurred in the Stroop task; participants with Down Syndrome performed lower in this verbal modality than those with William syndrome and the typically developing group. The results of the latter groups did not differ significantly. In contrast, significant differences among the three groups did not appear when analyzing the Go/no-go task (Van der Meere et al., 2005), showing general preservation in inhibition of a prepotent response in the visual modality.

Interestingly, Traverso et al. (2018) partially support these results from the Go/No-Go task with their comparative study between participants with Down Syndrome (n:32, mean age: 14.33 years old), five-years-old (n:35, mean age: 5.5 years old) and six-years-old (n:30, mean age:6.2 years old) typically developing children. Outcomes from the Go/No-Go task showed no differences between the participants with Down Syndrome and the five-years-old group. Nevertheless, the 6-years old group performed significantly better than the other two groups. These results highlighted how inhibition of a prepotent response increases significantly during school transition. Additionally, the study focused on fifteen participants with William syndrome by Menghini et al. (2010) showed significant difficulties in both verbal and visual modalities of inhibition (Stroop and Go/no-go tasks) when performance was compared with typically developing children matched for mental age. The effect was mainly because of the number of errors rather than the reaction times, which showed this population's impulsive behavior.

Another of the inhibitory control functions described by Friedman and Miyake (2004) is resistance to distractor interference. It refers to the ability to resist being distracted by irrelevant external stimuli when performing a task. A typical task to assess this ability is the Eriksen flanker task (Eriksen & Eriksen, 1974), which requires that the participant selectively attends to the target stimuli positioned in the center while avoiding the irrelevant adjacent flanker stimuli distractors of the tasks. The original version asks the participants to press the right or left arrow key according to the targeted letter direction. Sometimes, the Stroop paradigm mentioned before is considered a task to study the effects of resistance to distractor interference in the literature. However, Friedman and Miyake clarified that the stimuli to be avoided are the dominant ones, therefore, can be used to assess the inhibition of a prepotent response.

Research suggests that resistance to distraction is also impaired in children and adults with ID showing increased distractor interference effects. Nevertheless, fewer previous studies have examined this inhibition component compared to the research on response inhibition. An example is aforementioned research by Traverso et al. (2018), in which, in addition to using the Go/No-Go task to analyze the inhibition of a prepotent response, they also included a flanker task (Fish flanker task, adapted from Ridderinkhof and van der Molen, 1995) to study the resistance to distractor interference ability. The results of the Fish flanker task were similar to the outcomes of the Go/No-Go task in terms of accuracy; the 6-years old typically developed children performed significantly better than the 14-year-old participants with Down Syndrome and the five-years-old typically developed group. However, there were no significant differences between the last two groups. On the contrary, when comparing reaction times, the group with Down Syndrome had higher response times than both control groups on the Flanker task. Nevertheless, it is worth emphasizing that some of the limitations of this study are that the severity of the ID of the participants with Down syndrome is not specified, and it is not clear if at least one of the control groups was an aged-matched group.

In an interesting study, Bexkens et al. (2014b) aimed to investigate the contributions of ID (mild to borderline) and behavior disorder to interference control difficulties in adolescents. There is an estimated high prevalence of 25% of behavior disorders in populations with ID (Dekker & Koot, 2003), characterized for example, in a repetitive and persistent pattern of behavior when main age-appropriate social norms or rules are not met. Therefore, the authors were interested in verifying if this confounded disorder may have been contributing to the resistance to distractor interference challenges observed in the literature. Firstly, as expected, the outcomes showed significant difficulties on flanker interference control tasks compared to adolescents without ID matched by chronological age. Nevertheless, the authors found significant effects of the ID but not of the behavior disorder on flanker interference control, suggesting that the last two were not associated.

The third and last inhibitory control construct is resistance to proactive interference. According to Friedman and Miyake's work, it is the ability to resist the intrusion of memory traces from previously relevant information for the task that became irrelevant; therefore, it can obstruct the effective processing of the current target information to the task. The authors pointed out that this differs from the previous construct because on tasks requiring the resistance to distractor interference ability, the irrelevant interfering information is presented simultaneously with target information (p. 105). A good task example is the Cued recall task (Devenny et al., 2002; Tolan & Tehan, 1999), in which participants use prompts or cues to assist a semantical category retrieval on the most recent list of items. Retrieval refers to the means of accessing information stored in the memory (APA, 2021).

The cognitive profile of individuals with ID is known to be characterized by significant difficulties in this function as well. However, there is little evidence because resistance to proactive interference processes have not been studied widely. Moreover, as with the other two functions, the research has focused mostly on commonly associated genetic syndromes. For instance, Kittler et al. (2006) studied the verbal intrusion errors information from interfering with a simple items Cued Recall Test (Devenny et al., 2002). Twenty-three middle-aged participants with unspecified ID and forty-two with Down Syndrome matched on total IQ and receptive vocabulary skills were included in the study. The outcomes exhibited etiology pattern differences because participants with DS had significantly more intrusion errors than participants with an unspecified ID.

Finally, to better understand the inhibitory profile of the population with ID, we can mention two studies that include the different dimensions of this construct. First, Borella et al. (2013) research investigated whether persons with Down Syndrome have a general or specific difficulty in inhibitory control. They used one test for each inhibition function and included mental age-matched participants with typical development for comparison purposes. Findings indicated a generalized difficulty in inhibitory control among children with Down Syndrome. They showed significantly lower performance compared to the typical control group across all three inhibitory functions - prepotent response inhibition, resistance to distractor interference, and resistance to proactive interference. These results align with previous studies where challenges in cognitive control abilities beyond their mental age were observed in persons with ID with common associated genetic syndromes. In this sense, we must also consider the presence of other clinical features that could have significantly impacted the results. For instance, Down Syndrome is the predominant genetic origin of ID (Boat & Wu, 2015) and is associated with neurological problems and congenital heart defects, among other features (Asim et al., 2015). This suggests that other populations with ID with different etiologies, such as non-specific ID, could have other inhibitory control profiles. However, the studies in populations without associated syndromes are minimal, as highlighted previously.

Secondly, the meta-regression analysis of Bexkens et al. (2014a) aimed to assess inhibition significant difficulties in individuals with ID. The outcomes indicated medium to large inhibition-related difficulties in participants with ID. The authors used the taxonomy Nigg (2000) proposed, which includes three *executive inhibition functions* (behavioral inhibition, interference control, and cognitive inhibition). Nigg used the term *executive inhibition* functions to describe the processes of deliberate control or restraining responses in order to achieve higher-order goals. This classification is close to the later theoretical frame from Friedman and Miyake's work (2004). For example, the *behavioral inhibition* function described by Nigg (2000) is commonly measured by tasks as Go/No-go, as the *inhibition of a prepotent response* paradigm from Friedman and Miyake's work. The *interference control* function described by Nigg is usually measured by tasks such as Flanker tasks, as in the *resistance to distractor interference* paradigm from Friedman and Miyake's study. However, a significant difference is that Friedman and Miyake (2004) distinguished between simply suppressing of a prepotent response from inhibiting interfering internal representations (Visu-Petra et al., 2014). Another important difference is that Nigg (2000) proposed a *motivational inhibition* function that was also considered in Bexkens et al. (2014a) study, which includes an affective component in the tasks with motivational conditions like emotional Stroop tasks, in which two words categories are presented, either words with negative connotations or related to specific disorders (e.g., death, cancer, germs), or neutral words (e.g., table, bottle, auto), to study if persons are affected by emotional content (Ben-Haim et al., 2016). Bexkens et al. (2014a) meta-regression analysis study results showed that the difficulties were substantial in behavioral inhibition and interference control but not in the cognitive and motivational inhibition; in the lasts, the difficulties were not consistent. The effect size was not significantly influenced by either the mean IQ (in studies with participants with an IQ<70) or the age, but it was significantly moderated by the type of inhibition, suggesting that the inhibition functions may be associated with different underlying cognitive processes and that people with ID disabilities could have a distinct developmental pattern for the different functions of inhibitory control. However, regarding the age of the participants, we must consider the research limitation that from the twenty-six studies included, only three involved adults with ID, which prevents us from drawing general conclusions about this population.

We can conclude that the literature suggests that persons with ID experience challenges in different inhibitory control functions; however, it is observed that the majority of studies in this sense have been performed with participants with Down syndrome and Williams syndrome. Therefore, the lack of studies with participants with other types of etiologies, such as with non-specific ID, provided no clear picture of the different development trajectories, although it is recognized that they also experience these difficulties.

2.4.3 Attention Networks and Intellectual Disabilities

Attention is inevitably related to cognitive control due to its role in the controlled selection of some processes over others to achieve goal-oriented behavior (Cohen, 2017; Garon et al., 2008). Basically, this network priorities our brain's computational selections and resources, controlling internal and external information to be processed (Mackie et al., 2013; Posner & Fan, 2008). Attention is a complex, specialized network of interconnected mechanisms responsible for functions such as selecting information from different sensory events or maintaining an alert state (Bush et al., 2000; Posner & Fan, 2008).

Evidence suggests that the development of the ability to perform a wide variety of cognitive control tasks is related also to the development of attention, as it is an important network base for the development of more complex cognitive abilities with a modulatory role in information processing to achieve the goal of the task (Garon et al., 2008; Kane & Engle, 2000; Mackie et al., 2013). For instance, inhibitory functions have been associated with the attentional system to enhance the perception of target stimuli (Friedman & Miyake, 2004). Moreover, in the literature, cognitive control functions are often referred to or defined in terms of attention. For example, the task-switching paradigm for studying cognitive flexibility has also been referred to as attention switching (Miyake et al., 2000), and inhibitory control has been considered a set of attentional control processes (Borella et al., 2013).

Posner, Fan, and colleagues (Fan et al., 2009; Petersen & Posner, 2012; Posner & Fan, 2008) recognize three separate but somewhat interconnected attentional networks with different information processing functions and behavior control: alerting, orienting, and executive control. The alerting function is responsible for helping us to achieve and maintain an increased vigilance state to imminent incoming stimuli prior to a target event. This study focuses on the alerting function since its role in changing the state of cognitive readiness to perceive, process, and respond to an expected signal is essential for the performance of higher cognitive function tasks (Fan et al., 2003) such as inhibitory control and cognitive flexibility tasks. For example, the reaction time of a task might improve by a warning signal due to an increase in alerting attention (Petersen & Posner, 2012). Nevertheless, replacing the state of rest with a new state of vigilance is not an easy assignment since it implies sustaining attention over extended periods (Correia & Cohen, 2011).

The orienting network refers to the support mechanisms for selecting and prioritizing information among multiple sensory events (Fan et al., 2009; Petersen & Posner, 2012). Attentional orientation is usually associated with a spatial location that involves the movements of the head or eyes to a target and can be overt or covert. For example, a volleyball player looks up to detect where the ball is to make a pass (overtly) but also due to his peripheral vision, he can pay attention to the location of his teammates without actually moving his eyes or head to focus on them (covertly) (Fan et al., 2009; Worden, 2011). Lastly, the executive network of attention refers to a set of processes involved in detecting and resolving stimulus-response conflict situations in order to help other systems adapt under the current task demands, helping to control thoughts, feelings, or behaviors (Bush et al., 2000; Fan et al., 2009; Posner & Fan, 2008; Worden, 2011).

With all of the above, we can highlight the importance of attentional networks for integral development, particularly for developing more complex cognitive skills. The evidence has shown that persons with ID present attentional difficulties, and as with the cognitive control skills mentioned in previous sections, it has also been investigated primarily on participants with syndromes related to ID. For example, Menghini et al. (2010) observed attentional-related significant difficulties in verbal and visual-spatial modalities tasks in fifteen participants with Williams syndrome (mean chronological age: 19.11; mean mental age: 6.10) compared to a typically developing mental age-matched group. Lanfranchi et al. (2010) and Mento et al. (2019) also observed important attentional challenges in participants with Down syndrome in visual-spatial tasks. The first study with fifteen adolescents (mean chronological age: 15.2; mean mental age: 5.9) and the second with thirty children and adolescents (mean chronological age: 11.58; mean mental age: 5.59). On the other hand, in a comparative study of both syndromes, Costanzo et al. (2013) found some interesting similarities and differences, including fifteen participants with Williams Syndrome (mean chronological age: 17.6; mean mental age: 6.7), fifteen with Down syndrome (mean chronological age: 14.5; mean mental age: 6.2) and fifteen typically developed mental age-matched control group. Both groups with ID showed similar difficulties with sustained auditory attention (accuracy) and selective visual attention (time-per-target) compared to the control group. However, a different pattern was found in auditory selective attention and visual sustained attention because the two groups with ID did not demonstrate significant differences results (accuracy) from the typically developed group. Besides, the participants with Williams Syndrome had better individual results in sustained visual attention than the participants with Down Syndrome, but neither group with ID exhibited significantly different results in sustained visual attention compared to the control group.

Based on the findings of the studies presented, the outcomes are highly dependent on the domain component of the tasks. For example, individuals with Williams and Down syndrome exhibit delays in visual-spatial tasks compared to developing mental age-matched groups, but not in auditory selective attention tasks. However, when analyzing the attention functions in individuals with different inherited genetic syndromes associated with the ID, we must always consider, as mentioned before with the other cognitive functions, that there are factors that are commonly associated with some syndromes (e.g., autism spectrum disorder) that might have an impact in the results and are not considered in the majority of studies. We should always consider the heterogeneous nature of the population with ID when trying to draw conclusions, especially when comparing populations that are clearly different from the beginning (e.g., Williams Syndrome, Down syndrome, typically developing), as highlighted by Burack et al., 2012.

Finally, we can summarize and conclude by stressing the outstanding significance of cognitive control for human autonomous functioning and goal-directed behavior. Besides, it has been associated with integral development in different areas such as academic, school readiness and success (Nayfeld et al., 2013), professional success (Bailey, 2007), mental and physical health, and quality of life (Davis et al., 2010; Riggs et al., 2010; Tavares et al., 2007), among others. In the case of people with ID, on whom this study focuses, the literature emphasizes that they begin to show difficulties in cognitive control from an early age reflected in low performance in cognitive flexibility, inhibitory control, and attention. The meta-analysis of the current literature (26 studies from 1962–2020) performed by Spaniol and Danielsson (2022) to analyze the performances of these three cognitive control abilities in populations with ID (IQ $\leq$ 75) and the effect size moderators can help us to corroborate some conclusions from this section on cognitive control broadly. Firstly, the performance of attention, inhibition, and shifting of the groups with ID compared to age-matched control groups is statistically significantly lower. Secondly, there is great heterogeneity between the studies' effect sizes that could somewhat be explained by the ID etiology moderator (not by the cognitive control components).

The population with ID is a very heterogeneous group as a consequence of the wide range of etiologies and severities (mild-profound) of the ID raising many questions and mixed findings in the literature that require further research for resolution in the different developmental trajectories. In this sense, most research related to cognitive control has focused on people with syndromes associated with ID (e.g., Down syndrome, Williams syndrome). The studies with persons with ID with non-specific etiology (non-syndromic, without atypical neurological development) are even more scarce. Additionally, cognitive control research on people with ID commonly has a comparison with age-matched control groups. However, this approach has been criticized for not being enough due to it is based on the notion of a development delay without considering other factors such as motor abilities and lifelong experiences that make the groups basically different already (Burack et al., 2012). A straightforward example would be to compare a young person with ID with a chronological age of seventeen years old and a mental age of seven years old, with a seven-year-old child with typical development. The individual with ID has ten years of more positive and negative experiences, which may have a connotation in the cognitive control differences found between the groups, creating different weaknesses and strengths profiles.

However, the objective of the present study is not to examine the specificities of these cognitive control profiles in isolation rather provide a picture of the effectiveness of a physical education intervention on cognitive control functions and motor performance in children with mild ID with non-specific etiology by addressing some of the limitations of previous studies (See more in section 3). Therefore, the following section will provide an overview of the cognitive and motor relationship as described in the literature and will present correlational and experimental studies conducted with children with ID and other developmental trajectories.

2.5 AN OVERVIEW OF THE RELATION BETWEEN COGNITIVE AND MOTOR PERFORMANCE: STUDIES IN CHILDREN AND ADOLESCENTS WITH INTELLECTUAL DISABILITIES

It is recognized in the literature that motor learning requires cognitive processes to perform physical tasks. For example, Fitts and Posner (1967) highlighted the importance of cognitive processes in pursuing goal-directed motor behavior on motor skill acquisition. Adolph and Berger (2006) emphasized that motor behavior involves intrinsically psychological processes such as adaptability and flexibility to the limitations of the body and the environment. In fact, they considered that "motor behavior is the only way to translate mental activity into current activity" (p. 29) and pointed out that an essential basis and catalyst of general development is motor skill acquisition. Payne and Issacs (2012) stressed that cognition plays an important role when performing a voluntary movement because different cognitive processes are needed for learning, planning, decision-making, performing, and adjusting motor movements.

The cognitive and motor relation has had pronounced attention in the last decades, with evidence suggesting a positive association between the two (e.g., Afshari, 2012; Chirosa et al., 2016; Halperin et al., 2013; Hillman et al., 2014; Kamijo et al., 2011; Pesce et al., 2016; Razza et al., 2015). However, experimental studies that focus on the causal effects of these variables are still limited, and most of them have been carried out on populations with typical development (Fisher et al., 2011; Kamijo et al., 2011; Pesce et al., 2016).

A few comparative cross-sectional studies, such as the ones performed by Hartman et al. (2010) and Wuang et al. (2008), help us understand more about this relationship in populations with ID. Hartman et al. (2010) first compared the GMS and cognitive functions of children with borderline ID, children with mild ID, and chronological age-matched typical development children, and then, they investigated the associations between the motor and cognitive domains' performance. The TGMD-2 was used to assess locomotor and object control gross motor skills. The Tower of London task (Shallice, 1982) evaluated planning, problem-solving, and strategic decision-making cognitive abilities. According to the results, all children with ID had poor performance on cognitive and motor tasks compared to the typically developing children. These results are not surprising; finding significant differences by comparing populations with ID to typically developing populations using a matching system based on chronological age is not unexpected. This is a research methodology limitation (Burack et al., 2012) because the fundamental characteristics of the population with ID are not taken into account, given that this group is characterized by an atypical developmental trajectory translated into delayed in accomplishing milestones related to different domains, such as cognitive and motor, compared to the standards of typically developing children of the same chronological age (Davies et al., 2010).

However, Hartman et al. (2010) outcomes regarding the specific differences between the two groups with ID are interesting. Children with mild ID scored lower than participants with borderline ID in the locomotor skills, but there were no significant differences for the object control skills scores and the Tower of London scores. The literature suggests that object control skills are more complex and require more cognitive functioning than locomotor skills (Latash & Turvey, 1996; Westendorp et al., 2011). The cognitive and object control skills assessed in the study may have imposed high demands on both groups and perhaps with more sensitive tests developed considering the characteristics of different severities of people with ID, differences between groups could be reflected more clearly. In addition, it is important to consider how object control skills are typically developed in many societies. These skills, such as kicking a soccer ball or dribbling a basketball, typically occur within sporting and team environments, in contrast to locomotor skills like running or jumping. In this sense, Hartman et al. (2010) highlighted how this can have an impact on object control skills development and, therefore, on the results of their study since it is a population that tends to have less participation in this type of sports activities than the population with typical development. This also has a lot to do with the barriers to participation that individuals with ID encounter, such as limited options for extracurricular sports programs and a lack of inclusion and financial support (Bossink et al., 2017).

Finally, Hartman et al. (2010) found that the relation between motor and cognitive performance was positive and significant. Participants with the lowest motor scores also had lower cognitive performance scores and shorter reaction times; the reaction time of the cognitive task may be a mediator between the two domains. The authors suggest that this phenomenon may reflect difficulties inhibiting responses. Difficulties in inhibitory control processes could have impacted the performance by causing impulsive fast responses of the participants with ID that could compromise the accuracy, suggesting a speed-accuracy tradeoff typical in younger children (Davidson et al., 2006). At this point, it is also worth mentioning the study of Wuang et al. (2008) because their outcomes were close to those of Hartman et al. (2010). Wuang et al. (2008) studied the relationship between motor and cognitive performance of 223 children with mild ID between 7 and 8 years old. As expected, children with mild ID showed substantially low performances on all normative typical standardized test measures. Additionally, the study shows that total IQ significantly predicted overall motor performance, suggesting that motor learning requires cognitive processes that can be extrapolated to the intelligence quotient from standardized measurements. However, more research in this field is needed to understand this association.

Opportunely, in recent years experimental research has shown promising mental effects from physical activity interventions in people with ID. In this sense, St. John et al. (2020) performed a very interesting systematic review mentioned before (see section 2.3.2) to analyze the effects of physical activity interventions and include 18 quality studies based on experimental designs. However, only five included mental outcomes and were focused on adults with ID. Three studies included anxiety and depression measurements (Carraro & Gobbi, 2012, 2014; van Schijndel-Speet et al., 2014), and two assessed self-efficacy measurements (Marks et al., 2013; Melville et al., 2015). Results showed significant effects of physical interventions on the three mental assessments, especially in symptoms of anxiety and depression; however, outcomes were broad and imprecise. The authors emphasized the associations between mental health and physical exercise and the need for more quality research in this field.

In the literary review made for this research, only three studies (Fotiadou et al., 2020; Javan et al., 2014; Yılmaz & Soyer, 2018) examined the effects of physical activity interventions on the cognitive control functions in younger populations with ID (only studies on attention and inhibitory control but not on cognitive flexibility were found).

Javan et al. (2014) examined the impact of a three-month dance-oriented rhythmic movements and games program on attention among children and adolescents with mild ID (9-16 years old), finding benefits from the intervention in children's general attention performance and other attention networks such as the focus of attention, sustained attention, and shift of attention. Yılmaz and Soyer (2018) also focused their study on young participants with mild ID (7- 9 years old) and found a significant positive impact on self-regulation of a 24-weeks physical education intervention based on group play activities, including hand-eye and hand-foot coordination and rhythmic movements. Self-regulation is the process that allows us to control/regulate our emotions and thoughts and includes attentional and inhibitory control abilities (Diamond, 2013). Finally, Fotiadou et al. (2020) studied a 16-week psychomotor education program with children with moderate ID (8-12 years old) and found that the participants improved their performance in school behaviors associated with attention and inhibition. The program included static and dynamic balance motor activities while perceiving sensory stimuli (visual, audio, and tactile). For example, the intervention included exercises following the rhythm of the music and symbolic stories while performing the motor tasks. Nevertheless, outcomes from these three studies must be considered cautiously due to limitations in methodology, statistical analysis, and/or documentation. For example, in the statistical analysis, the authors (Fotiadou et al., 2020; Yılmaz & Soyer, 2018) did not perform controlling procedures for multiple outcomes comparisons using corrections (e.g., Bonferroni method), which increases the probability of finding significant false positive results (Vickerstaff et al., 2019). Another example is that the statistical analysis did not detect the intervention effects because differences between groups (intervention and control) were analyzed rather than the interaction between the variables (Fotiadou et al., 2020; Yılmaz & Soyer, 2018). However, these innovative studies show encouraging positive results and give us an inside of the nature of the physical activity interventions used with this population as a valuable starting point for this and future research. For example, some common factors are that the three studies included twenty young participants with ID (mild or moderate, none of the studies mention the etiology of ID) divided into the intervention and control group. The physical activity interventions were performed twice weekly (45 minutes/session) and offered variable practices, including music, symbolic stories, dancing, games and/or different sensory stimuli. This could substantially affect the participation and engagement in a physical education program of children with ID since they include motivational, emotional, and social elements, which could seem more exciting and attractive for them and could have influenced the positive results.

As reviewed above, cognitive control skills have not been experimentally studied in a physical activity intervention setting in participants with mild ID with non-specific etiology, to the author's knowledge, the population on which this study focuses. Therefore, peer-reviewed studies carried out with children with different developmental trajectories will also be briefly considered below to frame the theoretical approach on which this study has been built, considering the gaps in the literature and what has already been studied as a basis.

2.5.1 Physical Activity Interventions on Cognitive Performance in Young Populations with Different Developmental Trajectories.

Considering the scarcity of experimental research in a physical activity intervention setting targeting populations with mild ID and their motor and cognitive performance, which directly relates to the focus of this work, we find it essential to broaden our exploration by including studies involving other populations with diverse developmental trajectories. This approach allows us to provide valuable insights and a comprehensive understanding of the topic.

Within research that focuses on the effect of physical activity interventions on cognitive performance with other atypical development young populations, there are studies with participants with autistic spectrum disorder (ASD), such as Afshari (2012) and Pan et al. (2017) work; with individuals with attention-deficit hyperactivity disorder (ADHD) such as the studies of Chang et al. (2014), Halperin et al. (2013), Pan et al.

(2016, 2019), and Verret et al. (2012), and with participants with developmental coordination disorder, such as Tsai (2009) and Tsai et al. (2012, 2014) work.

Regarding demographic characteristics, the mentioned studies included participants with ages ranging from 5 to 12,5 years old (chronological age), and a common factor is that 80% had solely or predominantly male participants (e.g., Chang et al., 2014; Halperin et al., 2013; Pan et al., 2019; Tsai et al., 2014; Verret et al., 2012). One study lacked detailed reporting of the sex distribution of the atypical development population (Tsai, 2009), potentially leading to an even higher proportion of male participants. Furthermore, the sample sizes of individuals with atypical development varied between 21 and 40 participants. The mean sample size across the ten studies was 30 participants with atypical development (i.e., children with ASD, ADHD, or developmental coordination disorder). The limitations in the small sample sizes, recruitment difficulties, and/or inequality of sex of the participants were recognized in several of the studies (e.g., Halperin et al., 2013; Pan et al., 2016; Verret et al., 2012), which limited the generalizability of the results.

Forty percent of physical activity interventions were based on sports activities (e.g., Pan et al., 2019; Tsai et al., 2012), such as table tennis or soccer training. On the other hand, 50% of the studies focused on general exercises aimed at developing motor skills and physical fitness, such as locomotor and object control motor skills training (e.g., Pan et al., 2017), aerobic training (endurance) (e.g., Tsai et al., 2014) or perceptual motor skills training (Afshari, 2012). Only one program focused on recreational activities such as games to promote cognition enhancement of the participants (Halperin et al., 2013), which contrasts with the research mentioned in the previous section carried out with children with ID (Fotiadou et al., 2020; Javan et al., 2014; Yılmaz & Soyer, 2018), since they were all based on recreational activities, including games, music, symbolic stories or dancing. This could suggest that populations with ID could have better participation in these types of recreational activities, including motivational, emotional, and social elements, than other populations with atypical development. However, more research in this field is needed to corroborate this hypothesis.

The main findings of these studies were intervention-related cognitive improvements in attentional networks (e.g., Afshari, 2012; Tsai, 2009), inhibitory control (e.g., Chang et al., 2014; Tsai et al., 2012), working memory (Tsai et al., 2014) and cognitive flexibility (Pan et al., 2017), and motor improvements such as in gross motor skills (e.g., Pan et al., 2017; Verret et al., 2012) and physical fitness (Pan et al., 2016; Tsai et al., 2014). These outcomes showed that physical activity is valuable in promoting motor and cognitive outcomes in different populations with atypical development.

For example, Chang et al. (2014) studied the effects of an 8-week aquatic exercise program (90 minutes/session, twice a week) and examined its impact on inhibitory control in thirty children with ADHD (5 - 10 years old). Participants were assigned to either the intervention or control groups and were assessed before and after the exercise program. The authors used the Go/Nogo Task to assess the restraint inhibition component of response inhibition and the Basic Motor Ability Test-Revised (BMAT; Arnheim & Sinclair, 1979) to evaluate different motor skills (e.g., throwing for distance, target throwing, standing long jump and ball striking). Significant improvements were observed in children that participated in the intervention in the Go/Nogo Task (accuracy) and some motor skills (throwing and bead moving scores) compared to the control group. The authors suggest that one of the reasons might be that exercise regulates attention and information processing, consequently improving response inhibition.

The same pattern has been observed in studies carried out with children and young people with typical development, in which the physical activity intervention enhanced both cognitive and motor performance (Fisher et al., 2011; Hillman et al., 2014; Kamijo et al., 2011; Lakes & Hoyt, 2004; Pesce et al., 2016; Razza et al., 2015). For instance, for the present study, the work carried out by Pesce et al. (2016) provides a foundation because they used an enriched physical education intervention focused on deliberate play and cognitively variability factors (e.g., novelty, diversity, effort) and explored cognitive control functions and attention. The study included 460 typically developing children (5–10 years old) assigned to a 6-month intervention in randomized groups with or without enriched physical education. Children that participated in the enriched intervention displayed better outcomes in all motor coordination assessments (manual dexterity, ball skills, static/dynamic balance) measured before and after the intervention by the Movement Assessment Battery for Children (M-ABC) (Henderson & Sudgen, 1992). Regarding the cognitive measurements, similar positive results were found after the enriched physical education intervention with the inhibitory component of the Random Number Generation task- RNG (Towse & Neil, 1998) but not differential outcomes in the working memory component of the task. For the attention component, the authors used a subscale of the Cognitive Assessment System- CAS (Naglieri & Das, 1997), and the results showed no significant differences between the groups. These results could have occurred because the intervention's qualitative and/or quantitative aspects did not address the appropriate attentional and working memory engagement to enhance these cognitive abilities in typically developing children. For example, the authors highlighted that the non-significant outcomes could be due to the low number of weekly sessions (60 minutes/session, once a week). Another possible explanation for these findings is that the divergent outcomes may have stemmed from the developmental variations in cognitive abilities across time. For instance, inhibitory control, a fundamental cornerstone for cognitive control functions, demonstrates substantial enhancements during early childhood (Best & Miller, 2010), which could plausibly contribute to the observed significant gains due to the intervention. In contrast, the progression of working memory development unfolds gradually, accompanied by a persistent enhancement of precision, spanning across adolescence, particularly for the retention and manipulation of information for a goal-oriented task (Best & Miller, 2010).

When we refer to the enriched physical education program in this study, it is considered that the intervention has aspects of curricular content in the area and is designed with strategies to promote the development of cognitive and motor abilities in children (for more details about the intervention, see section 4.3.5).

Finally, it is essential to highlight that it can be observed in the literature that specific characteristics in the physical activity intervention programs generate better cognitive effects in the participants. For instance, a small to large positive cognitive effect (cognitive control, attention, and academic performance) has been shown in children in chronic physical activity interventions in contrast with positive small to moderate effects of acute physical activity (only attention) (De Greeff et al., 2018). Chronic physical activity refers to repeated amounts of bouts of exercise during a period of time; acute physical activity is a single bout of exercise. Likewise, better results were found in chronic participation in cognitively engaging interventions than in the ones focused only on non-engaging practices (e.g., walking, running) (Best 2010; De Greeff et al., 2018). It could also improve cognitive performance more effectively if the intervention contains progressively challenged tasks and addresses "children's emotional, social, and character development" (Diamond, 2012, p. 335).

This section can be summarized by pointing out that the associations between cognitive and motor performance have received more attention in recent decades, showing significant positive relations. Further, research has shown promising cognitive effects from physical activity interventions in people with different developmental trajectories. However, the nature of this relationship, especially in the heterogeneous population with ID, is not clear. The very scarce quality research carried out with participants with ID with different etiologies and severities prevents us from drawing firm conclusions on the distinctive profiles. For example, no studies on the effectiveness of physical activity interventions within participants with mild ID with non-specific etiology, the population on which this study focuses, were found. Yet, certain interesting characteristics of the physical activity interventions that generate better cognitive effects in the participants can be emphasized. The most prominent benefits were observed in continuous cognitively engaging physical activity over several weeks, addressing emotional and social aspects. With this background and taking into account that mostly all the studies presented highlight the importance of the early intervention and the need of more well-designed research in this field, the present investigation seeks to improve the understanding about the cognitive and motor relationship determining whether the practice of enriched physical activity has an effect on the cognitive control and motor skill performance of children with mild ID with non-specific etiology.

3 PURPOSE OF THE RESEARCH AND HYPOTHESES

Considering the clinical significance of an enhancement in cognitive functions in children with ID, the primary aim of the present study was to examine whether the effects of a 6-week enriched physical education program contribute to an improvement in cognitive control performance in children with mild ID, using measures of inhibitory control, vigilance, and cognitive flexibility. A further aim was to explore the effectiveness of the physical education program in the development of GMS by evaluating intentional and directed large muscles groups' involvement movements.

This study also aimed to address limitations in previous research to verify the relationship between physical activity and cognitive control development in this heterogeneous population in an experimental research setting. Although previous studies suggested a positive association between physical activity and cognitive control, there were very few studies including participants with mild ID with non-specific etiology.

Consequently, the present research was exploratory and had an experimental design with pretest-posttest for each cognitive and motor dependent variable, following the literature's recommendations about the need for studies such as this one to investigate the causality through adapted interventions of the motor and cognitive relationships identified in previous cross-sectional research (e.g., Hartman et al., 2010; Wuang et al., 2008). Additionally, it has been suggested that a comparison with mental age-matched typically developing control groups is not enough due to inherent differences between populations with and without ID on intellectual functioning and adaptive behavior development, and lifetime experiences (both positive and negative), which makes the groups fundamentally different from the beginning (Burack et al., 2012). Therefore, in the present study, participants had been randomly assigned to the experimental and control groups from a larger group with participants that had the same eligibility criteria. To ensure that the two groups did not differ at the beginning of the study, their performance on short-term memory and verbal fluency were analyzed. Besides, the study implemented a chronic enriched physical education intervention (six weeks), corroborating the previous research that has presented better cognitive results than the acute interventions (De Greeff et. al., 2018).

Finally, the study included a motor task used by the scientific community and was found to be appropriate for populations with ID, and cognitive tasks that have been adapted in terms of their complexity to be used with children with atypical development (See sections 4.3.3 and 4.3.4).

In accordance with the aims of this study, the following hypotheses were formulated:

a) Children with mild ID that participate in the enriched physical education program would present the following cognitive control outcomes after the intervention compared to those in the control group:
    1) Concerning attentional abilities, we expected significant intervention-related enhancements in accuracy and reaction time measurements in vigilance (alerting attention function). These findings would be in agreement with previous research on children with mild ID (Javan et al., 2014) and autism spectrum disorders (Afshari, 2012).

2) We hypothesized larger improvements in the accuracy scores in resistance to distractor interference and response inhibition measurements regarding inhibitory control functions in the intervention group. However, we did not expect any difference between the groups in reaction times. This would be consistent with previous studies which have demonstrated inhibitory control enhancements after a physical exercise program in populations with typical and atypical development (Chang et al., 2014; Fotiadou et al., 2020; Pesce et al., 2016).
3) Focusing on the function of cognitive flexibility, we predicted differences in performance between the groups in accuracy in the switching task. Moreover, greater reductions in mixing and switching costs (reaction times) were expected in participants in the intervention group compared to the control group. The hypotheses in this construct were based on Schmidt et al.'s (2015) study with typically developed children and Pan et al.'s (2019) with participants with attention deficit hyperactivity disorder. Both found improvement in shifting performance after a physical activity intervention.

b) The children with mild ID that participated in the enriched physical education program were expected to present the following GMS outcomes after the intervention, compared to those in the control group:
   1) We hypothesized significant intervention-related improvement in the overall GMS performance. This would be consistent with previous studies which have demonstrated enhancements in GMS competence after a physical activity program in populations with ID and attention deficit hyperactivity disorder (Pan et al., 2019; Verret et al., 2012; Zhang et al., 2021).
   2) Focusing on the GMS subtests, we predicted intervention-related enhancements with significantly higher scores in locomotor skills and tendencies of improvements in object-control skills scores. This would be consistent with the previous study by Verret et al. (2012), which showed similar positive impact patterns of a physical activity program in a population with attention deficit hyperactivity disorder. Moreover, we expected larger intervention-related improvements in gallop skill (locomotor subtest) and the overhand throw skill (object-control subtest) based on Westendorp et al. (2011) study.

4 RESEARCH DESIGN AND METHODOLOGY

4.1 OVERVIEW

The present research was an interventional single-center study with a simple randomized assignment and parallel groups design (non-blinded). The trial was registered retrospectively as ISRCTN17079009 in the International Standard Randomized Controlled Trial Number registry (ISRCTN; https://www.isrctn.com/), which is recognized by World Health Organization.

This experimental research analyzed the influence of an enriched physical education intervention (independent variable) on attention, inhibitory control, cognitive flexibility, and gross motor performances (cognitive control dependent variables: accuracy and reaction time; gross motor dependent variable: motor scores) in children with mild ID. There were baseline measures prior to intervention and post-tests measures following the intervention.

4.2 PARTICIPANTS

4.2.1 Eligibility Criteria for Participants

Participants in this research were students at a specialized educational institution for students with special needs associated with disability in Ecuador (Manabí province).

The first inclusion criterion for the participants was to have mild ID with non-specific etiology. Mild ID represents about 85 % of the total population with ID (APA, 2021). With non-specific etiology, we refer to the presence of a non-syndromic ID without accompanying congenital abnormalities such as physical and/or neurological (Kochinke et al., 2016). We focused on this group because the research in this field is scarce, and the literature has recommended that more studies are needed to better understand their profiles and developmental trajectories (St. John et al., 2020).

The official disability card issued by the Ecuadorian Ministry of Public Health was reviewed to verify the severity of the ID of the participants. It is important to clarify that in Ecuador, people with ID have a card that reflects the severity of the disability and is reviewed annually; this severity rating takes into consideration the three diagnostic criteria contemplated in the Diagnostic and statistical manual of mental disorders- DSM 5 (APA, 2013): significant difficulties in a) intellectual function, b) adaptive behavior and

c) beginning of intellectual and adaptive significant difficulties during the development period. The intellectual coefficient (IQ) is determined by applying standardized tests (Ministry of Public Health, 2018), as shown in Table 2. The disability percentages in Table 2. are assigned based on a generic scale, reflecting individuals' challenges in their daily lives and social integration. The generic scale ranges from 0-4%, denoting no or insignificant difficulties in performing daily activities and effortlessly navigating environmental barriers. On the other end, 96-100% signifies permanent disability, encompassing significant challenges that hinder overall functioning, necessitate third-party assistance, and cannot overcome environmental barriers (Ministry of Public Health, 2018).

Table 2. *Intellectual functioning difficulties classification*

Intellectual functioning	Reference document	IQ	Disability percentage
Limit intellectual functioning	DSM 5	70-80	22 %
Mild intellectual development disorder	DSM 5	51 - 69	30%
Moderate intellectual development disorder	DSM IV	35 - 50	45 %
Severe intellectual development disorder	DSM IV	20-34	59 %
Deep intellectual development disorder	DSM 5	19 ≤	59 %

Source: Adapted data from the Ecuadorian Disability Qualification Manual (Ministry of Public Health, 2018).

Therefore, although the specific IQ scores were not available, participants with an intellectual functioning classified as “Mild intellectual development disorder” were eligible for this study. It is worth mentioning that several studies cited in the theoretical background section encountered the same limitation regarding the determination of the IQ for each child (e.g., Frey & Chow, 2006; Rintala & Loovis, 2013).

The second eligibility criterion was a chronological age between 10 and 14 years. We sought the implementation of an intervention with a young population starting at ten years of age, due to younger children might be immature to perform the cognitive control tasks of this study, for example, by showing impulsivity that would compromise the accuracy of the task (Davidson et al., 2006). Furthermore, 10-14 years olds possess a higher level of receptive communication skills than younger children, indicating their ability to comprehend the information being conveyed (Schalick et al., 2012) that are essential for understanding the instructions of the activities included in the intervention and instructions of the cognitive and motor tests (See more details under section 4.3). Regarding motor skills, ages between 10 and 14 years old is a period with fast progress in motor learning abilities (Winter & Hartmann, 2007).

Exclusion criteria were the presence of significant medical conditions that could restrict the participation in a physical education program (e.g., heart diseases), other co-existing developmental disorders (e.g., autism spectrum disorder), or important physical/sensory limitations (e.g., hearing/visual impairment). This information was acquired by a medical history survey from the parents (See section 4.3.1.), in addition to the verification of available school records and a final confirmation of the leader teachers that the children met the eligibility requirements. These exclusion criteria were established in an effort to reduce the impact of confounding variables on the cause-and-effect relationships analysis of the study.

4.2.2 Participants' Progression and Randomization

An initial approach to discuss the study with the authority of the educational establishment was carried out to see the feasibility of achieving our target sample size of 30 participants based on previous studies (e.g., Chang et al., 2014). After reviewing general records, and referrals from teachers and parents, forty-five potentially eligible children were identified. Flyers containing general information (See Appendix 2) and direct contact with potential participants and parents were also used as recruitment approaches. Thereby, thirty-five children and their parents were interested and invited to participate. With the help of research assistants, the primary researcher assessed children's eligibility and obtained parents' informed consents (See Appendix 3) and participants' oral assents (See Appendix 4) before the study began. As a result, five children were excluded because they did not meet the inclusion criteria (n=4) or declined to participate (n=1). The recruitment and consent process were carried out in two months.

A total of thirty students (16 boys and 14 girls) participated in this study, with a mean chronological age of 12,67 years (age range = 10–14 years, SD = 1,35). Eighteen children belonged to the "Mestizo" ethnic group, which is a mixture between Europeans (mainly Spanish) and indigenous people (mainly Quechuas). Six children were "Montubios," a mestizo group that lives in the coastal region of Ecuador. Four children were "Afro-Ecuadorian", an ethnic group that descended from African persons the Spanish brought during the conquest and colony. Finally, two children belonged to the "White" ethnic group.

Before the randomized group assignment, all participants were assessed in general language skills and basic memory to ensure the groups did not differ (See section 4.3.2.). An independent person not involved in the study operated as a third-party randomization manager in the randomization process. For confidentiality matters, each child was given an identification number from one to thirty, and a freely accessible web-based software generated a simple randomization table at https://www.graphpad.com/ was used. Therefore, children were randomly assigned into two groups generated by the software (A and B); fifteen children in each group. Finally, the two groups were assigned by chance either to the control group or the intervention group by a draw procedure. The randomization and group assignment were concealed from the primary author of this study, her assistants, children, and parents until it was completed. The overall study flow is outlined in Figure 1.

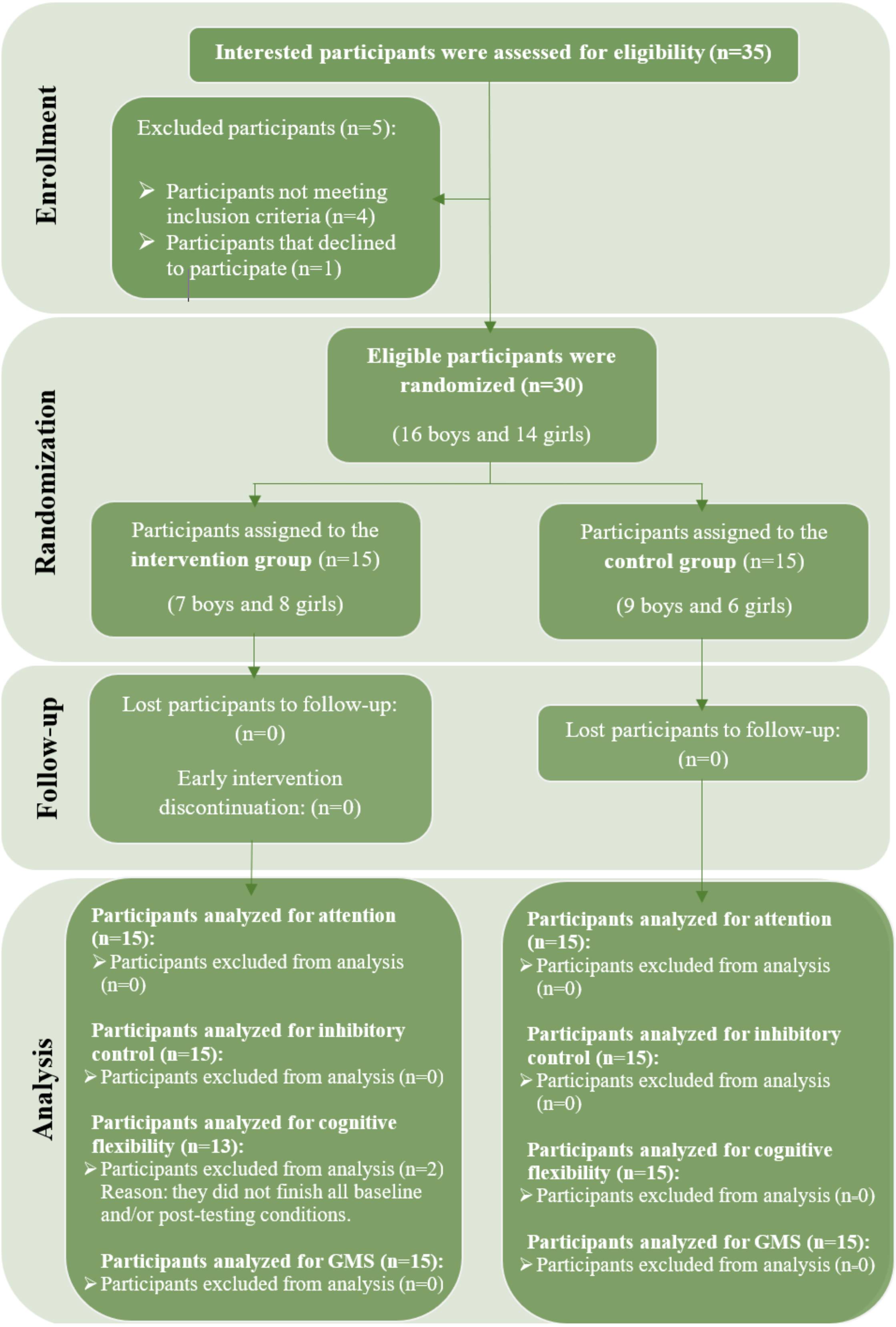


Figure 1. *CONSORT flowchart on participants progression over the stages of the study (Schulz et al., 2010).*

No children withdrew from the study or discontinued their participation in the intervention. Some retention strategies involved appropriate and effective communication with the children, parents, and teachers in all stages of the study, treating children respectfully and considering their particular needs, detecting the barriers to participation quickly and trying to solve them as much as we could, and record of daily attendance and in the case of absence, the representative was contacted to find out the cause and motivate them to do not miss the next session.

Participants assigned to the control group were part of the waiting list and were also able to participate in the second administration of the same program but after completing the final data collection phase for this study.

4.3. STIMULI AND PROCEDURES

A medical history survey was required for the parents or representatives of the participants with the aim of fulfilling the exclusion criteria of this study (See section 4.3.1. for more details). Additionally, all participants were assessed with a short-term memory test and a verbal fluency test prior to the trial to ensure the groups were not significantly different in basic memory and language skills (See section 4.3.2. for more details).

We administered the cognitive control tasks (attention, inhibitory control, and cognitive flexibility) and gross motor tests (locomotor and object control subtests) to all participants before and after the intervention to analyze the program's effectiveness in those domains (See sections 4.3.3 and 4.3.4.)

The intervention group (n=15) participated in a 6-week enriched physical education program (See section 4.3.5), and the control group (n=15) was required to continue normal school activities.

4.3.1. Medical History Survey

The survey required for the parents or representatives of the participants contained eight half-open questions with examples to get information about the presence of diagnosed congenital syndromes (e.g., Down syndrome, Fragile X syndrome, Prader-Willi syndrome), and other diagnosed developmental disorders (e.g., motor disorders, autism spectrum disorders, schizophrenia). Additionally, information about physical or sensory limitations that could restrict the participation in the intervention (e.g., visual impairment, hearing impairment, limb amputation) or any other health conditions worth mentioning for the children's participation (e.g., asthma, heart disease, high blood pressure) was required. The acquisition of this information was essential to meet the exclusion criteria set forth in this study. For more details, see Appendix 1. This data was also verified by available school records and confirmation of the leading teachers.

In the initial part of the survey, the birthdate and gender of the children were required for subsequent demographic analysis of the population. In addition, the education level (grade) was needed for practical and organizational matters, as well as the children's ethnicity, to observe the participants' cultural diversity due to Ecuador being a multicultural country.

4.3.2. General Prior Assessment

Although the participants were to be randomly assigned to the intervention group (n:15) or control group (n:15), an additional short-term memory test and a verbal fluency test prior to the trial were recommended for a comparison between groups to ensure that they were not significantly different in basic memory and language skills.

We selected these tests for several reasons. Firstly, since IQ data were not available, it was important to ensure that the groups had comparable backgrounds in this regard, as studies suggest that poor memory leads to learning difficulties (Alloway & Alloway, 2010), and in some atypical populations, such as children with autism spectrum disorder, the verbal IQ has been identified as a predictor of the performance of semantic verbal fluency (Pastor-Cerezuela et al., 2016).

Secondly, because of the connotations of language skills and short-term memory with cognitive control abilities. Enhanced language skills are closely correlated with more developed cognitive control abilities, such as attention, inhibitory control, and working memory. Remarkably, there are significant associations between vocabulary proficiency and both working memory and resistance to proactive interference (Gathercole, 2006; Marton et al., 2014). For instance, research on children with varying language abilities, including those with developmental language disorder and bilingual proficiency at different levels, reveals that individuals with larger vocabularies tend to make fewer interference errors (Bialystok & Feng, 2009; Marton et al., 2014). Moreover, research has provided supporting evidence for a link between these two cognitive control abilities (i.e., working memory and resistance to proactive interference), as shown by the interference model, a novel theory explaining the constraints of working memory using an interference model (Lewandowski et al., 2009; Oberauer, 2009). Finally, short-term memory was assessed due to its relationship with working memory, which comprises both short-term memory and executive (cognitive) control. The measurement of cognitive control abilities was done through specific tasks detailed in section 4.3.3., making it essential to verify at the beginning of the study if the experimental and control groups had comparable storage capacities (i.e., short-term memory).

By using these tests, we aimed to establish a reliable basis for comparison between the groups and mitigate potential confounding factors. Differences in the groups could affect the results of the experimental tasks; therefore, if the groups differed, these measures would then be used as covariates in analyzes of other cognitive and motor tasks to increase the reliability of the results.

A random ordering of tasks (Latin square design) was used. The tests were carried out in a school office without distractions, and the oral instructions were simplified for the understating of the children. In addition, participants had a practice trial to familiarize themselves with the rules, and each test lasted less than five minutes per child.

4.3.2.1.Short-term Memory Recall Test

It is a serial recall verbal test in which participants are asked to retrieve a list of words in the same order as they were given (Katkov et al., 2014). The children were presented with three lists, each corresponding to a different category, composed of two-syllable words in the Spanish language (See table 3). The recall entails a simple repetition of increasingly longer word lists (two words, three words, four words, etc.).

For example, the examiner read aloud the first row of the category A) professions (i.e., doctor, priest) at approximately one word per second. The participants had to repeat the words in the same order. Then, the examiner continued with category B) colors (i.e., red, gray) and category C) food (i.e., soup, cheese). Afterward, if the participant succeeded, we increased the length (second row) and continued with the same procedure as long as the child could repeat at least 2 out of 3 lists' categories at that particular length. In other words, we stopped the test at the length at which they repeated 1 or 0 lists only. The Short-Term Span was determined as the last length recalled correctly and could vary between 0 and 4. Errors in the recalling were considered if the participant repeated the words in a different order, repetition of elements more than one time, omission of words, or verbalization of words outside the list.

Table 3. *Sample lists of the Short-term memory recall test*

A) Professions	B) Colors	C) Food
1. doctor, priest	1. red, gray	1. soup, cheese
2. tailor, actor, painter	2. blue, pink, lilac	2. bread, cake, meat
3. nanny, chef, driver, magician	3. white, green, brown, silver	3. pizza, chicken, turkey, egg
4. shepherd, judge, guide, chief, nun	4. black, fuchsia, gold, cream, wine	4. popcorn, ham, pork, bolón, bean

Note: The original table used was in Spanish, and in that language, all words presented here have two-syllable. "Bolón" is a traditional Ecuadorian dish based on green plantains.

4.3.2.2.Verbal Fluency Task

The Verbal fluency task is a test in which children were asked to produce as many different possible words in each of the three test categories within one minute (per category). The test was conducted in Spanish, and children were instructed to start as soon as the researcher announced the category. The three categories were Animals, Body Parts, and Fruits. The children were instructed to name all the animals, body parts, or fruits that they know, trying to avoid repetitions and variations of the same word (e.g., dog and puppy).

The final score was the total number of correct words generated across the three categories. The incorrect responses were words that did not belong to the category, repetition of correct words, and morphological variants (e.g., flower, flowers). In the last two cases, repetitions and morphological variants, both words were counted as one, and in the first case, the irrelevant word for the category did not count in the total sum (Kosmidis et al., 2004).

4.3.3. Assessment of Cognitive Control Function

All tasks to assess cognitive control functions were administered through a laptop (39,5 cm screen size) using E-Prime 2.0 software to present stimuli and record responses (reaction time and accuracy data). The tasks were created in the Cognition and Language Laboratory at the Graduate Center of the City University of New York. Participants were seated in front of the computer in a school office without any interference or distraction.

A random ordering of the tests (Latin square design) was used; they were presented as computer games and were individually administered.

The instructions were orally explained in simplified age-appropriate language with visual support and repetition based on previously prepared scripts. Children had sufficient practice time and were motivated to ask questions. The experimental set in each task started only when the participants expressed that everything was clear. Children were instructed to answer as fast as they could without making mistakes. The same tasks and procedures were followed prior to and after the 6-week enriched physical education intervention over several sessions.

4.3.3.1.Nonverbal Attention, Distractor Interference and Response Inhibition Tasks

For examining vigilance (alerting attentional network function), resistance to distractor interference, and prepotent response inhibition, three subtasks from the information processing battery described by Szöllősi and Marton (2016) were used. These subtasks have been used with populations with different impairments and developmental trajectories (e.g., language impairment, autism, ADHD).

First, the participants were introduced to a set of response buttons and could press them until they felt comfortable. We used three Specs Switch Jelly Bean buttons with an auditory click and a 3.5-cm activation surface with tactile feedback. The buttons were plugged into a USB Switch Interface connected to the computer through the USB port, providing an effective communications link between the two parts. The buttons were located at a distance of 37 cm from the computer. A red button was located in the center and two black buttons on the sides, one on the left and the other on the right.

At the beginning of each trial (across the three subtasks) and after an oral and visual signal, children were instructed to push and hold down the start central red button until a red circle appeared in the center of the screen. In the Vigilance task, a green circle (target stimuli) appeared on one side of the screen, and the children had to observe if it was on the left side or the right side and respond pressing the black button corresponding to that side. For instance, if the green circle was on the left side of the screen, children had to press the black button on the left. Then another trial started (pushing the start red button again), and the child had to repeat the same sequence of actions. For more examples of trials, see Figures 2. A. Vigilance.

In the resistance to distractor interference condition, participants had to press the black button corresponding to the location (right or left) of the green circle (target stimuli), similar to the previous task. However, a new interference element was presented on the screen simultaneously, a blue circle (distractor stimuli) that needed to be ignored and that could appear on the same or opposite side as the target stimulus. Therefore, children only had to respond to the target stimuli in each trial. For instance, if a green circle appeared in the screen's upper-right corner and a blue circle appeared in the lower-left corner, children had to ignore the blue circle and press only the right black button as fast as they could. For more examples of trials, see Figures 2. B. Distractor interference.

The prepotent response inhibition condition was an adaptation of the well-known Go/no-go non-verbal task using the same base elements described before. In this subtask, a single circle was presented on the screen; either the blue or green circle appeared randomly in each trial. If the green circle was presented (target stimuli), participants had to press the black button corresponding to the location of the stimulus, as in the Vigilance condition. However, if the blue circle appeared (distractor stimuli), they had to inhibit their automatic reaction to press the black buttons on the sides, rather, children had to withhold their automatic response and press the central red start button to continue with the next trial. Therefore, the children had to distinguish between the two types of stimuli and respond according to the item's location only with the target stimuli. For examples of trials, see Figures 2. C. Response inhibition.

Each subtask consisted of five practice trials with feedback and twenty experimental trials with a random interval between 1 and 2 seconds. Before the stimuli disappeared (green or/and blue circle), the children had a maximum of eight seconds if no answer was provided, then another trial started (a red circle appeared in the center of the screen). Each trial was scored with a 1 when the child performed correctly, while a score of 0 was given for any inaccurate or missed trial. Additionally, the reaction time for each trial was recorded and considered for the data analysis. For more detailed information regarding the data analysis, kindly refer to Section 4.4.

There were breaks between the practice and the experimental parts and among the conditions. The test execution (three conditions) took approximately 15-25 minutes per child.

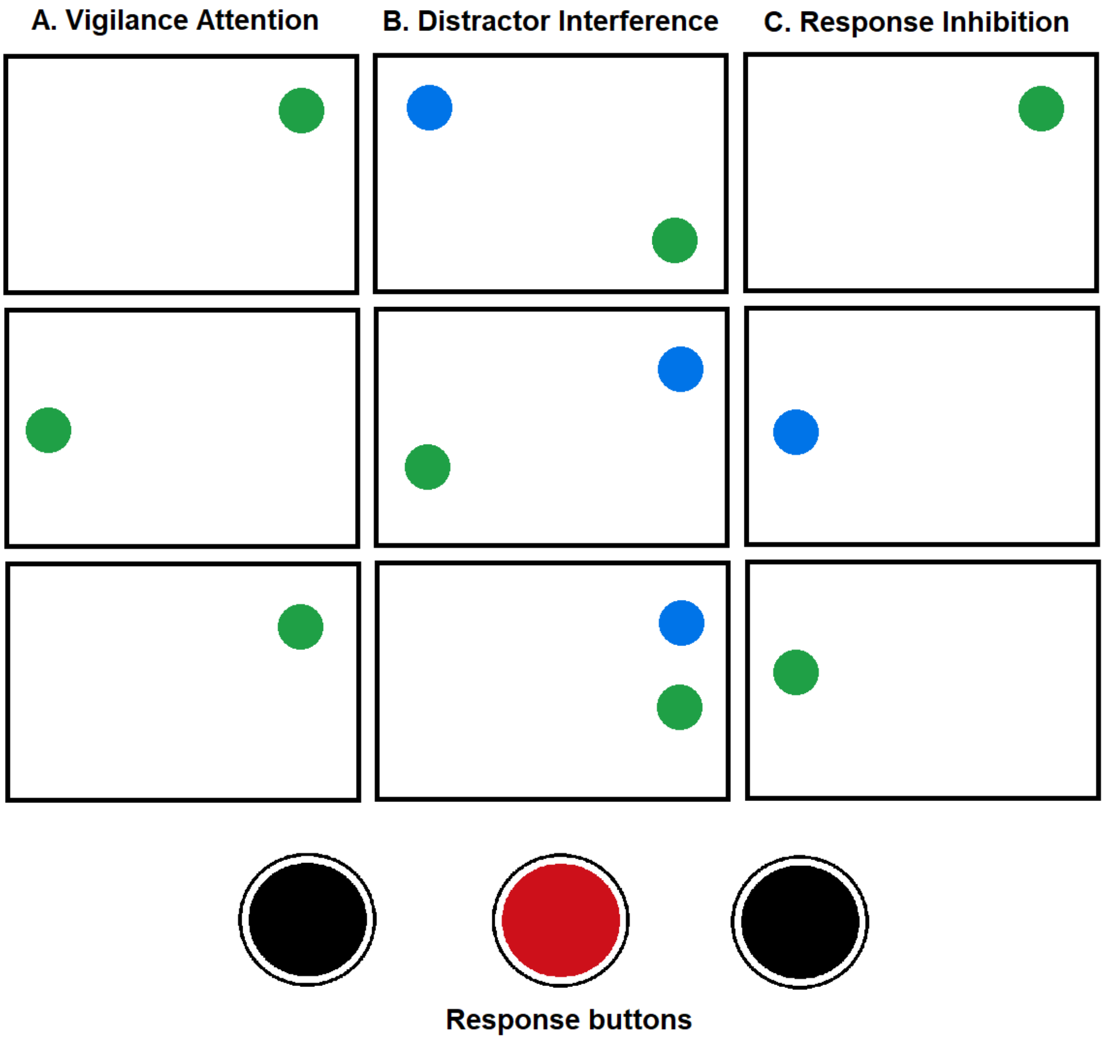


Figure 2. *Nonverbal Attention, Distractor Interference and Response Inhibition Tasks: Presentation of sample trials in each condition*

4.3.3.2. Task-Switching

For studying cognitive flexibility through the task-switching paradigm, we used a variation of the widely used Dimensional Change Card Sort task (Zelazo, 2006). Participants were required to sort bivalent stimuli and switch rules according to different dimensions.

We used two Switch Jelly Bean buttons with an auditory click and a 6.4-cm activation surface. The response buttons had stimuli pictures overlays; the left one had a blue dinosaur, and there was a green flower on the right button (See Figure 3). They were plugged into a USB Switch Interface connected to the computer through the USB port.

The buttons were located at a distance of 37 cm from the computer and there was 2.5 cm of distance between the two buttons.

Trials in three conditions were administered to measure the flexible use of rules. In the Single block-color condition, participants were required to sort the pictures on the screen according to the color dimension by pressing the matching button that contains the target color item (blue or green). Each stimulus had a visual rule cue (“rainbow” picture, referring to the color rule) and an auditory rule cue (“color” word, by the examiner). For instance, if a blue flower was presented on the screen, the correct response would be to press the button with the blue dinosaur. For sample trials, see Figures 3.A. Single block-color. First, participants were presented with the two colored items (flower and dinosaur) on the screen, followed by five practices trials in which the examiner provided feedback. If the participants had less than 60% accuracy in the practice trials, another five practices trials were presented to ensure they understood the instructions. Finally, the children responded to eighteen experimental trials.

In the Single block-shape condition, children were instructed to sort the items according to the shape dimension by pressing the matching shape item button (dinosaur or flower). Each stimulus had a visual rule cue (“triangle” picture, referring to the shape rule) and an auditory rule cue (“shape” word, by the examiner). For instance, if a green dinosaur was presented on the screen, the correct response was to press the button with the blue dinosaur. For sample trials, see Figures 3.B. Single block-shape. Participants also had five practices trials with feedback (60% accuracy rate was required) and eighteen experimental trials were presented in this condition.

Finally, participants were required to change dimensions in the mixed block condition, adjusting their responses by sorting by shape or color (See Figures 3.C.). For instance, after three straight trials matching by color, the children may have been asked to match two items by shape on the next couple of trials and then go back to color. This condition had the same five practice trials as the other tasks (60% accuracy rate was required) and thirty-six experimental trials were presented. The experimental trials included nineteen matchings by color and seventeen by shape, with ten switches between dimensions (30%) and twenty-five stay trials within the same dimension (70%). There were breaks between the practice and the experimental parts and between the conditions.

Each trial was scored with a 1 when the child performed correctly, while a score of 0 was given for any inaccurate or missed trial. Additionally, the reaction time for each trial was recorded and considered for the data analysis. For more detailed information regarding the data analysis, kindly refer to Section 4.4. The test execution (three blocks) took approximately 15-25 minutes per child.

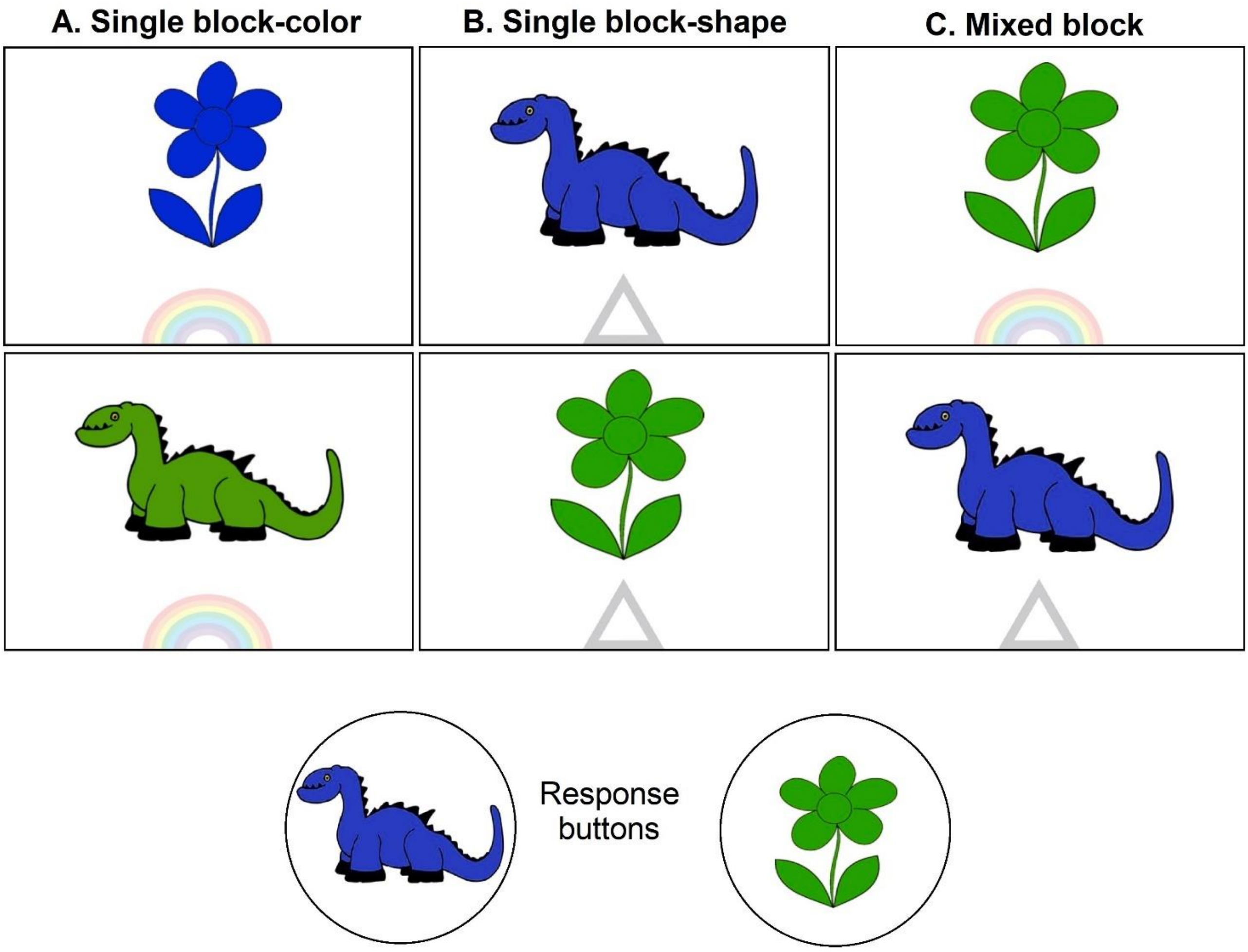


Figure 3. *Task-Switching: Presentation of sample trials in each condition*

4.3.4. Gross Motor Skills Assessment

The study used the Test of Gross Motor Development–Second Edition (TGMD-2) proposed by Ulrich (2000). A standardized motor assessment tool that examines qualitative aspects of fundamental movement skills in children between 3 and 10 years old.

The TGMD-2 evaluates twelve gross motor performance skills encompassed in two subtests. The locomotor subtest focuses on coordinated body movements involving displacement from one place to another, including jumps and turns. The instrument comprises the following locomotor skills: run, gallop, hop, leap, horizontal jump, and slide. The object control subtest focuses on movements in which the fundamental action implies the management and mastery of objects, including throws and receptions. The instrument comprises the following object control skills: striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll.

Although the test is not precisely designed for children older than ten years old, this study aimed to measure the gross motor proficiency prior to and post-intervention to later make a within- and a between-subjects comparison, not to make a purely normative standards comparison. In this sense, Ulrich (2000) pointed out that if the normative comparison is not relevant to the examiner, modifications can be made to achieve other specific aims. Therefore, the raw scores were used for comparison purposes without converting them into normative percentiles because they are not relevant to this study's aims. In addition, it is essential to highlight that this test has been used to assess GMS in adolescents (12 -18 years old) with ID (e.g., Eguia et al., 2015; Frey & Chow, 2006; Hartman et al., 2010) and without ID (Okely et al., 2001). Besides, Simons et al. (2008) evaluated its validity and reliability in children with a mild ID determining that it is an appropriate instrument for evaluating this population.

The test was administrated in the educational institution's multiple-use sports field, which was reserved according to the hours recommended by the director of the institution to make exclusive use of it without distractions and minimize the test administration time. Four participants attended the test session each time; however, the GMS were performed one by one, always alternating the children's order sequence of execution of the skills. We used a random ordering of the GMS skills (Latin square design).

There was a verbal description of each skill in simplified age-appropriate language, encouraging them to perform the best they could with phrases such as "let's jump very far". Besides, two demonstrations were provided for each skill by the author of this work, who has a bachelor's degree in physical education and sports with experience in special education. In addition, there was the assistance of the two senior physical education bachelor students who received training and practice to carry out this test in advance. Children had a practice trial for each skill to verify they understood the instructions.

The test duration was approximately 15-20 minutes per child in one testing session, and was video-recorded with the permission of the parents (See Appendix 3) to review the performance criteria for each skill and fill the Examiner Record Form (See Appendix 5). Each gross motor skill had three to five performance criteria that were scored with a 1 if the child performed correctly and a 0 if she did not. Therefore, after the demonstration by the examiner and the practice trial, the participants performed two experimental trials of each skill, obtaining a raw score per skill, subtest, and total (sum of the raw scores of the locomotor and object control subtests).

Participants wore their school physical education uniform, and the testing environment and conditions were settled in advance. The following equipment was used for the different subtests: tape, ten traffic cones, two 4-inch light-weight balls, two 5-inch square beanbags, two plastic bats, two 10-inch playground balls, two batting tees, and soccer, softball, basketball, and tennis balls (two of each sport).

The same test and procedures were followed before and after the 6-week enriched physical education intervention. Children had a break between the two subtests to rest and hydrate. However, it was granted without a problem when the children needed an extra break. For more information about the direction, materials, and performance criteria for each gross motor skill, see Appendix 5. For more information and illustrations about the TGMD-2, access the Examiner's Manual in the reference list under Ulrich, D. A. (2000). Test of Gross Motor Development, Examiner's manual.

4.3.5. Intervention Features and Procedures.

All the children with mild ID assigned to the intervention group participated in the physical education program for six continuous weeks. The frequency of the sessions in the program was two times a week with a total of 12 sessions; each session lasted one hour.

The intervention took place in the school's multiple-use sports field, the exact location where the TGMD-2 was administrated, on Wednesdays and Fridays at 10 am, as suggested by the school director. The place provided the optimal requirements for the development of the planned activities, considering parameters such as distraction, noise and security levels, and distance from the children's classrooms and bathrooms. An extra factor was that children felt comfortable since it was a place they already knew at their school.

The physical education program was developed on the basis of the Ecuadorian physical education curriculum, specifically on the first curricular block, "Playful practices: games and play" (Ministry of Education of Ecuador, 2016a). Moreover, it was focused on the notion that playing has an essential pedagogical value as a mediator in the teaching and learning processes of the physical education area (Mero Piedra, 2020b). The adjective "enriched" in the intervention of this study refers to it being designed with games to promote the cognitive and motor development of the participants. The program addressed social, emotional and character development through the games, taking into account what was mentioned by Diamond (2012, p. 335) that could generate greater cognitive benefits. For example, *the pied piper* game, where the teacher acts as the piper and the children play the role of mice (see more details in next section 4.3.5.1.), is a symbolic game with implements like a hat and a flute to enhance the narrative and provide auditory stimulation. Playing such games promotes creativity, social communication skills (e.g., understanding and using appropriate facial expressions and body language), playing fair, and like the other games used in this study, can bring joy and pleasure (Huizinga, 1972), encouraging participation (Bossink et al., 2017).

Two factors guided the decision regarding the length and frequency of the intervention (twice a week for six weeks). Firstly, we relied on the study of Schmidt et al. (2015), a randomized controlled trial investigating the effectiveness of a cognitively engaging physical activity intervention combining physical education curriculum requirements. This combination is an important characteristic of our work, as it was aligned with the Ecuadorian physical education curriculum and aimed to enhance cognition, even though the nature of the two interventions differed. Further, the Schmidt et al. publication describes that the intervention was based on principles of mental engagement by Tomporowski et al. (2015a) (p. 578); thus, it was based on the same principles as the physical activity games performed in our study (see next section for more details). Finally, Schmidt et al. found that a six-week cognitively engaging physical education program promoted cognitive improvements in children with typical development. The second reason was the timeframe that the educational institution offered. Permission was obtained from the director of the specialized educational institution to conduct the research in the second semester of the school year. Therefore, a period of 6 weeks of physical education program was feasible considering the recruitment period and the pre-and post-intervention testing times.

4.3.5.1.Intervention Playful practices

The program integrated games from Tomporowski et al. (2015a) based on three principles of mental engagement: contextual interference, mental control, and discovery play:

- **Contextual interference:** the intervention included five tag games that contained random conditions with unpredictable action response changes. These games promote mainly locomotor skills (running and jumping) and cognitive flexibility function (switching back and forth between two or more motor behaviors). Additionally, they also encourage inhibitory control (e.g., suppressing the motor response or inhibiting an ongoing action) and attention (e.g., by controlling and emphasizing task-relevant stimuli) functions.

  a) **The pied piper:** The teacher plays the role of a piper with the power to charm or captures the children, who play the role of mice. The children must follow the teacher when they are bewitched, but when they are not, they must react according to the expression and action of the teacher (switch between approaching and escaping according to the case).

  b) **The piper and the mice: Who tags whom**?: In this game, the complexity of the "The pied piper” game increases since two conditions are added to the two previously learned. According to the case, the children might also freeze (stopping) or catch the teacher (tagging).

  c) **The chameleon:** The teacher assumes the role of a chameleon that can transform into various animals (bird, frog, snake, and eagle). The children follow the teacher in a line, and when she stops, children should react depending on her expression (friendly or challenging) to either as their babies or their prey. Children must approach or scape with various movement patterns according to the designated animals.

  d) **Rock, paper, scissors: The tagged tagger:** Children take on the roles of rock, paper, or scissors. They must try to catch and escape according to the guidelines of the traditional game. For example, children who play as rocks must catch children who play as scissors and escape from the ones playing as papers. All the participants carried neck hanging cards to recognize the roles.

e) **Fly, frog, and snake: The tagged tagger:** Using the same argument as the “Rock, Paper, Scissors” game, this adaptation reflects an interaction between four animals. The fly annoys the snake, the snake eats the frog, and the frog eats the fly. All the participants carried neck hanging cards to recognize the roles.

- **Mental control:** the intervention included five games that promote mainly locomotor skills (running and hopping) and inhibitory control function (e.g., suppressing or delaying motor responses, inhibiting an ongoing action, or repressing habitual responses: contradictory signals). Additionally, they also encourage cognitive flexibility (switching between motor behaviors and rules) and attention (e.g., by controlling and emphasizing task-relevant stimuli) functions.

a) **The statues game: one, two, three…star:** In the context of a museum, the teacher initially plays the role of the curator. The children play the role of statues (stopping) only when the curator is watching, assuming a star pose. If the teacher is not looking, the children can get closer. The first child to touch the teacher wins.

b) **One, two, three…star or moon:** In this game, the complexity of the previous game is increased since one condition is added. The children might also freeze (stopping), assuming a "moon" pose depending on what the curator yells before turning: star or moon.

c) **One, two, three...star or moon or sun:** Similar to the previous game in a museum context, the children must freeze in two possible poses (star or moon), but if the curator yells "sun" before turning, the children can continue to move towards the curator.

d) **Crazy traffic lights:** The teacher plays the role of a traffic officer with a broken traffic light, in which the children must ignore what the officer says and obey the traffic lights (contradictory verbal and visual signals). For example, the teacher says "stop" while showing a big green object; in this case, the correct response would be to continue moving.

e) **My clock is late:** The teacher teaches a sequence of coordinated movements, then the children pretend to be delayed clocks and must replicate the same sequence that the teacher is executing but with a delay.

- **Discovery Play:** the intervention included three games focused on problem-solving with creative motor responses stimulating the imagination and exploration. The games promote mainly locomotor skills (running, galloping, hopping, and skipping), cognitive flexibility (generating alternative and creative motor solutions: new poses and movement patterns), inhibitory control (inhibiting an ongoing action), and attention (e.g., by controlling and emphasizing task-relevant stimuli) functions.

a) **Photo album:** The teacher assumes the role of a DJ and photographer. While the music is playing, the children can move freely, and when it stops, children must creatively assume a position that meets a predetermined condition.

b) **Pictures of courage:** The game's rules are the same as the "Photo album" game, but the complexity increases when performing the different poses on a climbing structure.

c) **Movie of the animal world:** The teacher now fulfills the role of a DJ and a filmmaker. Therefore, children no longer have to assume a static pose when the music stops but move according to the determined condition.

The basic implements for the development of the games were a flute, color cards, neck hanging cords, tape, colored objects, music, visual cues, climbing structure, safety mats, and small obstacles. Likewise, other materials were used to help maintain the children's attention (see section 4.3.5.3.), such as other sports equipment to delimit playing areas or costumes for the teacher to assume some roles.

For more information about the game’s characteristics, essential explanation elements, modifications, and other details, please review Tomporowski et al. book (2015a).

4.3.5.2.Structure of the sessions

Each intervention session was conducted by the author of this study and two trained assistants. The instructor–child ratio was 1:5 (number of children by the number of instructors). Each session was organized by the following structure:

- **Warm-up:** The aim was to be physically and mentally prepared for the physical activity, triggering an increase in body temperature, and heart and breathing rates.
  - This part of the session lasted approximately 7-10 minutes and included activities at a low intensity and slow pace, gradually increasing without the participants feeling fatigued.
  - The warm-up consisted of light aerobic movements, joint mobility exercises, and dynamic stretching, such as arm circles, slow jog, jogging on the spot, butt kickers, and knee and leg bend. The warm-up was appropriate for the activities in the main part of the session, so the muscles and joints to be used later on were ready.
  - At the beginning of each session, the whole group gathered in a circle to give a small welcome and briefly mentioned the games that we would play, emphasizing that we would have a lot of fun.

- **Cognitive enhancement games:** This was the main part of the session, and it lasted approximately 45 minutes. Games for children with typical development between three and six years of age were chosen to adapt to the needs and characteristics of the population with mild ID that is usually behind in cognitive and motor development.
  - Between two and three games detailed above (contextual interference, mental control, and discovery play) were performed in each session, considering slight game modifications also suggested by Tomporowski et al. (2015a) on some occasions. However, it was essential to remain constant until the children had learned the current conditions. Each game was played in between one or three different sessions depending on its difficulty, starting with its most basic versions to gradually increasing it over time by changes in intensity, volume, or conditions.
  - Although each session was planned in advance, weekly meetings were held (with the leading teacher and the two assistants) to define details. The

intervention was flexible; the sessions could be modified to the changing situations. For example, a game would take longer than planned, and we would have to lower the number of games set for that particular session. Therefore, the necessary modifications and adaptations were made. This is an essential requirement of all physical education classes, whether with this type of content or another, with children with or without disabilities.

- The leading teacher and the assistants were always active actors in the intervention; we participated in the games with the children, especially in the initial stages. We noticed that this improved the participation and the understanding of the game's rules considerably. Once the children felt comfortable with the basic requirements, they could continue playing independently. It should be noted that there was always an instructor outside the game moderating its general execution and fillings the game's leading role at all times.
- The children were told that they could take a break at any time during the intervention if they needed to. However, there was a planned break of 5 minutes approximately in the middle of the main part of the session to rest and drink water. A gallon of water was available for each session.

➢ **Cool-down:** The aim was to promote a gradually healthy transition from the main part of physical activities back to a steady-state of rest, returning the heart and breathing rates close to resting and progressively cool body temperature. Additionally, reducing the risk of having sore muscles due to the cool-down helps to reduce lactic acid and muscle tension.

- This part of the session lasted approximately 8 minutes and included a reduction of the intensity of the activities children were doing and lightly stretching the main muscles. For example, if the children were jogging or running in the games, during the cool-down, they were walking, following with a gentle crossover hamstring stretch.
- At the very end of each session, the whole group gathered again in a circle to review the session together, answer questions and take suggestions. If any, the children's recommendations related to the intervention were always associated with repeating one of the games from that session or previous ones. The

aroused questions about the intervention were usually related to when we would have the next session.

4.3.5.3 Intervention General Pedagogical Considerations

Pedagogical considerations associated with motor learning teaching to individuals with ID pointed out by Payne et al. (2010) and Mero Piedra (2020b) were taken into account:

- **Effective communication as an advantage for participation:** Communication adapted to the characteristics and needs of the students played a fundamental role in participation during the intervention. Strategies such as the use of simplified verbal language (e.g., short, using familiar vocabulary) and accompanied it by non-verbal language (e.g., facial expressions, body language, tone of voice) and visual elements (e.g., pictures, drawings) to facilitate the understanding of the games were essential.
  - Other strategies were: repeating the instructions as many times as necessary before and during the execution of the games and constantly asking if they needed any clarification; checking if they knew the meaning of uncommon words if their use was necessary (e.g., piper); the use of extra elements to help the comprehension of words that might be new to some children (e.g., using a hat and a flute to assume the role of the piper); creative stories were built around some games to increase understanding and interest.
  - If, during the execution of a game, the instructors noticed that a child did not understand what to do, first (s)he was allowed to continue playing to see if (s)he understands what to do by observing or imitating the other players. If this did not happen, the moderator instructor explained individually the instructions showing the other players as an example for better comprehension.
- **The class organization helped to stay focused:** Visual and verbal cues, extra sports equipment (to delimit the playing areas, for example), costumes, and music helped the students stay engaged and focus on the activities. Additionally, unnecessary external stimuli were avoided; for instance, on one occasion, a school teacher asked us for permission for a group of five other children to occupy a corner of the sports field to practice some act. However, we explained to him that, unfortunately, this situation could distract the children from the intervention. We proposed that he postpone his practice until after our session and that both the lead teacher and one assistant would help him in his act. He accepted and was happy to get the extra help.

Finally, the games with more complex rules were broken down into smaller parts so that children could understand the instructions more easily without losing interest.

- **Participation challenges:** Overall, the sessions were conducted satisfactorily without significant challenges in this matter. The fact that three instructors were leading/assisting the intervention helped to ensure that some situations did not escalate and were resolved as soon as possible. Specifically, we had some concerns related to momentary rejection or stopping participation. In these cases, the children were allowed to stop the current activity. Every effort was made to understand the root of the problem and subsequently develop strategies to reduce that behavior if needed. Then, using a gentle redirection back to the task was the key. There were no withdrawal, rather momentary breaks in the action, and soon the children continued playing. Examples of situations were as follow:
  - A child in the game " The statues game: one, two, three…star " was caught moving and had to return to the starting line, and he was upset because he felt he had lost. The leader teacher sat next to him and acknowledged that it is okay to be upset when we lose, that she also gets upset, but when that happens, she takes a couple of deep breaths, drinks some water, and then thinks about how she can do better next time. Also, always remember that the games in physical education are for learning and fun. He will have many more opportunities to win, and we could try to be happy for the other players that are winning in this particular turn. After a few minutes, the child continued playing with his peers. At the end of that class, in the group circle, these points were shared with all the children so that they would know that it is normal to feel this way and that they would begin to develop coping strategies if needed.
  - Another example was with a student who initially did not want to participate in the session, and when we approached her, she did not give us any reason. We gave her space for a moment, and then she came to tell us that she had her period. Although the menstrual period does not impede participation in physical education sessions, it is often difficult to cope with this situation, especially for young girls. For this reason, she was first asked if she wanted to participate in the session, and she said yes. Then she was reminded that she could take as many breaks as needed and if she needed further help, she should let us know. In the

end, she participated in the session normally with a couple of more breaks than her peers.

- The last example is related to a student who was a big hugger. Multiple times per session, she would stop playing and hug one of the teachers. Talking about this topic with her leading school teacher, she commented that they are working on teaching her personal boundaries, especially now that she is entering adolescence. Therefore, since we confirmed that it is a recurring behavior with everyone and that it is being worked on, we told her that there is no problem with giving us a big and friendly hug (as she liked it) but that we cannot stop the activity. So, the hugs had to be during the breaks, she agreed, but in reality, the behavior did not stop. However, the hugs became much shorter, and the child was back to playing right away.
- It is important to emphasize that these situations are normal and frequent in physical education sessions with young children and adolescents. Therefore, nothing out of the ordinary occurred during the intervention in this regard. Naturally, sessions with children with mild ID require more patience and adapted strategies since certain behaviors tend to be more noticeable and frequent than with children with typical development, but these strategies are needed to some degree with children without ID at different stages as well.

➢ **Values promotion:** To ensure the integral development of children, imparting values-based education is a crucial aspect and a key goal of physical education in Ecuador (Ministry of Education of Ecuador, 2016a). This requires teachers to effectively incorporate the promotion of values across all content blocks throughout the academic year to facilitate meaningful learning. Based on the recommendations of the Ministry of Education, the most significant values for the students were prioritized according to the context and characteristics of each game and the values emphasized in the curriculum. In this sense, due to the nature of the playful practices, there were many opportunities to promote different values, such as leadership when children could lead some of the games; teamwork when games were collaborative, resilience in learning to win or lose, and fair play respecting the rules of the game and their peers.

4.4 DATA ANALYSIS

4.4.1 Cognitive Control Measurements

The study utilized the R statistical computing system version 4.0.3 and IBM SPSS Statistics Version 26 as the statistical analysis software. The figures were generated by utilizing the ggplot2 package within the R library.

The study investigated two dependent variables: accuracy, measured on a binary scale (0 or 1), and reaction time (RT). Missed trials by the participants were considered inaccurate in the accuracy analysis, while only the accurate responses were included in the RT analysis. We identified outliers in the RT data by excluding RTs that were less than 300 milliseconds and RTs that exceeded three standard deviations from the individual means of the participants. Following these conditions, during data cleaning, 19.19% of the trials in the nonverbal attention, inhibition, and distractor interference tasks were excluded, as well as 18.07% in the switching tasks. This proportion of excluded trials would be considered high in typically developing populations but is not uncommon in populations with ID.

We employed mixed-effects logistic regression models to analyze the binary accuracy data (0 or 1). We estimated a series of models using the lmerTest open-source package in R (Kuznetsova et al., 2017) for each nonverbal attention, inhibition, and distractor interference tasks and switching tasks condition, with a decreasing degree of complexity. The fixed factors in our accuracy data analysis comprised session (session 1/session 2) and group (intervention/control), with subject serving as a random factor. The selected model was based on the Akaike Information Criterion (AIC); this method compares different possible models and estimates which one is the best fit for the given data.

The RTs were log-transformed before data analysis; and then underwent analysis using robust linear mixed models with the DASvar method (R package robustlmm; Koller, 2016), as the residual normality criterion was not met. The fixed factors in our RT data analysis included session (session 1/session 2) and group (intervention/control), with subject serving as a random factor. To select the best model, we employed the standard error of the Session x Group interaction estimate due to the unavailability of information criteria such as AIC for this method. In instances where two models yielded equal standard errors, we opted the less complex model. We calculated p-values for all effects.

A significant intervention effect is present if the Group x Session interaction reaches a significance level in RT or accuracy data. We used this type of analysis to avoid the multiple comparison problem and filter for irrelevant individual differences.

We also tested the influence of the intervention on mixing and switching costs. Mixing cost was determined as the difference between stay-trials in the single-block and the mixed-block. Switching cost was determined as the difference between the stay-trials and the switch-trials within the mixed-block. We tested the difference using two mixed-design ANOVAs. In the first one, where we tested for the impact of the intervention on mixing cost, the dependent variable was the mean RT of the stay-trials within the single versus the mixed-block; within-subject variables were session (session 1/session 2), cue type (color/shape), trial type (single-block/mixed-block), and the between-subject variable was group (intervention/control). In the second analysis, we aimed to test if the intervention affected the switching cost. The dependent variable was the mean RT of the stay and switch trials; within-subject variables were session (session 1/session 2), cue type (color/shape), trial type (stay/switch), and the between-subject variable was group (intervention/control). We report the trial type main effect to show if there is a mixing/switching cost regardless of intervention, the session x cue type x trial-type interaction when relevant, and the session x cue type x trial-type x group interactions. For the pairwise comparisons, we applied Bonferroni correction. Alpha level was determined at 0.05.

4.4.2 Gross Motor Skills Assessment

Regarding the motor skills assessment using the Test of Gross Motor Development (TGMD-2; Ulrich, 2000), the sum of the raw score values for the Locomotor skill and Object control skill subtests were calculated, as well as the total score values of the entire test. In order to verify if the enriched physical education program had an impact on the GMS, we ran mixed-design variance of analyses (ANOVAs) for the subtest scores and the individual skills as dependent variables, session (session 1/session 2) as a within-subject variable, and group (intervention/control) as between-subject variable. A pairwise comparison with Bonferroni correction was performed in case of significant results. Alpha level was determined at 0.05.

4.5 ETHICAL CONSIDERATIONS

This research took special consideration to relevant ethical issues throughout the study. First, the procedures followed the Scientific and Research Ethical Regulations of the Bárczi Gusztáv Faculty of Special Education of Eötvös Loránd University. Research ethics approval was obtained on June 11th, 2019 (Ref. No.: BGGyK/3773/1(2019)(T59); Permission No: KEB/2019/003).

Additionally, as the research was carried out in an Ecuadorian educational institution, authorization was requested from the Education District Directorate (13D02) according to current regulations. The Education District Directorate authorization was obtained on August 15th, 2019 (Official Letter No. 276-13D02-DD-2019). The physical education program also required two assistants. Therefore, a formal request was made to the authority of the Faculty of Educational Sciences of the Eloy Alfaro University of Manabí. A positive response was obtained on August 1st, 2019, and two experienced senior physical education bachelor students could fulfill this role.

Participants and their parents were introduced to the researcher and assistants and were informed about the study. Before applying the assessment tasks prior to the intervention, parents' informed consents and participants' oral assents were obtained (See Appendix 3-4), as was mentioned previously. However, it is worth emphasizing that the children and parents were told that their participation in the study was voluntary and that they might withdraw at any time.

Regarding confidentiality handling of research participants' data, children's data and scores were not associated with their names; rather, each child was given an identification number. Parents agreed that the non-identifiable datasets generated would be used only for this investigation, and the findings would be presented to people involved and key stakeholder organizations from appropriate scientific publications and a doctoral thesis. Therefore, after this research's institutional and public defense, the author undertakes the responsibility to translate the main findings into Spanish and present it to those involved.

Finally, it is essential to highlight that, as a personal right, if the parents (or children) had any concerns or were dissatisfied with any aspect of this study, they could report the grievances. These would have been recorded and be considered later. However, during the study, these situations did not occur.

5 Results

Sections 5.1, 5.2, and 5.3.1 of this dissertation findings have been published in:

Mero Piedra, A. L., Pesthy, O., & Marton, K., Effects of a physical education intervention on attention and inhibitory control in Ecuadorian children with intellectual disabilities, Journal of Intellectual Disabilities (Vol. 0(0) pp. 1–14). Copyright © 2023 (The Authors). DOI: https://doi.org/10.1177/17446295231189018.

5.1 Group comparison prior to intervention

The control and intervention groups did not show significant differences in terms of age, gender distribution, short-term memory, and verbal fluency performance (See Table 4).

Table 4. *Descriptive statistics of the sample and comparison between groups*

	Intervention Group		**Control Group**		**Statistics**
N (male, female)	15 (7, 8)		15 (9, 6)		χ^2 = 0.536, p = 0.464
	Mean (Min, Max)	***SD***	***Mean (Min, Max)***	***SD***	***Statistics***
Age (years)	12.733 (10, 14)	1.438	12.600 (10, 14)	1.298	U = 113.5, p = 0.967
Short-term memory span	2.143 (0, 4)	0.864	2.000 (0, 3)	0.864	U = 107.0, p = 0.917
Verbal fluency	22.786 (11, 37)	7.924	20.333 (10, 30)	6.683	t(27) = -0.903, p = 0.374

5.2 Attendance Rates

The attendance rate was determined by dividing the number of attended enriched physical education sessions by the total number of sessions. The frequency of the sessions in the program was two times a week, with a total of 12 sessions.

The arithmetic mean of the attendance rates for individual participation in the physical education intervention was 90.56%. All individual attendance rates were above 83,33%.

5.3 COGNITIVE CONTROL

We present in this section the results of our analyses focused on identifying the main effects and interactions concerning the study's dependent variables: accuracy and RT data in the cognitive control performance. Specifically, we investigated the variables Session (Session 1: prior intervention/Session 2: post-intervention) and Group (intervention/control).

A significant main effect for the variable "Group" indicates differences in RT and/or accuracy between the Control and Intervention. This allows us to discern whether there were substantial differences between the groups at the study's beginning and after the implementation of the physical intervention program. A significant main effect for the variable "Session" suggests differences in RT and/or accuracy between Session 1 and Session 2, regardless of the participation in the physical education program. Moreover, the presence of a significant "Session x Group" interaction implies that the impact of the physical education intervention on RT and/or accuracy differed between Session 1 and Session 2 for both the Control and Intervention groups. This interaction effect holds significant importance, as it indicates the impacts of the intervention with variations in RT and/or accuracy that are not uniform across the two sessions or between the two groups.

5.3.1 Nonverbal Attention, Inhibition and Distractor Interference Tasks

All participants' data were analyzed for inhibitory control and attention (fifteen children from the intervention group and fifteen from the control group). There were no participants excluded from the analysis of the results in these cognitive control functions.

5.3.1.1 Vigilance Task

AIC values of the random intercept robust linear mixed models fitted to the Vigilance task's RT data are shown in Table 5.

Table 5. *AIC values from the Vigilance task*

Models' description	AIC
Session x Group interaction slopes and intercepts vary randomly	1157.4
Session x Group slopes and intercepts are independent and vary randomly	1159.4
Session and Group slopes and intercepts vary randomly	1149.5
Session and Group slopes and intercepts are independent and vary randomly	1151.5
Session slopes and intercepts vary randomly	1144.6
Session slopes and intercepts are independent and vary randomly	1145.9
Group slopes and intercepts vary randomly	1146.5
Group slopes and intercepts are independent and vary randomly	1148.5
Intercepts are random	1143.9

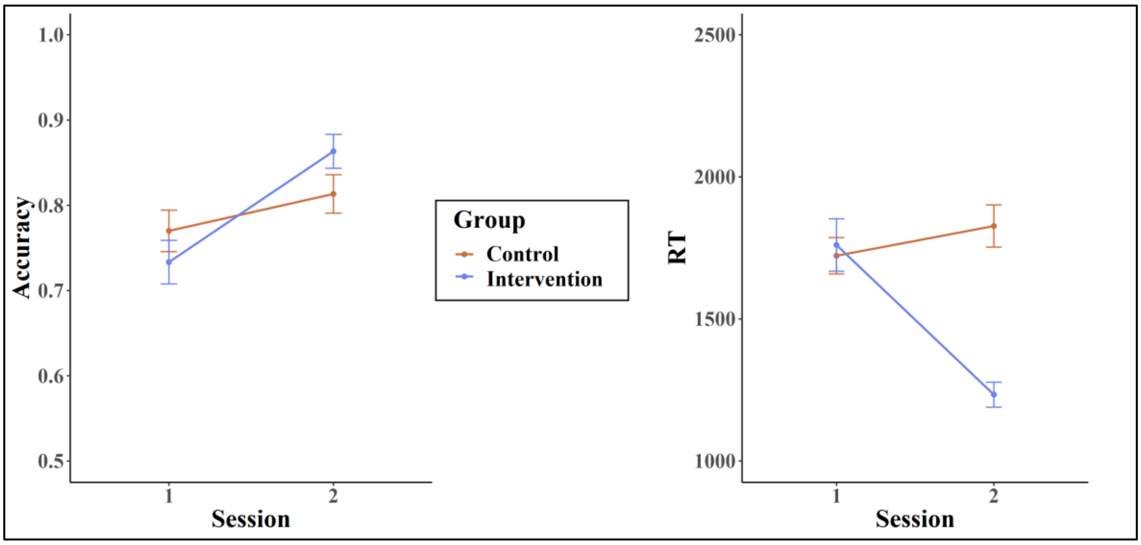
The findings presented in Table 6 indicate that while there were no significant Session or Group main effects in the Vigilance task RT and accuracy data, there were significant Session x Group interactions for both measures. Compared to the control group, children in the intervention group demonstrated significantly greater enhancements with respect to both measured variables (See Figure 4).

Table 6. *Results of the Vigilance task*

VIGILANCE ATTENTION TASK				
Reaction time				
Fixed effects	**β**	**Standard Error**	**t-value**	**p-value**
Intercept	7.314	0.111	65.76	< 0.001
Session	0.006	0.033	0.18	0.857
Group	0.169	0.157	1.07	0.289
Session x Group	-0.247	0.047	-5.24	< 0.001
Accuracy				
Fixed effects	**β**	**Standard Error**	**z-value**	**p-value**
Intercept	1.087	0.405	2.682	<0.05
Session	0.288	0.209	1.377	0.169
Group	-0.769	0.575	-1.337	0.181
Session x Group	0.639	0.305	2.092	< 0.05

Note: Random intercept models for both RT and accuracy measurements are presented.

Figure 4. *Results of the Vigilance task*



Note: Mean RT and accuracy results by group and session. Error bars indicate the standard errors of the mean.

5.3.1.2 Distractor Interference Condition

AIC values of the random intercept robust linear mixed models fitted to the Distractor Interference task's RT data are shown in Table 7.

Table 7. *AIC values from the Distractor Interference task*

Models' description	**AIC**
Session x Group interaction slopes and intercepts vary randomly	1312.9
Session x Group slopes and intercepts are independent and vary randomly	1314.9
Session and Group slopes and intercepts vary randomly	1305.0
Session and Group slopes and intercepts are independent and vary randomly	1307.4
Session slopes and intercepts vary randomly	1299.7
Session slopes and intercepts are independent and vary randomly	1297.9
Group slopes and intercepts vary randomly	1299.4
Group slopes and intercepts are independent and vary randomly	1301.4
Intercepts are random	1295.9

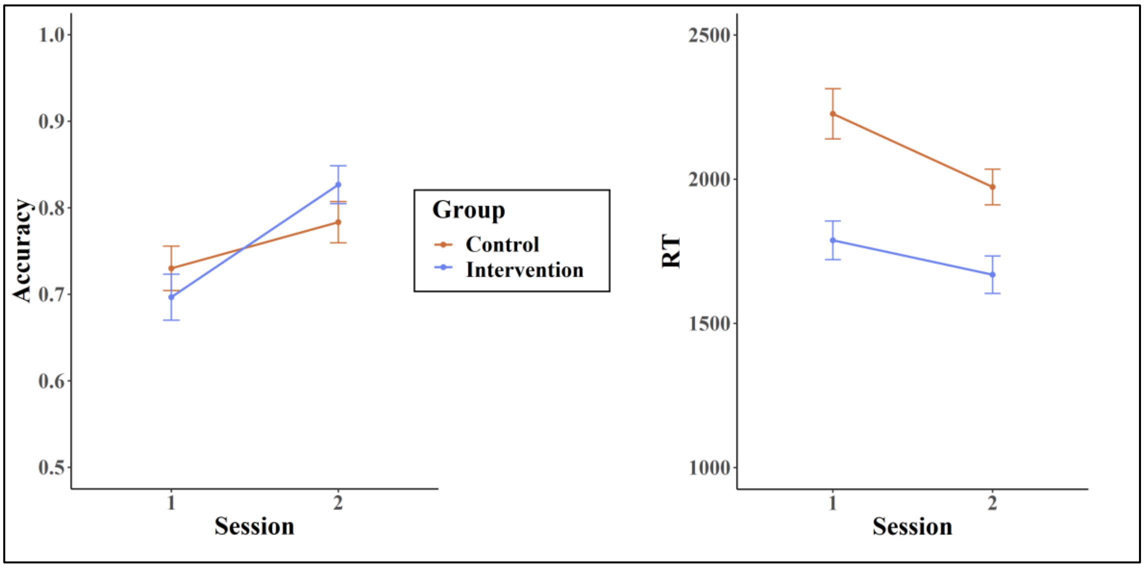
There was a significant Session main effect on RT in the Distractor interference task. All participants with mild ID, both in the intervention group and the control group, showed significantly decreased reaction times during the second administration of the task (See Figure 5). However, no other significant interactions were observed for either RT or accuracy measurements. More details are provided in Table 8.

Table 8. *Results of the Distractor Interference task*

DISTRACTOR INTERFERENCE TASK				
Reaction time				
Fixed effects	**β**	**Standard Error**	**t-value**	**p-value**
Intercept	7.635	0.099	76.82	< 0.001
Session	-0.068	0.033	-2.08	< 0.05
Group	-0.156	0.141	-1.10	0.274
Session x Group	-0.058	0.046	-1.24	0.215
Accuracy				
Fixed effects	**β**	**Standard Error**	**z-value**	**p-value**
Intercept	0.747	0.331	2.253	<0.05
Session	0.304	0.195	1.561	0.119
Group	-0.620	0.468	-1.324	0.185
Session x Group	0.462	0.280	1.648	0.099

Note: Random intercept models for both RT and accuracy measurements are presented.

Figure 5. *Results of the Distractor interference task*



Note: Mean RT and accuracy results by group and session. Error bars indicate the standard errors of the mean.

5.3.1.1 Prepotent Response Inhibition Condition

AIC values of the random intercept robust linear mixed models fitted to the Prepotent Response Inhibition task's RT data are shown in Table 9.

***Table 9**. AIC values from the Prepotent Response Inhibition task*

Models' description	AIC
Session x Group interaction slopes and intercepts vary randomly	1253.2
Session x Group slopes and intercepts are independent and vary randomly	1255.2
Session and Group slopes and intercepts vary randomly	1245.3
Session and Group slopes and intercepts are independent and vary randomly	1247.3
Session slopes and intercepts vary randomly	1239.9
Session slopes and intercepts are independent and vary randomly	1238.3
Group slopes and intercepts vary randomly	1240.1
Group slopes and intercepts are independent and vary randomly	1242.1
Intercepts are random	1236.3

There was a significant Session main effect on RT in the Prepotent Response Inhibition task. All participants with mild ID, both in the intervention group and the control group, showed significantly decreased reaction times at the second administration of the task (See Figure 6). There was a significant Group main effect on accuracy; participants in the control group performed better during pre-intervention testing than those in the intervention group. No other significant interactions were observed for either RT or accuracy measurements. More details are provided in Table 10.

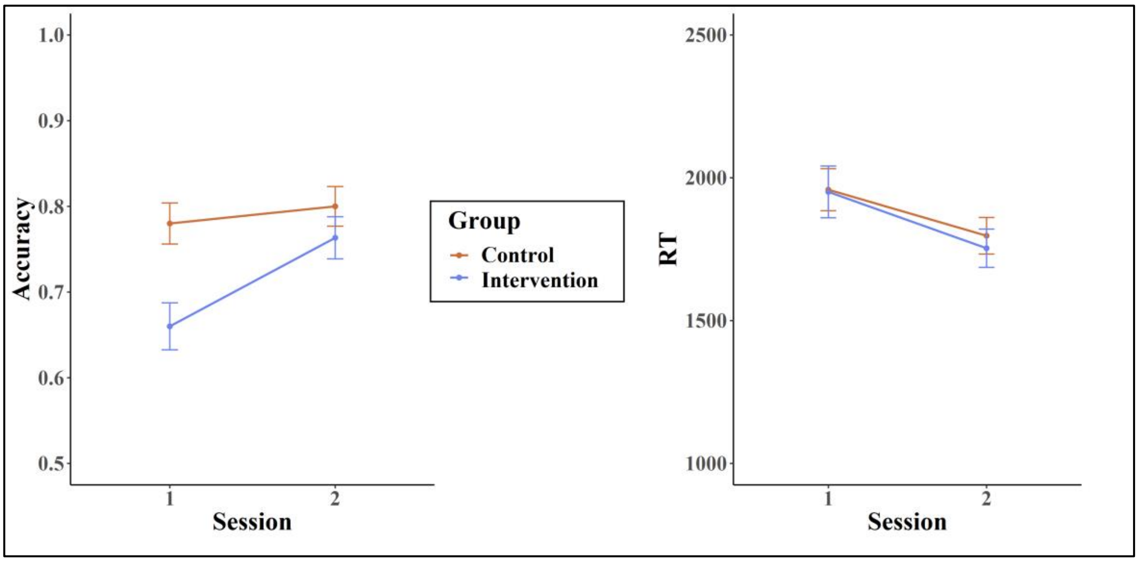
***Table 10.** Results of the Prepotent Response Inhibition task*

RESPONSE INHIBITION TASK				
Reaction time				
Fixed effects	**β**	**Standard Error**	**t-value**	**p-value**
Intercept	7.551	0.105	71.83	< 0.001
Session	-0.052	0.150	-2.68	<0.05
Group	-0.052	0.150	-0.35	0.730
Session x Group	-0.004	0.049	-0.08	0.938
Accuracy				
Fixed effects	**β**	**Standard Error**	**z-value**	**p-value**
Intercept	1.367	0.417	3.282	<0.05
Session	0.140	0.214	0.654	0.513
Group	-1.167	0.567	-2.061	<0.05

Session x Group	0.442	0.289	1.529	0.126

Note: Random intercept models for both RT and accuracy measurements are presented.

Figure 6. *Results of the Prepotent Response Inhibition task*



Note: Mean RT and accuracy results by group and session. Error bars indicate the standard errors of the mean.

5.3.2 Task-Switching

The participants' data analyzed for cognitive flexibility were thirteen children from the intervention group and fifteen from the control group. There were two participants excluded from the analysis of task switching because they did not finish all baseline and/or post-testing conditions.

4.3.5.1. Single block color condition

AIC values of the random intercept robust linear mixed models fitted to Single block color task's RT data are shown in Table 11.

Table 11. *AIC values from the Single block color task*

Models' description	**AIC**
Session x Group interaction slopes and intercepts vary randomly	858.6
Session x Group slopes and intercepts are independent and vary randomly	860.6
Session and Group slopes and intercepts vary randomly	850.6
Session and Group slopes and intercepts are independent and vary randomly	852.6

Session slopes and intercepts vary randomly	846.0
Session slopes and intercepts are independent and vary randomly	848.0
Group slopes and intercepts vary randomly	857.3
Group slopes and intercepts are independent and vary randomly	859.3
Intercepts are random	854.9

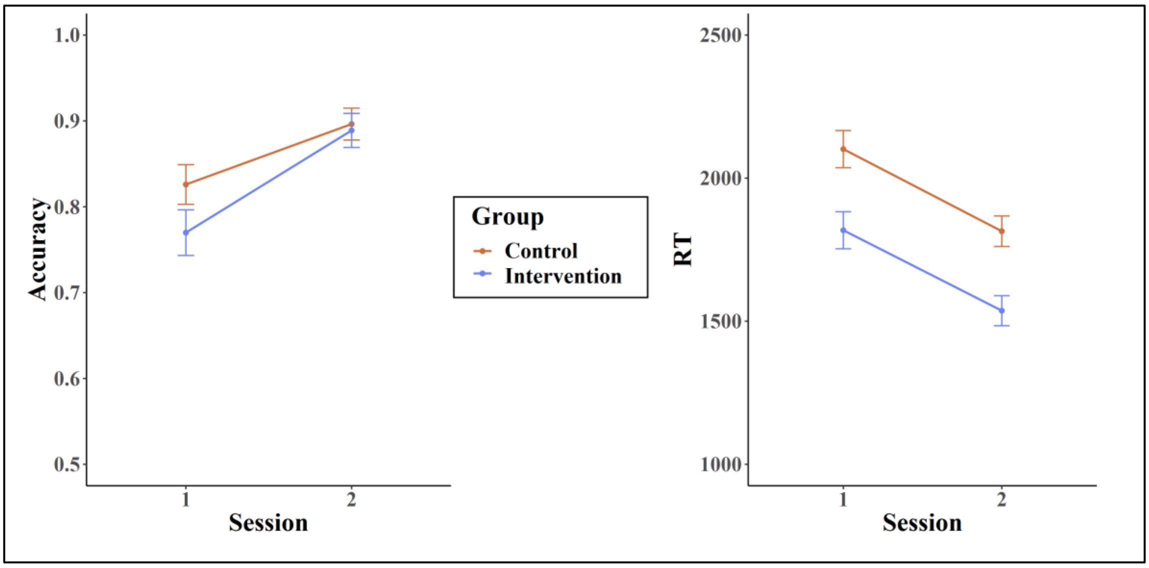
In the single-block color task, the random intercept model fitted to RT data has shown a significant Session main effect (See Figure 7). All participants with mild ID, both in the intervention group and the control group, showed significantly decreased reaction times at the second administration of the task. The Group main effect and Group x Session interaction were nonsignificant. In terms of accuracy, the final model revealed no significant effects. See results in Table 12.

Table 12. *Results of the single block color task*

SINGLE BLOCK-COLOR TASK				
Reaction time				
Fixed effects	**β**	**Standard Error**	**t-value**	**p-value**
Intercept	7.573	0.078	97.48	< 0.001
Session	-0.155	0.034	-1.27	< 0.001
Group	-0.142	0.112	-1.27	0.213
Session x Group	-0.24	0.049	-0.49	0.624
Accuracy				
Fixed effects	**β**	**Standard Error**	**z-value**	**p-value**
Intercept	1.811	0.3215	5.633	< 0.001
Session	0.693	0.443	1.563	0.118
Group	-0.331	0.447	-0.741	0.459
Session x Group	0.307	0.602	0.510	0.610

Note: For RT, we present the random intercept model. For accuracy, the model allowing random slope by session.

Figure 7. *Results of the Single block color task*



Note: Mean RT and accuracy results by group and session. Error bars indicate the standard errors of the mean.

4.3.5.2. Single block shape condition

AIC values of the random intercept robust linear mixed models fitted to Single block shape task's RT data are shown in Table 13.

Table 13. *AIC values from the Single block shape task*

Models' description	**AIC**
Session x Group interaction slopes and intercepts vary randomly	908.6
Session x Group slopes and intercepts are independent and vary randomly	910.6
Session and Group slopes and intercepts vary randomly	900.7
Session and Group slopes and intercepts are independent and vary randomly	902.7
Session slopes and intercepts vary randomly	895.8
Session slopes and intercepts are independent and vary randomly	897.8
Group slopes and intercepts vary randomly	895.0
Group slopes and intercepts are independent and vary randomly	897.0
Intercepts are random	892.0

We found a significant Session main effect in RT and accuracy in the single block shape-task. All participants, both in the intervention and control groups, showed significant improvements at the second administration of the task (See Figure 8).

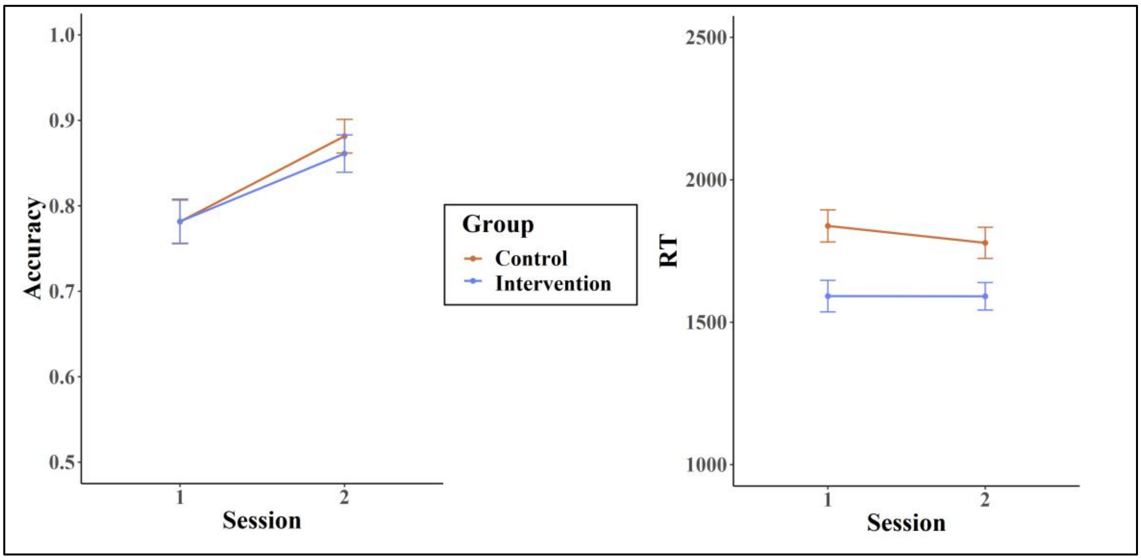
However, Group main effect and Session x Group interaction were not significant for RT or accuracy measurements. See the results in Table 14.

Table 14. *Results of the single block shape task*

SINGLE BLOCK-SHAPE TASK				
Reaction time				
Fixed effects	**β**	**Standard Error**	**t-value**	**p-value**
Intercept	7.570	0.075	101.09	< 0.001
Session	-0.080	0.030	-2.62	<0.05
Group	-0.133	0.108	-1.24	0.219
Session x Group	-0.002	0.044	-0.04	0.966
Accuracy				
Fixed effects	**β**	**Standard Error**	**z-value**	**p-value**
Intercept	1.488	0.308	4.835	< 0.001
Session	0.790	0.245	3.225	<0.05
Group	0.077	0.443	0.175	0.861
Session x Group	-0.144	0.353	-0.407	0.684

Note: Random intercept models for both RT and accuracy measurements are presented.

Figure 8. *Results of the Single-block shape task*



Note: Mean RT and accuracy results by group and session. Error bars indicate the standard errors of the mean.

4.3.5.3. Mixed block condition

AIC values of the random intercept robust linear mixed models fitted to Mixed block task's RT data are shown in Table 15.

Table 15. *AIC values from the Mixed block task*

Models' description	AIC
Session x Group interaction slopes and intercepts vary randomly	2217.8
Session x Group slopes and intercepts are independent and vary randomly	2219.8
Session and Group slopes and intercepts vary randomly	2209.8
Session and Group slopes and intercepts are independent and vary randomly	2211.8
Session slopes and intercepts vary randomly	2203.8
Session slopes and intercepts are independent and vary randomly	2205.8
Group slopes and intercepts vary randomly	2203.8
Group slopes and intercepts are independent and vary randomly	2205.8
Intercepts are random	2199.8

In the mixed block task, we found a significant Session main effect in RT, but neither Group main effect nor significant Session x Group interaction was found. All participants with mild ID, both in the intervention group and the control group, showed significantly increased reaction times at the second administration of the task (Figure 9). In accuracy, there was no significant improvement across sessions. The Session x Group interaction was also not significant. See results in Table 16.

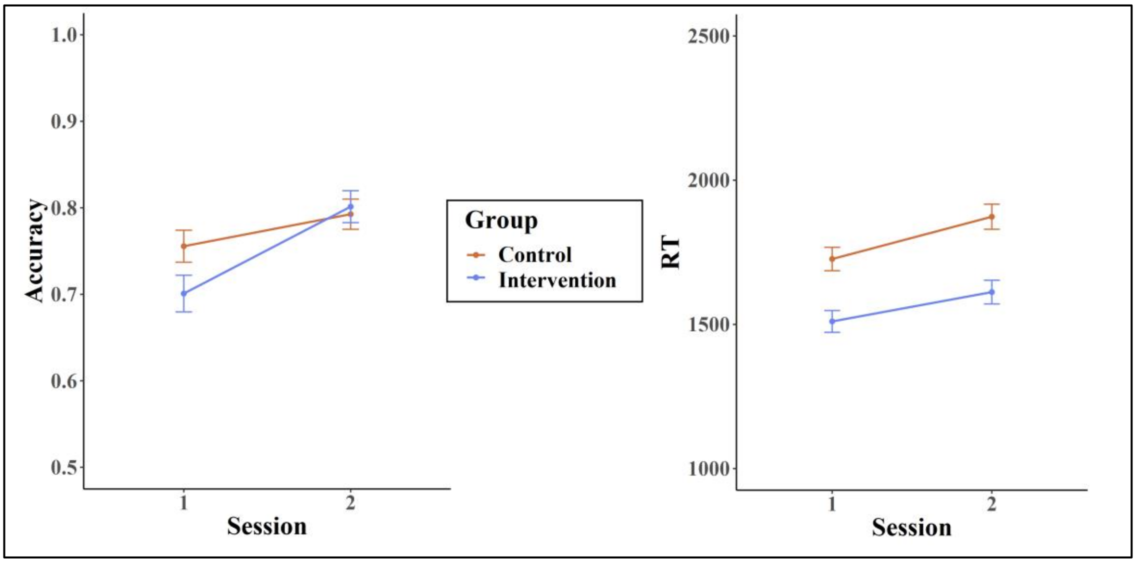
Table 16. *Results of the mixed block task*

MIXED BLOCK TASK				
Reaction time				
Fixed effects	**β**	**Standard Error**	**t-value**	**p-value**
Intercept	7.353	0.055	132.64	< 0.001
Session	0.078	0.029	-1.31	<0.05
Group	-0.107	0.082	-1.31	0.199
Session x Group	-0.038	0.043	-0.87	0.385
Accuracy				
Fixed effects	**β**	**Standard Error**	**z-value**	**p-value**
Intercept	1.128	0.100	11.270	< 0.001
Session	0.212	0.146	1.454	0.146

Group	-0.277	0.142	-1.949	0.051
Session x Group	0.331	0.212	1.561	0.118

Note: Random intercept models for both RT and accuracy measurements are presented.

Figure 9. *Results of the Mixed block task*



Note: Mean RT and accuracy results by group and session. Error bars indicate the standard errors of the mean.

4.3.5.4. Switching and Mixing Costs

We tested the effect of the intervention on the mixing and switching costs using ANOVA, where we compared single-block trials to mixed block stay-trials (mixing cost), or mixed block stay-trials to switch-trials (switching cost) using color and shape cues.

The ANOVA revealed a significant negative mixing cost (trial type main effect: $F(1,26) = 9.252$, $p = 0.005$, $\eta^2_p = 0.262$), participants with mild ID were faster on the mixed-block trials (M=1648.218, SEM=64.263), than on the single-block trials (*M* = 1792.257, *SEM* = 79.171). The Session x Cue type x Trial-type interaction was also significant ($F(1,26)= 7.938$, $p = 0.009$, $\eta^2_p = 0.234$). This significance was due to a difference between mixed and pure stay trials in Session 1: participants had a higher reaction time on single-block trials both on color (*M* = 2019.613, *SEM* = 116.918) and on shape (*M* = 1757.396, *SEM* = 94.619) stimuli compared to the mixed block trials (color: *M* = 1627.927, *SEM* = 68.925; shape: *M* = 1579.092, *SEM* = 77.016), as indicated by the pairwise comparisons (Session 1, color: $p < 0.001$, shape: $p = 0.025$; Session 2 all *p* values >= 0.700). Taken together, these results show a negative mixing cost regardless of intervention, but only in Session 1 (participants were faster on the mixed block trials), but no mixing cost in Session 2. We found no effect of intervention on the mixing cost, as shown by the nonsignificant Session x Cue type x Trial-type x Group interaction ($F(1,26) = 3.192$, $p = 0.086$, $\eta^2_p = 0.109$). However, the effect size indicates a medium effect, and the p-value reached trend level, thus, this result might be due to low statistical power. ANOVA results in Table 17.

Table 17. *Mixing cost ANOVA results*

Effect	F	p	η^2_p
Session	.948	.339	.035
Session x Group	.228	.637	.009
Cue	4.495	.044	.147
Cue x Group	.416	.525	.016
Type	9.252	.005	.262
Type x Group	.001	.980	.000
Session x Cue	2.894	.101	.100
Session x Cue x Group	1.000	.326	.037
Session x Type	7.944	.009	.234
Session x Type x Group	1.103	.303	.041
Cue x Type	.944	.340	.035
Cue x Type x Group	.523	.476	.020
Session x Cue x Type	7.938	.009	.234
Session x Cue x Type x Group	3.192	.086	.109
Group	3.017	.094	.104

Note: df1 = 1, df2 = 26 in each main effects and interactions

When comparing stay and switch trials in the mixed-block, we found a significant switching cost (trial type main effect: $F(1,26) = 6.502$, $p = 0.017$, $\eta^2_p = 0.200$), participants with mild ID were faster on the stay-trials ($M = 1648.218$, $SEM = 64.263$) than on the switch-trials ($M = 1751.923$, $SEM = 71.950$). This switching cost was similar across sessions and cue types, and the intervention did not affect it significantly, as indicated by the nonsignificant Session x Cue type x Trial-type x Group interaction ($F(1,26) = 0.272$,

p = 0.606, η^2_p = 0.010). See ANOVA results in Table 18. Means and standard errors of the means for switching and mixing costs are in Table 19.

Table 18. *Switching cost ANOVA results*

Effect	F	p	η^2_p
Session	1.193	.285	.044
Session x Group	.004	.952	.000
Cue	7.168	.013	.216
Cue x Group	.229	.636	.009
Type	6.502	.017	.200
Type x Group	.045	.834	.002
Session x Cue	.328	.572	.012
Session x Cue x Group	1.381	.251	.050
Session x Type	.078	.782	.003
Session x Type x Group	3.405	.076	.116
Cue x Type	16.046	.000	.382
Cue x Type x Group	.581	.453	.022
Session x Cue x Type	.483	.493	.018
Session x Cue x Type x Group	.272	.606	.010
Group	3.580	.070	.121

Note: df1 = 1, df2 = 26 in each main effects and interactions

Table 19. *Switching and mixing costs: Means and standard errors of the mean.*

Group	Session	Cue type	Trial type	Mean (ms)	SEM
Control	**Session 1**	Color	Single-block trials	2152.675	159.3325
		Color	Mixed/stay trials	1716.142	93.92953
		Color	Switch trials	1687.244	127.2335
		Shape	Single-block trials	1886.939	128.9434
		Shape	Mixed/stay trials	1650.875	104.9546
		Shape	Switch trials	2027.064	154.5407
	Session 2	Color	Single-block trials	1808.209	125.7628
		Color	Mixed/stay trials	1804.188	131.7379

		Color	Switch trials	1754.053	150.8052
		Shape	Single-block trials	1791.973	104.6957
		Shape	Mixed/stay trials	1897.258	112.7605
		Shape	Switch trials	2049.368	163.0471
Intervention	**Session 1**	Color	Single-block trials	1886.55	171.1506
		Color	Mixed/stay trials	1539.713	100.8965
		Color	Switch trials	1321.223	136.6707
		Shape	Single-block trials	1627.853	138.5074
		Shape	Mixed/stay trials	1507.31	112.7393
		Shape	Switch trials	1749.564	166.0034
	Session 2	Color	Single-block trials	1593.033	135.0909
		Color	Mixed/stay trials	1626.662	141.5092
		Color	Switch trials	1588.992	161.9908
		Shape	Single-block trials	1590.826	112.4612
		Shape	Mixed/stay trials	1443.596	121.1242
		Shape	Switch trials	1837.873	175.1406

5.4 GROSS MOTOR PERFORMANCE

All participants' data were analyzed for GMS performance (fifteen children from the intervention group and fifteen from the control group). No exclusions were made in the analysis process.

We present in this section the results of our analyses focused on identifying the main effects and interactions concerning the GMS performance-dependent variables. Specifically, we investigated the variables Session (Session 1: prior intervention/Session 2: post-intervention) and Group (intervention/control).

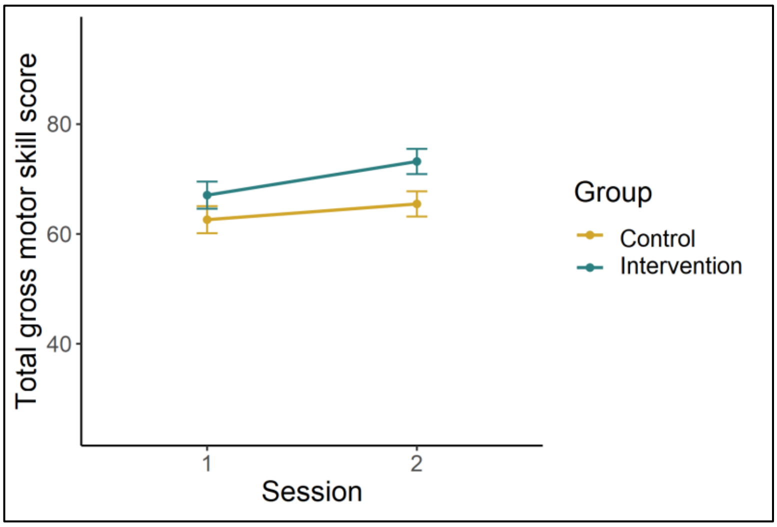
A significant main effect for the variable "Group" indicates differences in GMS between the Control and Intervention. This allows us to discern whether there were substantial differences between the groups at the study's beginning and after the implementation of the physical intervention program. A significant main effect for the variable "Session" suggests differences in GMS between Session 1 and Session 2, regardless of the participation in the physical education program. Moreover, the presence of a significant "Session x Group" interaction implies that the impact of the physical education intervention on GMS differed between Session 1 and Session 2 for both the Control and Intervention groups. This interaction effect holds significant importance, as it indicates the impacts of the intervention with variations in GMS that are not uniform across the two sessions or between the two groups.

5.4.1 Overall Gross Motor Skill

Analysis of the total GMS scores showed a significant Session main effect ($F(1, 28) = 44.591$, $p < .001$, $\eta^2_p = 0.614$). In Session 1, all participants with mild ID had a lower score ($M_{session1} = 64.833$, $SEM = 1.745$) than in Session 2 ($M_{session2} = 69.333$, $SEM = 1.622$). The Group main effect reached a trend level ($F(1.000, 28) = 3.415$, $p = .075$, $\eta^2_p = 0.109$): the control group had a lower score ($M_{control} = 64.03$, $SEM = 2.334$) than the intervention group ($M_{intervention} = 70.133$, $SEM = 2.334$). The Session x Group interaction was significant ($F(1, 28) = 5.875$, $p = .022$, $\eta^2_p = .173$).

The pairwise comparisons revealed that even though both groups developed between the sessions ($p_{control} = .006$, $p_{intervention} < .001$), the intervention group performed significantly better than controls in Session 2 ($p = .024$), but not in Session 1 ($p = .211$). See Figure 10.

Figure 10. *Overall GMS results.*

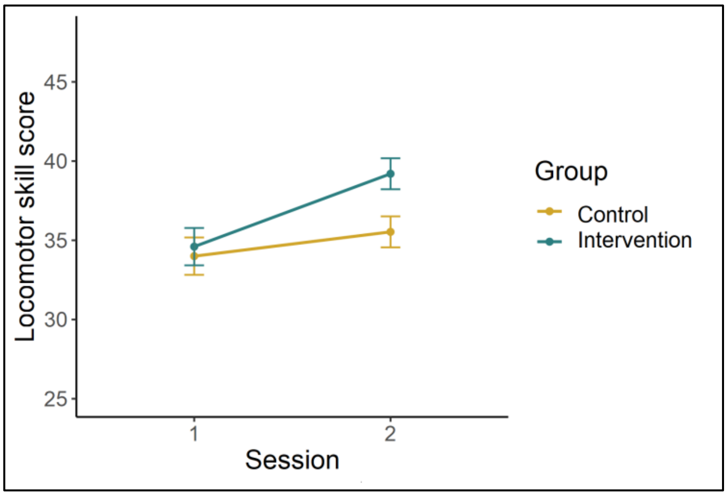


Note: Error bars indicate standard error of the mean.

5.4.2 Locomotor Skills Subtest

On the Locomotor skill subtest, we found a significant Session main effect ($F(1, 28) = 53.618$, $p < .001$, $\eta^2_p = 0.657$), indicating higher locomotor skills in Session 2 compared to Session 1 ($M_{session1} = 34.300$, $SEM = 0.834$, $M_{session2} = 37.367$, $SEM = 0.692$). We did not find a significant Group main effect ($F(1, 28) = 2.096$, $p = .159$, $\eta^2_p = 0.070$). However, the Session x Group interaction reached significance ($F(1, 28) = 13.405$, $p = .001$, eta2 = 0.324). Pairwise comparisons revealed that this significant difference was due to a higher performance of the intervention group than the control group in Session 2 (p = .013), but not in Session 1 (p = .722), indicating that the intervention group developed more locomotor skills than the controls (See Figure 11). See descriptive statistics of the locomotor skill subtest in Table 20.

Figure 11. *Locomotor skills subtest results.*



Note: Error bars indicate standard error of the mean.

Table 20. *Descriptive statistics of the locomotor subtest*

Subtest	Minimum	Maximum	Mean	Std. Deviation
Locomotor	29	45	37.37	4.165

4.3.5.5. Individual Locomotor Skills Results

In order to understand the impact of the intervention on individual locomotor skills, we ran ANOVA separately on each of them. The results are shown in Table 21.

Table 21. *Locomotor skills ANOVA results*

Effect	F	p	η^2_p
Running			
Session	7.383	.011	.209
Group	.006	.939	.000
Session x Group	.639	.431	.022
Galloping			
Session	11.544	.002	.292
Group	1.291	.265	.044
Session x Group	5.338	.028	.160
Hopping			
Session	11.247	.002	.287

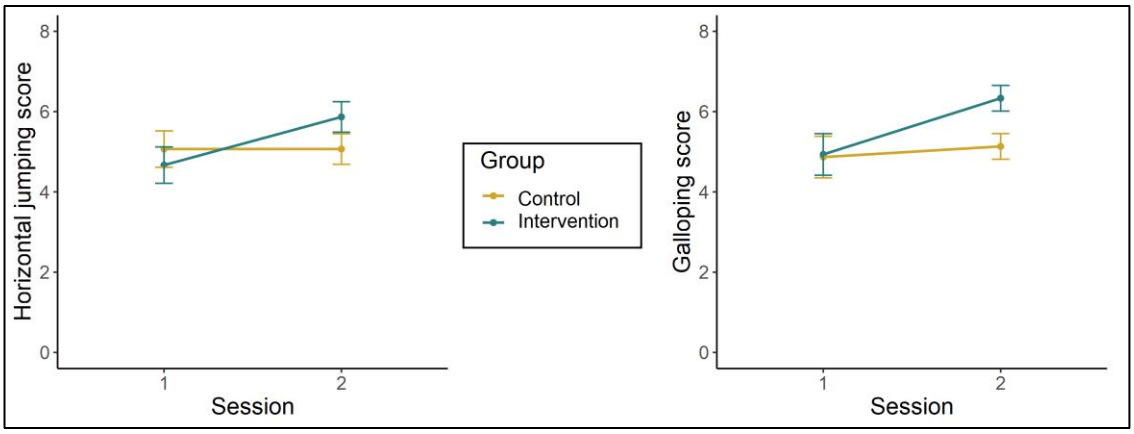
Group	.523	.476	.018
Session x Group	.162	.690	.006
Leaping			
Session	.099	.755	.004
Group	1.525	.227	.052
Session x Group	1.583	.219	.054
Horizontal jumping			
Session	12.393	.001	.307
Group	.125	.727	.004
Session x Group	12.393	.001	.307
Sliding			
Session	.581	.452	.020
Group	1.039	.317	.036
Session x Group	2.814	.105	.091

Note: degrees of freedom are in each case 1 and 28.

In the locomotor skills, there was a significant improvement from Session 1 to Session 2 in each case, except in leaping and sliding. We found no significant Group main effect in any of the locomotor skills. However, there was a significant Session x Group interaction in case of galloping and horizontal jumping.

In galloping, there was a significant difference between Session 1 and Session 2 in the intervention group ($p < .001$), but not in the control group ($p = .448$), and a between-group difference in Session 2 ($p = .013$), but not in Session 1 ($p = .928$). Thus, only the intervention group indicated significant development between sessions. In horizontal jump, the significant interaction was due to the Session 1 – Session 2 improvement in the intervention group ($p < .001$), but not in the control group ($p = 1.000$). See Figure 12.

Figure 12. *Horizontal jumping and Galloping results*

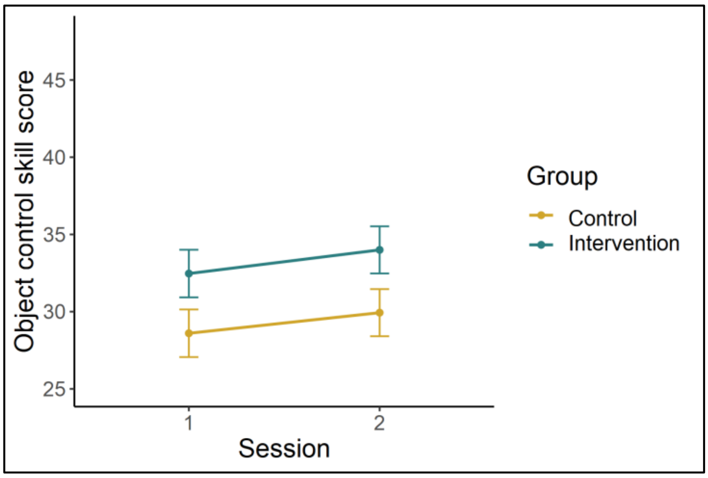


Note: Error bars indicate standard error of the mean.

5.4.3 Object Control Skills Subtest

There was a significant Session main effect on the Object control skill subtest ($F(1, 28) = 7.878$, $p = .009$, $\eta^2_p = 0.220$), in Session 2, all children with mild ID performed better than in Session 1 ($M_{session1} = 30.533$, $SEM = 1.090$, $M_{session2} = 31.967$, $SEM = 1.078$). The Group main effect reached a trend level ($F(1.000, 28) = 3.544$, $p = .070$, $\eta^2_p = 0.112$), children in the intervention group had a tendency to perform better compared to the control children ($M_{control} = 29.267$, $SEM = 1.490$, $M_{intervention} = 33.233$, $SEM = 1.490$). The Session x Group interaction did not reach significance ($F(1, 28) = .038$, $p = .846$, $\eta^2_p = .001$), meaning that the change between sessions was similar in the two groups (See Figure 13). See descriptive statistics of the Object control skill subtest in the sample in Table 22.

Figure 13. *Object control skills subtest results*



Note: Error bars indicate standard error of the mean.

Table 22. *Descriptive statistics of the object control skill subtest*

Subtest	Minimum	Maximum	Mean	Std. Deviation
Object control	17	44	30.53	6.185

4.3.5.6. Individual Object Control Skills Results

In order to understand the impact of the intervention on individual skills, we ran ANOVA separately on each of them. The results of the object control skills are shown in Table 23.

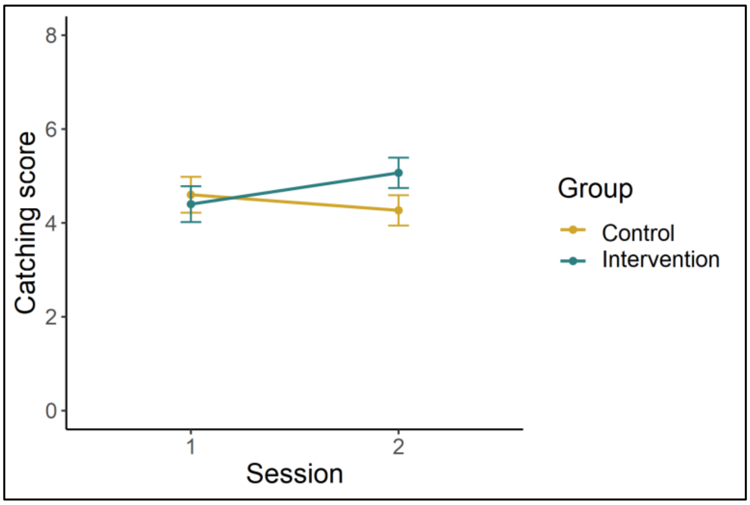
Table 23. *Object control skills ANOVA results*

Effect	F	p	η^2_p
Striking			
Session	0.365	.551	.013
Group	3.503	.072	.111
Session x Group	.365	.551	.013
Dribbling			
Session	5.528	.026	.165
Group	0.087	.771	.003
Session x Group	0.818	.374	.028
Catching			
Session	0.714	.405	.025
Group	.426	.519	.015
Session x Group	6.429	.017	.187
Kicking			
Session	2.350	.137	.077
Group	2.766	.107	.090
Session x Group	0.000	1.000	.000
Throwing			
Session	0.000	1.000	.000
Group	2.982	.095	.096
Session x Group	2.000	.168	.067
Rolling			
Session	1.446	.239	.049
Group	2.116	.157	.070
Session x Group	0.018	.895	.001

Note: degrees of freedom are in each case 1 and 28.

Regarding the object control skills, we found a significant Session main effect only in dribbling. There was a trend level Group main effect in striking and throwing, indicating higher scores in the intervention group compared to the control group. The only skill where the Session x Group main effect was significant, was catching, which was the result of a significant improvement of the intervention group from Session 1 to Session 2 ($p = .024$) but not in the control group ($p = .242$). See Figure 14.

Figure 14. *Catching results.*



Note: Error bars indicate standard error of the mean.

6 DISCUSSION

This section is composed firstly with an overall view of the study, and secondly, with a specific discussion of each hypothesis, summarizing and interpreting the key findings.

This research has provided valuable evidence, for the first time, about the effectiveness of a physical education program enriched with cognitively engaging games in children with mild ID with non-specific etiology. The research aimed to provide a better understanding of the associations between motor and cognitive skills by analyzing the contribution of the intervention program on the cognitive control functions and GMS. This research had an experimental parallel groups design approach and was performed at a specialized educational institution for students with special needs associated with disability in Ecuador.

Our focus on cognitive control was based on its great significance for human autonomous functioning and goal-directed behavior (Cohen, 2017; Medaglia, 2019) and the emphasis that the literature gives to the significant cognitive control difficulties of the populations with ID (e.g., Danielsson et al., 2012; Lanfranchi et al., 2010). Therefore, the study was centered on three underlying cognitive control mechanisms, cognitive flexibility, inhibitory control, and attention. For this purpose, tasks developed at the Cognition and Language Laboratory at the Graduate Center of the City University of New York were used.

Moreover, because of the motor delays in persons with ID, as highlighted in the literature, which can already be seen from an early age *(*APA, 2021*)*, this research also intended to determine the extent to which the physical education program impacted the development of the gross motor performance. This study explored GMS because they are the fundamental motor skills for movement competence and are essential for more complex motor skill development (Stodden et al., 2008). We studied these motor skills by employing the Test of Gross Motor Development–Second Edition (TGMD-2) proposed by Ulrich (2000).

With this background, we sought to corroborate our key hypothesis related to the children's cognitive and motor intervention-related enhancements by comparing participants' performance, who were randomly assigned to an intervention or control group.

Overall, we found strong evidence about the effectiveness of the enriched physical education program on attentional control enhancements, in the sense that the children with mild ID became more accurate and faster in the vigilance task to the imminent incoming stimuli, increasing the cognitive readiness state (Fan et al., 2009). On the other hand, this study does not fully support the assumptions related to improvements in inhibitory control and cognitive flexibility since no significant differences were observed between the control and intervention groups. However, improvement trends in the intervention group suggest an emerging modulatory role of attention on inhibitory control.

The GMS outcomes revealed a significant positive impact of the enriched physical education program on overall GMS performance. Children with mild ID in the intervention group produced better quality movement patterns on the motor criteria examined in this study compared to the controls. Besides, meaningful intervention-related improvements were found in the overall locomotor skills scores, particularly galloping and horizontal jump motor skills. However, this study has been unable to demonstrate the effectiveness of the intervention on the overall object control skills scores due to no significant differences observed between the groups. Yet, it was found that only children in the intervention group showed larger improvements in catching skills, which could be linked to their significant attentional increases because it is an indispensable cognitive requirement in the execution and success in performing this motor skill (Davids et al., 2005; Populin et al., 1990).

6.1 COGNITIVE CONTROL FUNCTIONS HYPOTHESES

Hypothesis 1

Concerning attentional abilities, we expected significant intervention-related enhancements in accuracy and reaction time measurements in vigilance (alerting attention function). These findings would be in agreement with previous research on children with mild ID (Javan et al., 2014) and autism spectrum disorders (Afshari, 2012).

The vigilance task examined the children’s alerting attentional network responsible for achieving and maintaining an increased vigilance state to imminent incoming stimuli prior to a target event (Fan et al., 2009).

The findings supported our hypothesis about the enriched physical education program's influence on vigilance performance. In the accuracy analysis, when comparing post-intervention testing with pre-intervention testing results, we can observe that participants with mild ID in the intervention group had a significant improvement. The intervention group participants' responses became more accurate, showing a considerable increase in the proportion of the correct responses.

In addition to these findings, equally important is the fact that the reaction time results also showed a substantial enhancement in the participants in the intervention group compared to the control group. Thus, children in the intervention group increased their accuracy and decreased their response time to the stimuli indicating a positive effect of the enriched physical education program in both studied dependent variables. These outcomes suggest that children in the intervention group had a better alerting state for perceiving the visual stimulus presented in the task than children in the control group.

The present study is not directly comparable with other literature, although we can mention that, in general, it is in accordance with two previous physical activity intervention studies that have demonstrated enhancements across different attention networks in young populations with ID. Javan et al. (2014) rhythmic play intervention showed improvements in attention problems and general attention, and Fotiadou et al. (2020) psychomotor education program also showed positive school behavioral changes in activities that required attention.

However, the novelty of the present research is that it addresses some of these previous studies' limitations, such as including only participants with mild ID with non-specific etiology with a stricter selection criterion in order to analyze their developmental trajectories. Javan et al. (2014) and Fotiadou et al. (2020) studies, for example, do not specify participants' criteria related to associations with a syndrome or co-existing developmental disorders (e.g., autism spectrum disorder), which prevents us from drawing firm conclusions on the distinctive profiles. Analyzing more specific developmental trajectories is considered a need reflected in the literature to improve our understanding of the within-group differences of this very heterogeneous population by studying groups with similar etiologies and characteristics as much as is feasible (Burack et al. 2012).

Another point that contrasts between the studies mentioned and the present study is the attentional assessment tools. Javan et al. (2014) and Fotiadou et al. (2020) studies used behavior questionnaires and scales designed to be completed by parents and teachers, while this is the first physical activity intervention study that administered directly a computer-based attentional task to the children with mild ID with non-specific etiology. The results indicate that the participants understood the instructions and were able to respond using the buttons according to instructions. Therefore, while preliminary, these findings suggest that this attention task is suitable for young populations with mild ID.

Due to the lack of evidence concerning the application of physical activity interventions in populations with the characteristics of our sample, we might mention that this study's results also support the findings from previous studies with positive attentional effects in populations with other developmental trajectories. For example, studies on children with autism spectrum disorders (Afshari, 2012), attention-deficit hyperactivity disorder (Halperin et al., 2013; Pan et al., 2016; Verret et al., 2012), and developmental coordination disorder (Tsai et al., 2012). Although these studies have fundamental differences in the sample, characteristics of the intervention and attentional networks studied, we can suggest that this study provides further support for the growing body of literature that suggests a relationship between physical activity interventions and cognitive benefits.

In contrast, our findings partially diverge from those of Pesce et al. (2013; 2016) in their studies involving both typically and atypically developing populations. For example, in Pesce et al. (2013), a cognitively demanding physical education intervention promoted attention enhancement only in typically developing children and not in children with developmental coordination disorder, suggesting important differences in the program's effectiveness depending on the groups' developmental trajectories. In this sense, the literature proposes that not all physical activity intervention might generate cognitive gains (De Greeff et al., 2018; Diamond, 2012; Diamond, 2015; Tomporowski et al., 2011; Tomporowski et al., 2015b), and factors such as the quantity and quality of the intervention and the emotional and social experiences are essential factors to consider. Besides, these factors might vary with the participants' age, characteristics, and needs. However, it is an openly recognized fact that our knowledge in this regard is still very limited. More will be discussed on this topic in the following sections of the Discussion.

Therefore, this study's positive attentional results may be explained because we addressed some of the above-mentioned factors. We performed a chronic physical activity program (quantity) with cognitively challenging conditions in which the children needed to be focused and attentive to the instructions (quality). Besides, we selected playful practices that brought joy and pleasure to the participants (emotional and social experiences) and took into account pedagogical considerations associated with this particular population. All with the aim of following the general recommendations of the literature about factors that could generate cognitive benefits.

Overall, these findings confirm that alerting attentional function enhancements could be associated with cognitively enriched physical education practices. Considering that the evidence has shown the attentional difficulties of people with ID, these results have important implications for their attentional development and learning processes (Posner & Rothbart, 2014). Attention is essential in achieving and maintaining focus in any goal-directed behavior, is involved in behavior and emotional regulation, and is a fundamental component to develop more complex cognitive control functions (Cohen, 2017; Garon et al., 2008; Posner & Rothbart, 2005).

Hypothesis 2

We hypothesized larger improvements in the accuracy scores in resistance to distractor interference and response inhibition measurements regarding inhibitory control functions in the intervention group. However, we did not expect any difference between the groups in reaction times. This would be consistent with previous studies which have demonstrated inhibitory control enhancements after a physical exercise program in populations with typical and atypical development (Chang et al., 2014; Fotiadou et al. 2020; Pesce et al., 2016).

The inhibitory control task consisted of two conditions. The first one was the resistance to distractor interference condition, aiming to study the children's ability to avoid being distracted by irrelevant stimuli (distractor stimuli) that were presented concurrently with the target stimuli, and was interfering with task performance. The second was the prepotent response inhibition condition, to examine children's ability to actively suppress the ongoing/habitual behavior that is no longer relevant to pursuing the condition goal (Friedman & Miyake, 2004). The goal of the condition was to identify the display side of the target stimuli exclusively and inhibit the ongoing responses when a distractor item was presented.

Contrary to our expectations regarding accuracy, this study did not find a significant difference when comparing post-intervention with pre-intervention testing results between the two groups' performances in either of the inhibitory control functions. Therefore, outcomes revealed non-significant statistical intervention-related accuracy effects from the enriched physical education program.

One unanticipated finding in the response inhibition condition was the main group effect in accuracy, showing that the children with mild ID in the intervention group had a significantly lower performance in the pre-intervention testing condition compared to the control group. However, this difference was not shown in the post-intervention testing condition, suggesting that the children in the intervention group showed more improvement across sessions than the control children. Moreover, we observed an interesting positive accuracy trend of improvement in both groups and conditions with more prominence in the intervention group, but it did not become statistically significant.

Additionally, it was hypothesized no difference between the groups in reaction time, which was supported by this study's findings. We found a significant session main effect in both inhibitory control conditions in the control and intervention groups. Results showed a reaction time performance improvement in post-intervention testing compared to pre-intervention testing in all participants regardless of the group they belonged to.

These findings are in contrast to two previous -most comparable- studies. The first one is the aforementioned Fotiadou et al. (2020) psychomotor education program that, in addition to showing enhancements in school behavioral changes in activities that required attention in children with moderate ID, also found school behavioral changes in activities that required inhibition. Second, our research outcomes are also inconsistent with the study by Yılmaz and Soyer (2018), in which positive changes were observed in self-regulation ability (a process that requires inhibitory control; Diamond, 2013) after physical education and play lessons in participants with mild ID. Discrepancies between our research and these previous studies' results could be attributed to methodological distinctions. For example, Fotiadou et al. (2020) and Yılmaz and Soyer (2018) studies utilized students' behavior scales reported by teachers, which is not equivalent to the variables directly examined in our study (i.e., accuracy and reaction time), therefore, straightforward comparisons across these studies are not possible. Additionally, the statistical analysis of Fotiadou et al. (2020) and Yılmaz and Soyer (2018) studies did not detect the intervention effects because differences between groups (intervention and control) were analyzed rather than the interaction between the variables as in this study. Hence, as mentioned in the theoretical background of this dissertation, although these studies show preliminary encouraging positive outcomes, they need to be considered with caution due to potential limitations in methodology, statistical analysis, and documentation, which may have contributed to the inconsistent findings observed between these studies and our own.

Regarding studies with participants with other developmental disorders, the current research findings are in line with Verret et al. (2012) study where no significant differences in inhibition abilities were found from a 10-week moderate to vigorous intensity physical activity intervention in children with attention-deficit hyperactivity disorder.

In contrast, our results do not support other previous research on populations with attention-deficit hyperactivity disorder, developmental coordination disorder, and typical development. For example, Chang et al. (2014) studied the effects of an 8-week aquatic exercise program on response inhibition in children with attention-deficit hyperactivity disorder, and significant accuracy improvements were observed. Tsai (2009) also reported improved inhibitory control in children with developmental coordination disorder engaged in a 10-week table tennis program. The inconsistent results may be attributed to the types of physical activity used in the different interventions. Verret et al. (2012) and the present study used a broad and diverse approach focused on a combination of recreational games and/or various sports. Conversely, the studies conducted by Chang et al. (2014) and Tsai (2009) focused on more specialized activities, such as table tennis, or aimed to develop specific skills, such as cardiovascular fitness and motor coordination. It may be that this type of program has the potential to facilitate inhibitory control improvements in children with different developmental trajectories by promoting appropriate cognitive engagement. However, given that studies involving individuals with ID have primarily focused on a more integral approach with diverse practices, as this study, with positive outcomes (Fotiadou et al., 2020; Yılmaz & Soyer, 2018), further research is necessary to draw conclusions regarding this population.

Pesce et al.'s (2016) study could be compared with ours in terms of the content of the intervention. They carried out a physical education program enriched with physical activity games from Tomporowski et al. (2015a) but focused on children with typical development. We can observe contradictory findings when we compare these two studies and consider our hypotheses on intervention-related effects on attention and inhibitory control. Pesce et al. (2016) found a causal relationship between the intervention and benefits in inhibition but not differences in attention results, whereas we found significant differences in attention but none in inhibition.

One plausible explanation for the divergent outcomes observed between Pesce et al. (2016) and ours could be attributed to developmental variations in cognitive abilities across time in the two populations: children with mild ID and typically developed children. Inhibitory control undergoes substantial enhancements during early childhood, with significant improvement between the ages of 3 to 5 years in typically developed children (Best & Miller, 2010). Attention networks also undergo a robust developmental period during early childhood, starting earlier than inhibitory control, from as young as two years of age (Posner & Rothbart, 2005). Therefore, including typically developed children between 5–10 years old in Pesce et al.'s (2016) study may have contributed to the significant gains in inhibitory control only in that particular developmental period. Conversely, limited research exists regarding developmental variations in cognitive abilities across time in children with mild ID, but our findings could suggest that attention networks may undergo significant development between the ages of 10 to 14 years with interventions such as the one from this study. Following the pattern of the typical population, it may be observed that older children with mild ID have different results in inhibitory control ability. It is also important to consider that the longer duration and greater statistical power of Pesce et al.'s (2016) study, which included four hundred children and a 6-month intervention, may have significantly impacted the contrast of results in the evaluated cognitive control abilities. It is possible that a more extended program and a larger population could have led to the detection of significant improvements in inhibitory control in children with mild ID in our age range.

Overall, the non-significant intervention-related effects in this study showed that the physical education program did not generate clear benefits in inhibitory control capacity. There are several possible explanations for these results related to qualitative and quantitative aspects of the intervention. First, these findings could be because our program did not reach the appropriate cognitive engagement to promote inhibitory control enhancements in children with mild ID. Despite including a substantial number of cognitively demanding motor tasks, such as games that require suppression or delay of motor responses, inhibition of ongoing actions, or suppression of habitual responses, this type of physical activity may not be optimal for eliciting significant cognitive benefits in children with mild ID between 10-14 years old. It is possible that physical activity that requires different motor demands in terms of exercise type and intensity may be more effective. As previously mentioned, studies focusing on more specialized activities, such as specific sports, or aimed at developing particular skills like cardiovascular fitness and motor coordination, have facilitated improvements in inhibitory control in children with other developmental trajectories, which may also apply to individuals with ID. In this sense, there is a current agreement in the literature about the need for more research in this field to examine the cognitive, emotional, and motor engagement required in physical activity interventions in order to have an impact on children's cognitive control capacity (Diamond & Ling, 2016; Tomporowski et al., 2015b). Due to the scarce quality research in this matter and the mixed results, it is challenging to identify the best methods and procedures considering the different research contexts and participants (De Greeff et al., 2018; Diamond & Ling, 2016; Pesce et al., 2019; St. John et al, 2020; Tomporowski et al., 2015b). For instance, Pesce et al. (2013) found that the cognitive benefits of a physical activity intervention on attention are different for children with atypical and typical motor development. The authors highlighted that task variables (e.g., exercise intensity, complexity) might moderate this difference.

Secondly, regarding quantitative aspects of the intervention, essential elements to consider are the duration and the frequency. Maybe children with mild ID needed a longer intervention duration (in weeks), more frequent sessions per week, or daily sessions that extend beyond one hour in order to show intervention related improvements in inhibitory control. In particular, the most salient factor appears to be a more extended intervention duration in weeks, based on studies that have demonstrated positive intervention outcomes in populations with diverse developmental trajectories (e.g. Chang et al., 2014; Pesce et al., 2016; Tsai, 2009).

An interesting finding was the accuracy trends of improvement with more prominence in the intervention group, which might suggest that the small sample size of this study may have contributed to the outcomes (i.e., finding only a trend of improvement but not significant change (Serdar et al., 2021). Additionally, if we take into account the attention ability results discussed above, these prominent trends toward improvement in the intervention group may be due to the significant attentional function enhancements. Attention has an essential role in cognitive control conflict resolution by controlling and emphasizing task-relevant stimuli and is a fundamental component of more complex cognitive abilities, including inhibitory control and cognitive flexibility (Burgoyne, & Engle, 2020; Cohen, 2017; Garon et al., 2008). This possibility of physical intervention effectiveness on inhibitory control accuracy results induced by the moderator function of attention has been emphasized in Chang et al. (2014) study with children with attention-deficit hyperactivity disorder.

A possible explanation for the post-testing results with a significant decrease in reaction time in the inhibitory control tasks in both groups might be related to a learning/practice effect due to repeated exposure to the test conditions (Dutilh et al., 2009). Another aspect of consideration is the inherent developmental progression of cognitive functions over time, which is an important factor in young cohorts (Finger & Rand, 2003). Acknowledging this phenomenon is relevant despite the relatively brief interval between the two assessment periods (pre- and post-testing).

Moreover, when considering both accuracy and reaction time results in the response inhibition task, pre-intervention results in the intervention group could have been due to a speed-accuracy tradeoff. Children in the intervention group had significantly more imprecise responses than the control group, but they had similar reaction times. However, in the post-testing results, children that participated in the intervention managed to reduce the accuracy difference between the two groups without increasing their reaction times, although these results did not reach statistical significance. This might also be associated with the limited statistical power of this study.

In summary, these findings revealed that enriched physical education intervention did not significantly affect inhibitory control abilities. However, due to encouraging prominent preliminary tendencies in the intervention group, results suggest that future research might replicate these methods and procedures in a statistically bigger sample to examine if there is a positive cognitive contribution in these cognitive constructs.

Hypothesis 3

Focusing on the function of cognitive flexibility, we predicted differences in performance between the groups in accuracy in the switching task. Moreover, greater reductions in mixing and switching costs (reaction times) were expected in participants in the intervention group compared to the control group. The hypotheses in this construct were based on Schmidt et al.'s (2015) study with typically developed children and Pan et al.'s (2019) with participants with attention deficit hyperactivity disorder. Both found improvement in shifting performance after a physical activity intervention.

Three tasks based on the task-switching paradigm were performed with the children with mild ID to study the cognitive flexibility function. The first two were the Single blocks aimed at examining the participants' ability to sort bivalent stimuli according to one of two dimensions (color or shape). The third task was the mixed block condition to assess participants' ability to quickly adjust their responses to frequently changing rules by sorting by shape and color according to the cues (Diamond, 2013; Vandierendonck et al., 2010).

Our findings did not support our hypothesis about the enriched physical education program's influence on cognitive flexibility performance. Contrary to our expectations, no significant intervention-related effects were found in either of the two dependent measures studied (reaction time and accuracy) in the switching task conditions.

This capacity has scarcely been studied in physical activity intervention settings, and to the author's knowledge, there is no study of intervention-related effects in participants with mild ID. Our outcomes are in contrast to Schmidt et al.'s (2015) and Pan et al.'s (2019) studies, which found significant improvements in cognitive flexibility capacity. Schmidt et al. (2015) focused on a 6-week cognitively engaging physical education program with typically developing children using a modified Flanker task to assess this construct. Although typically, the Flanker task is not a task-switching paradigm but rather a test to assess resistance to distractor interference, the authors included measurement of inhibition control and cognitive flexibility in a single modified Flanker task (Jäger et al., 2014; Röthlisberger et al., 2012). The modification included a fourth Mixed Flanker Task combining previous conditions, where children had to switch between two rules. On the other hand, Pan et al. (2019) performed a 12-week table tennis exercise with children with attention deficit hyperactivity disorder using the Wisconsin Card Sorting Test (Heaton & PARStaff, 2003).

These contradictions can partly be explained by the main difference between the studies related to the participants' characteristics, the cognitive flexibility assessment tools used, and the nature of the interventions. In the last one, we can highlight that Schmidt et al. (2015) and Pan et al. (2019) were focused on a sport ball games (floorball, basketball, and table tennis), which have more competitive and regulatory connotations than the recreational games used in this study.

Future interventions could then focus on activities related to ball sports games to see if they also promote cognitive flexibility benefits in children with ID. However, it is important to mention that these games often have greater gross and fine motor skills demands than our current intervention, and those skills are usually delayed in populations with ID (Westendorp et al., 2011; Wuang et al., 2008; Zhang & Chen, 2004). Additionally, the literature suggests that motor skills performance, physical fitness (e.g., body composition, strength), and exercises habits (e.g., physical activity routines, outdoor play) might be a mediator of the influence of physical activity intervention on cognition in young populations with different developmental disorders (Gapin & Etnier, 2010; Pan et al., 2019; Pesce et al., 2016; Tomporowski et al., 2011). In this sense, physical fitness and exercise habits also might have had an impact on the effectiveness of this study's physical education program. Young populations with ID tend to be more sedentary, overweight, and obese compared to young populations without disabilities (Foley & McCubbin, 2009; Slevin et al., 2014).

Furthermore, results also showed significant changes in reaction times in both groups regardless of the intervention; all children showed decreased reaction times in the two single conditions (color and shape) but increased their reaction time in the mixed condition’s when we compared the post-intervention testing results with the pre-intervention testing ones. These findings in the increase in reaction time in the mixed condition are interesting when considering that at the same time there was a tendency to improve accuracy in both groups with more prominence in the intervention group.

First, it raises the question of whether these more prominent accuracy trends in the intervention group are associated with the study's limited statistical power. Second, we can see how the participants in both groups prioritized accuracy over speed while performing the mixed block, which was the most complicated task since it combined the two previous conditions, and they had to adjust their responses to frequently changing rules according to the cues.

This result may also be explained by natural changes over time through maturation. The speed-accuracy tradeoff patterns in cognitive flexibility ability evolve with age; young children tend to be more impulsive compromising correctness. However, from early ages to adulthood, the capacity to modulate the speed in order to make fewer errors is developed (Cragg & Chevalier, 2012; Davidson et al., 2006; Yeniad et al., 2014). Perhaps these results reflect a crucial period for the development of this cognitive function in children with mild ID. However, this has not previously been described in the literature to the author's knowledge. Future studies could focus on comparing different age groups' performance for a better understanding.

An alternative explanation of these outcomes might be a learning/practice effect from the task-switching paradigm due to the repeated exposure to the same items. This would suggest that children did not require much practice to obtain significant gains in cognitive flexibility because they performed the test only twice with a break of at least six weeks between the two testing sessions. Considering that previous research has shown cognitive flexibility difficulties of people with ID, this learning effect explanation has potentially important clinical implications, particularly in special education settings. Cognitive flexibility is essential to face changing environmental situations and internal demands quickly and effectively and to generate appropriate responses throughout our lives (Braver et al., 2009; Cohen, 2017; Meiran et al., 2015). In young populations, it has been associated with children's potential for learning (Stad et al., 2019) and academic achievement, such as in reading (Engel de Abreu et al., 2014) and mathematics (Clark et al., 2010). Hence, special educational professionals may need to consider selecting and implementing a variety of school activities that promote the ability to shift attentional focus, as it could have a significant development in this age range.

Overall, these outcomes showed that the enriched physical education intervention did not significantly influence cognitive flexibility in participants with ID. However, due to the significant improvements regardless of the groups, this study's results highlight that the children's capacity to configure and execute different responses to changing situations might be enhanced in a relatively short period of time. This is contrary to what tends to be found in the literature, highlighting the significant challenges in cognitive flexibility in the population with ID (Danielsson et al., 2012; Lanfranchi et al., 2010). This could be because these studies often have a mental age-matched peers' comparison, which might be insufficient because they are two fundamentally different groups and consequently have different developmental trajectories (Burack et al., 2012). Future research might replicate this study with bigger samples to verify if there is a positive cognitive contribution to accuracy performance. Besides, future studies could compare different age groups' cognitive flexibility performance to understand better the development of people with mild ID across the lifespan.

6.2 GROSS MOTOR SKILLS PERFORMANCE HYPOTHESES

Hypothesis 1

We hypothesized significant intervention-related improvement in the overall GMS performance. This would be consistent with previous studies which have demonstrated enhancements in GMS competence after a physical activity program in populations with ID and attention deficit hyperactivity disorder (Pan et al., 2019; Verret et al., 2012; Zhang et al., 2021).

To study the gross motor proficiency of children, we examined qualitative aspects of basic movement patterns (Ulrich, 2000) that develop early in life and are needed for physical education and deliberate play (Staples et al., 2012).

As expected, the findings supported our hypothesis about the enriched physical education program's impact on overall GMS performance. When comparing post-intervention testing with pre-intervention testing results, we can observe that both the intervention and control groups improved their total GMS scores. However, children that participated in the enriched physical education program performed significantly better in the post-intervention testing than the children from the control group. Therefore, the intervention group participants produced better quality movement patterns to achieve the GMS performance criteria examined in this study compared to the controls.

Our outcomes are not precisely comparable with other studies because the physical activity intervention research on young populations with mild ID is mainly focused on balance skills and physical fitness (Maïano et al., 2019; St. John et al., 2020), which are not really comparable parameters with the overall GMS performances of this study which included locomotor and object control skills.

To the author's knowledge, only one recent experimental design study with a physical activity intervention analyzed the effect on the same GMS performances in children with ID. Zhang et al. (2021) studied a one-year program with 42 boys with severe ID between 7 to 12 years old. Children in the intervention group participated in a physical activity program including locomotor (e.g., running, sliding) and object control (e.g., catching, kicking) exercises. Children in the control group joined a free play program with supervision. Outcomes showed a significant positive enhancement in the total TGMD-2 scores in the intervention group compared with the control. However, these benefits were observed only in the long term and not in the midterm (6 months).

Although Zhang et al. study and our research show important differences, such as the severity of the ID of the participants and the nature and duration of the intervention, both studies share positive results in GMS performance. An explanation of the differences could be that children with severe ID needed a considerably longer intervention in order to obtain significant results. In this sense, the literature suggests that there is a relationship between the severity of ID and motor delay in populations with ID; the greater the severity, the greater the motor difficulties (Frey & Chow, 2006; Hartman et al., 2010;

Vuijk et al., 2010; Wuang et al., 2008). This notion is strengthened when considering that, in general, persons with mild ID have higher cognitive abilities (e.g., IQ: 50–69, higher understanding and communicative abilities) and need some levels of support in conceptual, social, and practical domains compared with persons with severe ID (IQ: 20–35) that need daily assistance with supervision (APA, 2013; Boat & Wu, 2015), which might suggest different developmental trajectories and therefore, different physical activities interventional needs. For example, in the practical domain, a person with mild ID may require assistance with complex daily tasks, such as managing finances and preparing healthy meals, while performing household chores and traveling to familiar places independently. Conversely, individuals with severe ID typically require support with almost all aspects of daily living, including dressing and bathing.

Furthermore, it is compelling to mention the studies by Verret et al. (2012) and Pan et al. (2019) (referred to in the discussion section 6.1), which, like ours, aimed to examine cognitive control abilities such as inhibition and cognitive flexibility with children with attention deficit hyperactivity disorder; but the same authors also studied the GMS performance using the TGMD-2. The motor outcomes are consistent with the findings of our study; the physical activity intervention positively impacted the overall GMS of the participants. These results are relevant to our study because they demonstrate that physical activity interventions that target both motor and cognitive development do not compromise the enhancement of motor skills, which may be a concern for some physical education professionals. This is encouraging while searching for the cognitive and motor engagement required to impact children's cognitive control, as suggested in the literature (Diamond & Ling, 2016; Tomporowski et al., 2015b).

The performance enhancements in this study can be explained because the program was designed based on the playful practices by Tomporowski et al. (2015a), which required GMS, particularly locomotor skills. Additionally, the children in this study were in an age stage of fast progress in motor learning abilities, which could have facilitated the acquisition of the examined GMS patterns. This is supported by existing literature on children with typical development (Winter & Hartmann, 2007).

GMS are essential for general movement competence and developing more complex motor skills (Stodden et al., 2008). Therefore, the literature emphasizes the necessity for research on physical activity interventions such as the one utilized in this study (Maïano et al., 2019) in view of the exhibited motor delays of children with ID when compared to their typically developing peers (e.g., Westendorp et al., 2011; Wuang et al., 2008; Zhang & Chen, 2004). The findings of this study hold significant implications for the implementation of similar enriched physical education programs aimed at promoting GMS benefits in children with mild ID with non-specific etiology between 10 and 14 years.

Hypothesis 2

Focusing on the GMS subtests, we predicted intervention-related enhancements with significantly higher scores in locomotor skills and tendencies of improvements in object-control skills scores. This would be consistent with the previous study by Verret et al. (2012), which showed similar positive impact patterns of a physical activity program in a population with attention deficit hyperactivity disorder. Moreover, we expected larger intervention-related improvements in gallop skill (locomotor subtest) and the overhand throw skill (object-control subtest) based on Westendorp et al. (2011) study.

We examined qualitative aspects of locomotor and object control basic movement patterns focused on two subtests. The locomotor subtest aimed to study coordinated body movements involving displacement from one place to another (i.e., run, gallop, hop, leap, horizontal jump, and slide), and the object-control subtest intended to analyze fundamental actions implying manipulation and projection of objects (striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll) (Ulrich, 2000).

Our hypothesis of intervention-related enhancements in the GMS subtests was partially supported. Locomotor subtest results followed the same pattern observed in the overall GMS performance. Both groups improved their total locomotor subtest scores when comparing post-intervention testing with pre-intervention testing results. Further, children who participated in the enriched physical education program performed significantly better in post-intervention testing than the children from the control group. In the object control skill subtest, both groups improved their performance, but contrary to our expectations, there were similar changes in the two groups showing that the enriched physical education program did not have an influence on children's performance in the object control skill subtest.

Considering the limited experimental research on physical activity interventions' effectiveness on locomotor and object-control GMS in children with ID (Maïano et al., 2019; St. John et al., 2020), we based our hypothesis on the effects of the 10-week physical activity intervention study from Verret et al. (2012) on children with attention-deficit hyperactivity disorder between 7 to 12 years old. Our results regarding the locomotor subtest are in line with their research since both studies found significant improvements in the locomotor subtest in the intervention groups after the physical activity programs compared to the control group. However, the outcomes of the object control skills subtest are inconsistent, we expected intervention-related trends of improvements that were observed in their study, but we did not find the positive tendencies after our intervention. Likewise, the results of this study partially coincide with those of Pan et al. (2019), who found significant improvements in both the locomotor subtest and the object control in children with attention deficit hyperactivity disorder between 7 to 12 years old after a 12- week table tennis exercise.

This difference in the object control results may be related to the participants' characteristics and the fact that Verret et al. (2012) and Pan et al.'s (2019) interventions were based on different aims and components. Their intervention aimed to maintain a moderate to vigorous intensity (e.g., heart-rate) with various aerobic and sports activities (e.g., table tennis, basketball, tag games, soccer), conditioning and/or motor skills exercises. In our case, our program mainly integrated recreational games with varying intensity, requiring locomotor skills but did not include manipulating objects such as balls or directly explicitly training the motor skill.

Cognition has an important role in pursuing goal-directed motor behavior on motor skill acquisition (Fitts & Posner,1967). Besides, it is suggested in the literature that object control skills require more cognitive functioning than locomotor skills (Latash & Turvey, 1996; Westendorp et al., 2011), probably because the motor movements require the coordination of the own body and the manipulation of external objects. This is perhaps why, in Hartman et al. (2010) and Westendorp et al. (2011) comparison studies, children with mild ID scored lower than participants with borderline ID (IQ: 70 - 85) in the locomotor skills, but there were no significant differences for the object control skills scores. Overall, the object-control skills subtest scores were lower than the locomotor in both groups with ID. Particularly, in Hartman et al. (2010) study, results showed that object control skills performance was positively associated with cognitive functioning (i.e., decision-making, planning, and solving problem skills). Children with ID with the lowest object-control skills subtest scores also had lower cognitive functioning scores. However, considering that our intervention was designed to promote cognitive and motor development through cognitive engagement games by Tomporowski et al. work (2015a) and the literature assumes that the object-control skills require more cognitive functioning due to their complexity, we expected improved performance.

Therefore, we can deduce that the physical education program did not have the necessary motor and cognitive engagement and/or intervention load (intensity, frequency, volume, etc.) to promote a change in the object-control skills subtest scores. When discussing intervention load, it is relevant to consider the duration and frequency of the program. For instance, Verret et al. (2012) found that their program, which lasted for 10 weeks with sessions occurring three times per week, had tendencies of improvements in object-control skills scores in the participants. The duration and frequency of our intervention were determined primarily by the findings of Schmidt et al. (2015). They performed a randomized controlled trial study involving a cognitively engaging physical activity program to enhance cognitive abilities in children with typical development. Moreover, secondly, considering the timeframe that the educational institution offered. However, it may be that for this type of content (playful practices), more extensive and frequent interventions could be required to observe changes in the object-control skills subtest scores.

Other possible explanations for object-control skills subtest results may be personal factors that may influence intervention efficiency on these motor skills performances. Physical fitness and lifestyle habits may contribute to the results. The Westendorp et al. (2011) comparison study with children with mild ID, borderline ID, and typically developing children is a good example of this matter. The authors found that the higher object-control skills subtest scores in the three groups belonged to children with higher participation in organized sports. The organized sports were in sports club settings, and soccer was the most practiced. Nevertheless, findings did not show this positive relationship with the locomotor skills subtest. The authors also highlighted that children with ID participate considerably less in sports than the typically developing children.

Populations with ID tend to have greater sedentary habits from an early age than young populations without disabilities, which increases the percentages of overweight and obesity in this population when accompanied by inadequate dietary behavior (Foley & McCubbin, 2009; Slevin et al., 2014). Bossink et al. (2017) performed an interesting systematic review, including 24 studies, to understand why people with ID have low physical activity participation. The authors found essential barriers to participation such as staffing level and expertise, limited options for physical activity, lack of inclusion and financial support, among others. Besides, the most outstanding facilitators for participation were activities with fun components and social interaction. This could explain the high participation in the physical education program of this study (overall average intervention attendance rate of 90.56%,), since both components were primary factors throughout the intervention.

Furthermore, as expected, when we analyzed the individual locomotor skills, results showed that galloping skills significantly improved only in the intervention group. In addition, a positive unanticipated finding was that the horizontal jump locomotor skill also improved in the children that participated in the program. On the other hand, results from the individual object control skills did not support our hypothesis because no significant intervention-related enhancement was found in the intervention group in overhand throw skills. However, unexpectedly, only children in the intervention group showed larger improvements in catching skills.

Regarding the individual motor skill analysis, we based our hypotheses on Westendorp et al. (2011) comparative study due to the very limited data available from previous research on this matter. Although research examining these skills is scarce in populations with ID, the few that exist only report overall total results and no data on each specific item, which considerably limited the prediction of significant individual motor skill changes. An excellent example of this is that none of the physical education studies mentioned in this section using the TGMD reported analyzes per motor skill individually. This is part of the gap recognized in literature (Maïano et al., 2019). Westendorp et al. (2011) comparative study found that the children with mild ID performed significantly lower in all individual motor skills compared to children with typical development except for gallop (locomotor) and the overhand throw (object control). Therefore, our hypothesis was focused on that their motor strengths would benefit from the intervention, which was partially supported, as mentioned before.

Our results are consistent with Westendorp et al. (2011) study with significant increases in galloping locomotor skills, and in addition, we found an unexpectedly positive result in the horizontal jump locomotor skill. These results are not entirely surprising since most of the games required movements involving displacement from one place to another, especially walking and running at different paces and under different conditions. In any case, only three games included jumping or galloping freely (the chameleon, photo album, and movie of the animal world). For example, in the chameleon game, children had to move assuming the movement pattern of different animals, in which a frog was one of the main characters. Therefore, children had to perform an approach or avoid jumping motor behavior accordingly. However, the quality of movement was not previously determined or evaluated; the children could move by jumping as they wanted according to their imagination and motor skills.

The results of our study did not support our expectation of an intervention effect on overhand throw skill (object control skill), but rather a significant improvement in catching skills was detected. Our intervention did not include any catching movement training or any activity with manipulation of objects. However, this difference between the two groups can be linked to the significant attentional increases in the children who participated in the intervention.

The important role of attention in catching skills has been pointed out for some decades now. Populin et al. (1990) research, for example, showed that visual attention is a requirement to position the hand in the catching movement pattern regardless of the motor skill level of the participants. Davids et al. (2005) also highlighted that the ability to program postural and orientational motor responses to an oncoming ball requires attentional mechanisms and visual perception. In this study, the evaluated criteria included the arms', hands', and elbows' position and movement in relation to the rest of the body and the ball in the preparation and ball anticipation phase (i.e., when the ball was approaching). Finally, we evaluated the ball-hands contact criteria that require precise spatial and temporal perception (Mazyn et al., 2007), which in this case, could have benefited from enhancement attention.

Regarding the no significant intervention-related effects of the intervention on the overhand throw, an explanation for these results may be that the performance of this skill demands a high degree of motor coordination, being one of the most challenging fundamental skills for individuals of all ages (Hamilton & Tate, 2002; Seroyer et al., 2010). Throwing overhead is considered a complex motor skill that requires the coordination of the entire body, in contrast to other GMS as catching, which is predominantly focused on upper extremity positioning and ball contact, as described above. The overhand throw encompasses a range of movement components, including arm and foot movement and hip and shoulder rotation, as detailed in Appendix 5's performance criteria. Therefore, it is probable that significant enhancements in the execution quality of this skill in children with mild ID would necessitate a more focused training approach targeting the specific movement patterns instead of relying solely on the cognitive and motor skills development promoted by the intervention utilized in this research.

Overall, these outcomes showed that the enriched physical education program promoted a significant development of locomotor skills in children with ID. Altogether, when considering the results of both the locomotor and object-control skills subtests, it appears that the substantial positive impact of the intervention on the overall GMS test can be attributed to the significant improvement seen in the locomotor subtest. Additionally, we found that the intervention promoted improvements in three specific GMS: galloping, horizontal jump, and catching, which could have been due to the motor and cognitive demands of the games included in the intervention and due to the attentional benefits in the group that participated in the enriched physical education program.

Maïano et al. (2019) systematic review highlighted that the effectiveness of physical interventions on locomotor and object control motor skills in young populations with ID remains unclear due to the lack of quality studies. In this sense, this study contributes to growing research focused on developing these specific motor skills helping to fill this critical gap. These motor skills are fundamental for more complex skills (Stodden et al., 2008) and are required for participation in playful practices, sports, and physical activity practices throughout our lives (Eguia et al., 2015). Therefore, this intervention seems a good alternative to provoking an improvement in GMS in children with mild ID, which is essential due to the delays observed in comparison with the typically developing population. In turn, it could help counteract the levels of sedentary lifestyle (Engel et al., 2018; Foley & McCubbin, 2009), obesity (Slevin et al., 2014) and reduce the barriers to participation observed in this population (Bossink et al., 2017), but its effects on these parameters should be investigated in future research.

7 CONCLUSIONS

7.1 LIMITATIONS, CHALLENGES AND FUTURE RESEARCH

Although some of the present findings are promising, they should be considered preliminary, given certain limitations that need to be addressed. As previously mentioned, the most significant limitation is the relatively small sample size and consequently insufficient statistical power to detect potential intervention-related small effects and differences; and increase the probability of sampling biases.

The reason for this is that the study set out to develop the intervention in the only specialized educational institution for students with special needs associated with disability in Manta city at that time. After initial contact with the institution's authority and based on previous studies (Chang et al., 2014), it was decided that it is a realistically achievable sample size given the circumstances and the context. Additionally, it was essential for the author to carry out the study in an educational institution and conduct it as physical education lessons for the practical educational implications that it could entail. Therefore, although small, the participants of our sample represent the majority of specialized educational institution-schooled children of Manta City between 10- and 14 years old with mild ID with non-specific etiology (without other co-existing developmental disorders and significant physical/sensory limitations).

The sample size constraint, together with the limited number of trials, and the typical heterogeneous nature of the ID groups, restrict the study findings' generalizability to the larger young population. Therefore, although this research represents an improvement over the past most comparable studies on this population, it would be beneficial for future research to consider a larger sample and a greater number of trials to increase the statistical power and decrease sampling biases.

There were other inherent methodological limitations to the current study developed in a single special needs educational center. For example, group assignment blinding was not possible in this setting, nor for children, teachers, or parents. Although all the people involved knew that the thirty children were going to participate in the program, it was made clear from the beginning that one group would receive the intervention first (intervention group) and the other later (control group). Perhaps, this could have increased the engagement and expectations for changes for the first group (i.e., Hawthorne and Halo effect) and consequently influenced the outcomes.

Additionally, due to the two groups attending the same school each day, we could not control possible social interactions between the participants from the two groups during the school break times or extracurricular free time. Strategies such as blinding, keeping control and intervention groups separated, and placebo control groups could eliminate this bias in further studies (Barnes, 2010).

Other limitations were related to the specific characteristics of the sample. It is important to mention that Ecuador's specialized education institutions for students with special needs associated with disability are a preparatory basis for the possible inclusion of students in the so-called inclusive educational institutions. Inclusive educational institutions are regular schools whose students are mainly typically developing but with processes to integrate students with disabilities meeting certain requirements such as accessibility, infrastructure, and support teams (Ministry of Education of Ecuador, 2018). Therefore, these results could have been different if this intervention had been carried out with children matching the same inclusion criteria of this research but already attending an inclusive educational institution. Not only because they might have exhibited different motor and cognitive profiles but because they may be exposed to different educational and environmental factors when attending a school with children without disabilities. However, the school director mentioned that some of the children involved in this study were already in the process of being transferred to inclusive educational institutions.

Furthermore, the participants' IQs were not available, which is an important factor to consider in this population (DSM-IV Criteria; APA, 1994). Unavailability of IQ scores is a common limitation in studies performed in schools (e.g., Frey & Chow, 2006; Rintala & Loovis, 2013). Future research could focus on a sample with different educational backgrounds (i.e., from specialized and inclusive educational institutions) to generalize the results to the schooled population with mild ID and include the IQs to better understand the differences between the participants.

We used the games from Tomporowski et al. work (2015a) based on three principles of mental engagement: contextual interference, mental control, and discovery play. However, no validated standardized instrument to measure the cognitive control engagement components of the games for the sample was used, and to the author's knowledge, such instruments are not available. Moreover, there was no follow-up to measure the sustainability over time of the positive intervention-related outcomes in the children in the intervention group. Therefore, methods for detecting the cognitive engagement inherent in this and other physical activity and performing follow-up studies to verify their long-term impact could be the focus of future studies.

Future research could also consider additional individual factors and physical activity components. In the first one, it would be beneficial to include physical fitness measurements (e.g., body composition, strength) and lifestyle habits (e.g., physical activity routines/patterns, deliberate play, diet) to analyze if there is an association or if they are moderating the efficiency of the program, as has been seen in other research (Gapin & Etnier, 2010; Hsu et al., 2021; Pan et al., 2019; Pesce et al., 2016; Salse-Batán et al., 2021; Sulton & Jajat, 2019; Tomporowski et al., 2011; Westendorp et al., 2011). Additionally, it would be important for future research to evaluate and analyze the participants' socioeconomic status (SES) since the literature suggests a relationship between SES and health, achievement, learning, and development (e.g., Darin-Mattsson et al., 2017; Naeem et al., 2018; Sweeney, 2015). Regarding physical activity components, more studies are recommended to explore the best practices in physical activity interventions (e.g., frequency, intensity, volume, movement patterns) to generate cognitive and motor gains.

Despite the limitations of this study, findings can thus provide preliminary encouraging evidence on the potential of enriched physical education programs to enhance attention control and locomotor performance in children with non-specific mild ID. However, the interpretability and generalizability of the results to a larger young population are limited. Despite the constraints, it is believed that this study is a valuable contribution to the sparse literature available on this topic, providing a useful reference for replication and future research directions.

Finally, it is important to mention that a challenge encountered in this study was that, in the beginning, some teachers hesitated to invite children with their parents to participate in the program because other researchers had not shared their results with them following the completion of their studies. Thus, the principal investigator spent more time than what had been originally planned with the teachers to assure them that the researcher would return with the study outcomes. Finally, we agreed that the findings would be presented to people involved and key stakeholder organizations in appropriate scientific publications and a doctoral thesis summary. Additionally, descriptions of the games (in Spanish) were given to all teachers after the intervention to enlarge their repertoire of fun physical activities with the children.

7.2 Conclusion and Practical Implications

To our knowledge, this is the first physical activity intervention research using an experimental design and computer-based cognitive tasks to examine the effects on cognitive control and GMS in children with mild ID with non-specific etiology. Although this study provides preliminary data, the findings offer encouraging evidence of the potential of physical activity to promote significant enhancements in locomotor skills and attentional control functions, suggesting that the latter one had an emerging modulatory role due to tendencies of improvements in more complex control functions and object control motor skills (i.e., catching skill).

Both the attentional and motor enhancements associated with the enriched physical education program are of great importance, considering the challenges shown by children with mild ID and the implications that these entail in the daily life of children. For example, attention is essential in children's learning processes (Posner & Rothbart, 2014), achieving and maintaining focus in goal-directed behaviors (Cohen, 2017), regulation of emotions, and the development of more complex cognitive control functions (Garon et al., 2008; Posner & Rothbart, 2005). The literature also highlights its importance as a prerequisite for complex motor patterns (Populin et al., 1990). This suggests that future physical education programs could strategically integrate activities that specifically target attentional improvement, offering meaningful support to children with mild ID, potentially fostering their cognitive development and equipping them with enhanced capabilities to participate effectively in various aspects of life.

Furthermore, GMS are fundamental for movement competence and are the basic building blocks for more complex motor skill development (Stodden et al., 2008) and all physical activity and sports participation throughout our lives. Therefore, forthcoming physical education strategies promoting GMS to enhance movement competence and to counteract the sedentary lifestyle tendencies and overweight issues often prevalent in this population (Engel et al., 2018; Foley & McCubbin, 2009; Slevin et al., 2014) play an essential role.

Moreover, with this study's findings, teachers and educators could make appropriate modifications and adaptations according to the educational objectives of the Ecuadorian physical education curriculum and use programs like this one to enhance motor and cognitive skills. Play is a right of every child (United Nations Children's Fund [UNICEF], 1989), an agent of global development (Juan & Montes, 2001), and can be organized with flexible structures that can be adapted to the characteristics of the children with mild ID (Mero Piedra, 2020b). In light of teachers' recommendation of selecting the physical education content by prioritizing the most significant values, interests, and needs of the students in each unique context stipulated by the Ministry of Education of Ecuador (2016a), this intervention emerges as an appropriate educational avenue to explore.

The outcomes of present study hold immediate implications and extend to reshaping the landscape of future physical education practices. The innovative approach highlights the potential for a more holistic paradigm shift in physical education in Ecuador; by centering the curriculum around activities that promote physical well-being and address significant cognitive control enhancement. Educators can effectively create an inclusive learning environment that caters to the diverse requirements of students, particularly those with mild ID. This approach further underscores the malleability of educational systems, suggesting that a proactive and adaptive approach to curriculum development can address a wider range of student abilities and needs.

The enriched physical education program's potential applicability can be extended beyond the cohort initially targeted, opening doors for children with other eligibility criteria such as Down Syndrome. The intervention's versatility lies in its adaptability; its implementation can be seamlessly integrated into various educational settings in an open and safe space in any school, as well as be employed as a complementary physical therapy program.

This study leads to re-examining the circumstances and experiences children are exposed to in our schools. Taking into consideration the responsibility of teachers and educators to critically reflect and restructure our own teaching (Zeichner, 1986) and the policy-making sphere that nowadays contemplates physical education and, in general, physical activity as a public health priority, physical education professionals should try to maximize this opportunity advocating the best practices promoting an integral development in populations with ID, eliminating the barriers to participation that usually this population encounters (Bossink et al., 2017). As we seek to create inclusive frameworks that address diverse learning needs, interventions such as this one stand as an example of innovation by recognizing that physical education can be a powerful conduit for more holistic and integrated development.

8 REFERENCES

Adolph, K. E., & Berger, S. E. (2006). *Motor development.* In D. Kuhn & R. S. Siegel (Eds.), Handbook of child psychology: Vol. 2: Cognition, perception and language (6th ed., pp. 161-213). New York: Wiley

Afshari, J. (2012). The effect of perceptual-motor training on attention in the children with autism spectrum disorders. *Research in Autism spectrum disorders*, *6*(4), 1331-1336. https://doi.org/10.1016/j.rasd.2012.05.003

Alloway, T. P., & Alloway, R. G. (2010). Investigating the predictive roles of working memory and IQ in academic attainment. *Journal of experimental child psychology*, *106*(1), 20-29. https://doi.org/10.1016/j.jecp.2009.11.003

Alvarez-Bueno, C., Pesce, C., Cavero-Redondo, I., Sanchez-Lopez, M., Martínez-Hortelano, J. A., & Martinez-Vizcaino, V. (2017). The effect of physical activity interventions on children's cognition and metacognition: A systematic review and meta-analysis. *Journal of the American Academy of Child & Adolescent Psychiatry*, *56*(9), 729-738. https://doi.org/10.1016/j.jaac.2017.06.012

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.).

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

American Psychiatric Association. (2021). *What is Intellectual Disability?* Retrieved from https://www.psychiatry.org/patients-families/intellectual-disability/what-is-intellectual-disability

American Psychological Association. (n.d.). Intellectual function. In *APA Dictionary of Psychology*. Retrieved January 14, 2023, from https://dictionary.apa.org/intellectual-function

American Psychological Association. (n.d.). Mental abilities. In *APA Dictionary of Psychology*. Retrieved January 14, 2023, from https://dictionary.apa.org/mental-abilities

American Psychological Association. (n.d.). Retrieval. In *APA dictionary of psychology*. Retrieved November 18, 2021, from https://dictionary.apa.org/retrieval

Antequera Maldonado, M., Bachiller Otero, B., Calderón Espinosa, M. T., Cruz García, A., Cruz García, P. L., García Perales, F. J., ... & Ortega Garzón, R. (2008). *Manual de atención al alumnado con necesidades específicas de apoyo educativo derivadas de discapacidad intelectual*. Sevilla: Junta de Andalucía, Consejería de Educación, 2008. Retrieved from https://redined.educacion.gob.es/xmlui/bitstream/handle/11162/3180/00120122000058.pdf?sequence=1&isAllowed=y

Arnheim, D., & Sinclair, W. A. (1979). The basic motor ability tests-revised. In D. Arnheim, & S. Sinclair (Eds.), The clumsy child (2nd ed., pp. 119–144). St Louis: Mosby.

Asim, A., Kumar, A., Muthuswamy, S., Jain, S., & Agarwal, S. (2015). Down syndrome: an insight of the disease. *Journal of biomedical science*, *22*(1), 1-9. https://doi.org/10.1186/s12929-015-0138-y

Baddeley, A. D., Allen, R. J., & Hitch, G. J. (2011). Binding in visual working memory: The role of the episodic buffer. *Neuropsychologia*, *49*(6), 1393-1400. https://doi.org/10.1016/j.neuropsychologia.2010.12.042

Bailey, C. E. (2007). Cognitive accuracy and intelligent executive function in the brain and in business. *Annals of the New York Academy of Sciences*, *1118*(1), 122-141. https://doi.org/10.1196/annals.1412.011

Bailey, R., Armour, K., Kirk, D., Jess, M., Pickup, I., Sandford, R., & Education, B. P. (2009). The educational benefits claimed for physical education and school sport: an academic review. *Research papers in education*, *24*(1), 1-27. https://doi.org/10.1080/02671520701809817

Baler, R. D., & Volkow, N. D. (2006). Drug addiction: the neurobiology of disrupted self-control. *Trends in molecular medicine*, *12*(12), 559-566. https://doi.org/10.1016/j.molmed.2006.10.005

Barnes, B. R. (2010). The Hawthorne effect in community trials in developing countries. *International Journal of Social Research Methodology*, *13*(4), 357-370. https://doi.org/10.1080/13645570903269096

Bartholdy, S., Cheng, J., Schmidt, U., Campbell, I. C., & O'Daly, O. G. (2016). Task-based and questionnaire measures of inhibitory control are differentially affected by acute food restriction and by motivationally salient food stimuli in healthy adults. *Frontiers in Psychology*, *7*, 1303. https://doi.org/10.3389/fpsyg.2016.01303

Beery K. E. (1997) *Developmental Test of Visual-Motor Integration*, 4th ed. Western Psychological Services, Los Angeles, CA.

Ben-Haim, M. S., Williams, P., Howard, Z., Mama, Y., Eidels, A., & Algom, D. (2016). The emotional Stroop task: assessing cognitive performance under exposure to emotional content. *Journal of visualized experiments: JoVE*, (112). https://doi.org/doi:10.3791/53720

Best, J. R. (2010). Effects of physical activity on children’s executive function: Contributions of experimental research on aerobic exercise. *Developmental review*, *30*(4), 331-351. https://doi.org/10.1016/j.dr.2010.08.001

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child development*, *81*(6), 1641-1660. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Betancourt, M. (2018). Visibilización de las personas con discapacidad en el Ecuador: Un enfoque desde los derechos de participación ciudadana/política. *Revista Latinoamericana en Discapacidad, Sociedad y Derechos Humanos*, 37-52.

Bexkens, A., Ruzzano, L., Collot d'Escury-Koenigs, A. M. L., Van der Molen, M. W., & Huizenga, H. M. (2014a). Inhibition deficits in individuals with intellectual disability: a meta-regression analysis. *Journal of Intellectual Disability Research*, *58*(1), 3-16.

Bexkens, A., Van der Molen, M. W., Collot d’Escury-Koenigs, A. M., & Huizenga, H. M. (2014b). Interference control in adolescents with mild-to-borderline intellectual disabilities and/or behavior disorders. *Child Neuropsychology*, *20*(4), 398-414.

Bialystok, E., & Feng, X. (2009). Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults. Brain and Language, 109(2-3), 93–100. https://doi.org/10.1016/j.bandl.2008.09.001

Biddle, S. J., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise*, *42*, 146-155. http://dx.doi.org/10.1136/bjsports-2011-090185

Boat, T. F., & Wu, J. T. (Eds.). (2015). *Mental disorders and disabilities among low-income children*. National Academies Press.

Borella, E., Carretti, B., & Lanfranchi, S. (2013). Inhibitory mechanisms in Down syndrome: Is there a specific or general deficit?. *Research in developmental disabilities*, *34*(1), 65-71. https://doi.org/10.1016/j.ridd.2012.07.017

Bossink, L. W., van der Putten, A. A., & Vlaskamp, C. (2017). Understanding low levels of physical activity in people with intellectual disabilities: A systematic review to identify barriers and facilitators. *Research in Developmental Disabilities*, *68*, 95-110. https://doi.org/10.1016/j.ridd.2017.06.008

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological review*, *108*(3), 624-652. https://doi.org/10.1037/0033-295X.108.3.624

Botvinick, M., & Braver, T. (2015). Motivation and cognitive control: from behavior to neural mechanism. *Annual review of psychology*, *66*, 83-113. https://doi.org/10.1146/annurev-psych-010814-015044

Bracht, V. (1996). *Educación física y aprendizaje social: educación física/ciencia del deporte:¿ qué ciencia es esa?*. Córdoba, Argentina: Vélez Sársfield.

Braver, T. S. (2012). The variable nature of cognitive control: a dual mechanisms framework. *Trends in cognitive sciences*, *16*(2), 106-113. https://doi.org/10.1016/j.tics.2011.12.010

Braver, T. S., Paxton, J. L., Locke, H. S., & Barch, D. M. (2009). Flexible neural mechanisms of cognitive control within human prefrontal cortex. *Proceedings of the National Academy of Sciences*, *106*(18), 7351-7356. https://doi.org/10.1073/pnas.080818710

Bruininks, R. H. (1978). *Bruininks Oseretsky test of motor proficiency*. American Guidance Service, Circle pines-Minnesota.

Bruininks, R.H. & Bruininks, B.D. (2005). *Test of Motor Proficiency*. 2nd edition. *Manual*.: AGS Publishing. Circle Pines.

Burack, J. A., Russo, N., Flores, H., Iarocci, G., & Zigler, E. (2012). The more you know the less you know, but that's OK: Developments in the developmental approach to intellectual disability. *The Oxford handbook of intellectual disability and development*, 3-12. https://doi.org/10.1093/oxfordhb/9780195305012.013.0001

Burgoyne, A. P., & Engle, R. W. (2020). Attention control: A cornerstone of higher-order cognition. *Current Directions in Psychological Science*, *29*(6), 624-630. https://doi.org/10.1177/0963721420969371

Burton, A. W., & Miller, D. E. (1998). *Movement skill assessment*. Human Kinetics.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in cognitive sciences*, *4*(6), 215-222. https://doi.org/10.1016/S1364-6613(00)01483-2

Camacho Vásconez, A. E., Jácome Gavilánez, F. R., Chacón Velásquez, F. D., Giler Alarcón, G. A., María Daniela, N. P., Mena Bustamente, M. G., & Santos Reppeto, S. (2018). Política pública en discapacidad. Del enfoque biológico al enfoque de derechos 2007-2015.

Camacho Vásconez, A., Fraga Figueroa, G., Jácome Gavilánez, F., & Albán Morejón, D. (2013). Política de atención a personas con discapacidad en el Ecuador: hacia un modelo de exportación. *Línea Sur*, *6*, 95-110.

Capio, C. M., & Eguia, K. F. (2021). Object Control Skills Training for Children With Intellectual Disability: An Implementation Case Study. *SAGE Open*, *11*(3), 21582440211030603. https://doi.org/10.1177/21582440211030603

Carraro, A., & Gobbi, E. (2012). Effects of an exercise programme on anxiety in adults with intellectual disabilities. *Research in developmental disabilities*, *33*(4), 1221-1226. https://doi.org/10.1016/j.ridd.2012.02.014

Carraro, A., & Gobbi, E. (2014). Exercise intervention to reduce depressive symptoms in adults with intellectual disabilities. *Perceptual and Motor Skills*, *119*(1), 1-5. https://doi.org/10.2466/06.15.PMS.119c17z4

Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: what have we learned about cognitive development?. *Trends in cognitive sciences*, *9*(3), 104-110. https://doi.org/10.1016/j.tics.2005.01.011

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports (Washington, D.C.: 1974)*, *100*(2), 126–131.

Cassotti, M., Agogué, M., Camarda, A., Houdé, O., & Borst, G. (2016). Inhibitory control as a core process of creative problem solving and idea generation from childhood to adulthood. *New directions for child and adolescent development*, *2016*(151), 61-72. https://doi.org/10.1002/cad.20153

Chang, Y. K., Hung, C. L., Huang, C. J., Hatfield, B. D., & Hung, T. M. (2014). Effects of an aquatic exercise program on inhibitory control in children with ADHD: a preliminary study. *Archives of Clinical Neuropsychology*, *29*(3), 217-223. https://doi.org/10.1093/arclin/acu003

Chirosa, L. J. , Mendo, A. H., Walle, J. L., Garrido, R. E. R., de Mier, R. J. R., & Martínez, I. M. (2016). Efectos de un programa de juegos reducidos sobre la función ejecutiva en una muestra de chicas adolescentes. *Retos*, *30*, 171-176.

Clark, C. A. C., Pritchard, V. E., & Woodward, L. J. (2010). Preschool executive functioning abilities predict early mathematics achievement. *Developmental Psychology*, *46*(5), 1176–1191. https://doi.org/10.1037/a0019672

Clark, J. E., & Metcalfe, J. S. (2002). The mountain of motor development: A metaphor. *Motor development: Research and reviews*, *2*(163-190), 183-202.

Cohen, J. D. (2017). Cognitive control: core constructs and current considerations. *The Wiley handbook of cognitive control*, 1-28. https://doi.org/10.1002/9781118920497.ch1

Consejo Nacional para la Igualdad de Discapacidades. (2021). *Estadísticas de Discapacidad*. Retrieved from http://www.consejodiscapacidades.gob.ec/estadisticas-de-discapacidad/

Constituyente, E. A. (2008). Constitución de la República del Ecuador. Retrieved from https://educacion.gob.ec/wp-content/uploads/downloads/2012/08/Constitucion.pdf

Cools, W., De Martelaer, K., Samaey, C., & Andries, C. (2009). Movement skill assessment of typically developing preschool children: A review of seven movement skill assessment tools. *Journal of sports science & medicine*, *8*(2), 154.

Correia, S., & Cohen, R. A. (2011). Vigilance. In J. S. Kreutzer, J. DeLuca, B. Caplan (Eds.), *Encyclopedia of Clinical Neuropsychology*. Springer, New York, NY. https://doi.org/10.1007/978-0-387-79948-3_1338

Costanzo, F., Varuzza, C., Menghini, D., Addona, F., Gianesini, T., & Vicari, S. (2013). Executive functions in intellectual disabilities: a comparison between Williams syndrome and Down syndrome. *Research in developmental disabilities*, *34*(5), 1770-1780. https://doi.org/10.1016/j.ridd.2013.01.024

Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: key roles of growth factor cascades and inflammation. *Trends in neurosciences*, *30*(9), 464-472. https://doi.org/10.1016/j.tins.2007.06.011

Cragg, L., & Chevalier, N. (2012). The processes underlying flexibility in childhood. *Quarterly Journal of Experimental Psychology*, *65*(2), 209-232. https://doi.org/10.1080/17470210903204618

Danielsson, H., Henry, L., Messer, D. and Rönnberg, J. (2012). Strengths and weaknesses in executive functioning in children with intellectual disability. *Research in developmental disabilities*, 33 (2), pp. 600-607. doi: 10.1016/j.ridd.2011.11.004

Darin-Mattsson, A., Fors, S., & Kåreholt, I. (2017). Different indicators of socioeconomic status and their relative importance as determinants of health in old age. *International journal for equity in health*, *16*(1), 1-11. https://doi.org/doi:10.1186/s12939-017-0670-3

Davids, K., Williams, A. M., & Williams, J. G. (2005). *Visual perception and action in sport*. Routledge.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037-2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

Davies, M. N., Banyard, P., Norman, C., & Winder, B. (Eds.). (2010). *Essential Psychology: A concise introduction*. Sage.

Davis, J. C., Marra, C. A., Najafzadeh, M., & Liu-Ambrose, T. (2010). The independent contribution of executive functions to health related quality of life in older women. *BMC geriatrics*, *10*(1), 1-8. https://doi.org/10.1186/1471-2318-10-16

De Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., & Hartman, E. (2018). Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. *Journal of science and medicine in sport*, *21*(5), 501-507. https://doi.org/10.1016/j.jsams.2017.09.595Get rights and content

Dekker, M., & Koot, H. M. (2003). DSM-IV disorders in children with Borderline to Moderate Intellectual Disability. I: Prevalence and impact. *Journal of the American Academy of Child*, *42*, 915–922.

Dempster, F. N. (1991). Inhibitory processes: a negleted dimension of intelligence. *Intelligence*, *15*(2), 157-173. https://doi.org/10.1016/0160-2896(91)90028-C

Denson, T. F., Pedersen, W. C., Friese, M., Hahm, A., & Roberts, L. (2011). Understanding impulsive aggression: Angry rumination and reduced self-control capacity are mechanisms underlying the provocation-aggression relationship. *Personality and Social Psychology Bulletin*, *37*(6), 850-862. https://doi.org/10.1177/0146167211401420

Diamond, A. (2012). Activities and programs that improve children’s executive functions. *Current directions in psychological science*, *21*(5), 335-341. https://doi.org/10.1177/0963721412453722

Diamond, A. (2013). Executive functions. *Annual review of psychology*, *64*, 135-168. https://doi.org/10.1146/annurev-psych-113011-143750

Diamond, A. (2015). Effects of physical exercise on executive functions: going beyond simply moving to moving with thought. *Annals of sports medicine and research*, *2*(1), 1011.

Diamond, A., & Ling, D. S. (2016). Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not. *Developmental cognitive neuroscience*, *18,* 34-48. https://doi.org/10.1016/j.dcn.2015.11.005

DiRocco, P. J., Clark, J. E., & Phillips, S. J. (1987). Jumping coordination patterns of mildly mentally retarded children. *Adapted Physical Activity Quarterly*, *4*(3), 178-191. https://doi.org/10.1123/apaq.4.3.178

Dutilh, G., Vandekerckhove, J., Tuerlinckx, F., & Wagenmakers, E. J. (2009). A diffusion model decomposition of the practice effect. *Psychonomic Bulletin & Review*, *16*(6), 1026-1036. https://doi.org/10.3758/16.6.1026

Eguia, K. F., Capio, C. M., & Simons, J. (2015). Object control skills influence the physical activity of children with intellectual disability in a developing country: The Philippines. *Journal of Intellectual and Developmental Disability*, *40*(3), 265-274. https://doi.org/10.3109/13668250.2015.1041466

Eisenberg N., Hofer C. & Vaughan J. (2007) Effortful control and its socioemotional consequences. In: *Handbook of Emotion Regulation* (ed. J. J. Gross), pp. 287– 306. Guilford, New York, NY.

Engel de Abreu, P. M., Abreu, N., Nikaedo, C. C., Puglisi, M. L., Tourinho, C. J., Miranda, M. C., ... & Martin, R. (2014). Executive functioning and reading achievement in school: a study of Brazilian children assessed by their teachers as "poor readers". *Frontiers in psychology*, *5,* 550. https://doi.org/10.3389/fpsyg.2014.00550

Engel, A. C., Broderick, C. R., van Doorn, N., Hardy, L. L., & Parmenter, B. J. (2018). Exploring the relationship between fundamental motor skill interventions and physical activity levels in children: A systematic review and meta-analysis. *Sports Medicine*, *48*(8), 1845-1857. https://doi.org/10.1007/s40279-018-0923-3

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16,* 143–149.

Falcón, V.z C., & Rivero, E. D. (2010). Aprendizaje motor. Las habilidades motrices básicas: coordinación y equilibrio. *Revista Lecturas: Educación Física y Deportes*, *1*(4), 29-36.

Fan, J., Gu, X., Guise, K. G., Liu, X., Fossella, J., Wang, H., & Posner, M. I. (2009). Testing the behavioral interaction and integration of attentional networks. *Brain and cognition*, *70*(2), 209-220. https://doi.org/10.1016/j.bandc.2009.02.002

Fan, J., Raz, A., & Posner, M. I. (2003). Attentional mechanisms. In M. J. Aminoff, R. B. Daroff (Eds.), *Encyclopedia of neurological sciences* (Vol. 1, pp. 292-299). Academic press. https://doi.org/10.1016/B0-12-226870-9/00749-8

Fernell, E., & Gillberg, C. (2020). Borderline intellectual functioning. In *Handbook of clinical neurology* (Vol. 174, pp. 77-81). Elsevier. https://doi.org/10.1016/B978-0-444-64148-9.00006-5

Finger, M. S., & Rand, K. L. (2003). Addressing validity concerns in clinical psychology research. *Handbook of research methods in clinical psychology*, 13-30.

Fisher, A., Boyle, J. M., Paton, J. Y., Tomporowski, P., Watson, C., McColl, J. H., & Reilly, J. J. (2011). Effects of a physical education intervention on cognitive function in young children: randomized controlled pilot study. *BMC pediatrics*, *11*(1), 1-9. https://doi.org/10.1186/1471-2431-11-97

Fitts, P.M., & Posner, M.I. (1967). *Human performance*. Oxford, England: Brooks/Cole.

Foley, J. T., & McCubbin, J. A. (2009). An exploratory study of after-school sedentary behaviour in elementary school-age children with intellectual disability. *Journal* *of Intellectual and Developmental Disability*, *34*(1), 3-9. https://doi.org/10.1080/13668250802688314

Folio, M. R., & Fewell, R. R. (1983). *Peabody developmental motor scales and activity cards*. DLM Teaching Resources.

Folio, M. R., & Fewell, R. R. (2000). *Peabody developmental motor scales: Examiner's manual*. Pro-ed.

Fotiadou, E. G., Neofotistou, K. H., Dampa, A., & Giagazoglou, P. F. (2020). The Effect of a Psychomotor Education Program on School Behavior of Children with Intellectual Disability.

Fournidou, I., Kudlacek, M., & Evagellinou, C. (2011). Attitudes of in-service physical educators toward teaching children with physical disabilities in general physical education classes in Cyprus. European Journal of Adapted Physical Activity, 4(1). https://www.eujapa.upol.cz/pdfs/euj/2011/01/02.pdf

Frey, G. C., & Chow, B. (2006). Relationship between BMI, physical fitness, and motor skills in youth with mild intellectual disabilities. *International journal of obesity*, *30*(5), 861-867. https://doi.org/10.1038/sj.ijo.0803196

Friedman, N., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology-General, 133*(1), 101-135. doi:10.1037/0096-3445.133.1.101

Gapin, J., & Etnier, J. L. (2010). The relationship between physical activity and executive function performance in children with attention-deficit hyperactivity disorder. *Journal of Sport and Exercise Psychology*, *32*(6), 753-763. https://doi.org/10.1123/jsep.32.6.753

García-Hermoso, A., Alonso-Martínez, A. M., Ramírez-Vélez, R., Pérez-Sousa, M. Á., Ramírez-Campillo, R., & Izquierdo, M. (2020). Association of physical education with improvement of health-related physical fitness outcomes and fundamental motor skills among youths: A systematic review and meta-analysis. *JAMA pediatrics*, *174*(6), e200223-e200223. https://doi.org/10.1001/jamapediatrics.2020.0223

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: a review using an integrative framework. *Psychological bulletin*, *134*(1), 31. https://doi.org/10.1037/0033-2909.134.1.31

Gathercole, S. E. (2006). Nonword repetition and word learning: The nature of the relationship. *Applied psycholinguistics*, *27*(4), 513-543. https://10.1017/S0142716406060383

Georgiopoulos, A. M. (2008). The DSM-IV-TR: A multiaxial system for psychiatric diagnosis. In *Massachusetts General Hospital Comprehensive Clinical Psychiatry* (pp. 205-214). Mosby.

Giaouri, S., Alevriadou, A., & Tsakiridou, E. (2010). Theory of mind abilities in children with Down syndrome and non-specific intellectual disabilities: An empirical study with some educational implications. *Procedia-Social and Behavioral Sciences*, *2*(2), 3883-3887. https://doi.org/10.1016/j.sbspro.2010.03.609

Gkotzia E. Venetsanou F., & Kambas A. (2017). Motor proficiency of children with autism spectrum disorders and intellectual disabilities: a review. *European Psychomotricity Journal, 9*(1), 46-69.

Gligorović, M., & Buha Đurović, N. (2014). Inhibitory control and adaptive behaviour in children with mild intellectual disability. *Journal of intellectual disability research*, *58*(3), 233-242. https://doi.org/10.1111/jir.12000

González Serrano, S., & Ubilla Navarro, V. (2007). Guía de apoyo técnico-pedagógico: necesidades educativas especiales en el nivel de educación parvularia. Retraso del desarrollo y discapacidad intelectual. Retrieved from https://centroderecursos.educarchile.cl/bitstream/handle/20.500.12246/50524/GuiaIntelectual.pdf?sequence=1&isAllowed=y

Gonzalez-Gil, F., Martín-Pastor, E. y Poy, R. (2019). Educación inclusiva: barreras y facilitadores para su desarrollo. Análisis de la percepción del profesorado. *Profesorado. Revista de Currículum y Formación de Profesorado, 23* (1), 243-263. https://doi.org/10.30827/profesorado.v23i1.9153

Goodway, J. D., & Branta, C. F. (2003). Influence of a motor skill intervention on fundamental motor skill development of disadvantaged preschool children. *Research quarterly for exercise and sport*, *74*(1), 36-46. https://doi.org/10.1080/02701367.2003.10609062

GraphPad QuickCalcs. (n.d.). *Randomly assign subjects to treatment groups.* Retrieved from http://www.graphpad.com/quickcalcs/randomize1.cfm. Accessed September, 2019

Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Simonoff, E., & Baird, G. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine & Child Neurology*, *51*(4), 311-316. https://doi.org/10.1111/j.1469-8749.2008.03242.x

Guerin, S., Buckley, S., McEvoy, J., Hillery, J., & Dodd, P. (2009). The psychometric properties of the Attention–Distraction, Inhibition–Excitation Classroom Assessment Scale (ADIECAS) in a sample of children with moderate and severe intellectual disabilities. *Research in developmental disabilities*, *30*(4), 727-734. https://doi.org/10.1016/j.ridd.2008.10.003

Hagerman, R. J., Berry-Kravis, E., Hazlett, H. C., Bailey, D. B., Moine, H., Kooy, R. F., ... & Hagerman, P. J. (2017). Fragile X syndrome. *Nature reviews Disease primers*, *3*(1), 1-19. https://doi.org/10.1038/nrdp.2017.65

Halperin, J. M., Marks, D. J., Bedard, A. C. V., Chacko, A., Curchack, J. T., Yoon, C. A., & Healey, D. M. (2013). Training executive, attention, and motor skills: a proof-of-concept study in preschool children with ADHD. *Journal of attention disorders*, *17*(8), 711-721. https://doi.org/10.1177/1087054711435681

Hamilton, M. L., & Tate, A. L. (2002). "Constraints on throwing behavior: an exploratory analysis," in *Advances in Motor Development Research American Alliance for Health, Physical Education, Recreation, and Dance,* Vol. 2, ed. J. E. Clark (Reston, VA: NASPE Publications), 49–61.

Hardy, L. L., Reinten-Reynolds, T., Espinel, P., Zask, A., & Okely, A. D. (2012). Prevalence and correlates of low fundamental movement skill competency in children. *Pediatrics, 130*(2), e390-e398. https://doi.org/10.1542/peds.2012-0345

Hartman, E., Houwen, S., Scherder, E., & Visscher, C. (2010). On the relationship between motor performance and executive functioning in children with intellectual disabilities. *Journal of Intellectual Disability Research*, *54*(5), 468-477. https://doi.org/10.1111/j.1365-2788.2010.01284.x

Haywood, K. M., & Getchell, N. (2005). *Lifespan Motor Development 4th Edition*. Champaign, IL: Human Kinetics.

Haywood, K. M., & Getchell, N. (2009). *Life Span Motor Development 5th Edition*. Champaign, Illinois: Human Kinetics.

Haywood, K., & Getchell, N. (2014). *Life Span Motor Development 6th Edition*. Human Kinetics.

Heaton, R. K., & PARStaff. (2003). Wisconsin Card Sorting Test:Computer Version 4, Research Edition (WCST:CV4). *Odessa, FL: Psychological Assessment Resources.*

Henderson, S.E. & Sugden, D.A. (1992). *Movement Assessment Battery for children*. Sidcup. Therapy skill builders, Kent-England.

Henderson, S.E., Sugden, D.A., & Barnett, A.L. (2007). *Movement Assessment Battery for children – 2 Examiner's Manual*. Harcourt Assessment, London.

Henry, L.A., Bettenay, C. & Carney, D. (2011). Children with intellectual disabilities and developmental disorders (Chapter 13). In M. Lamb, D. La Rooy, C. Katz & L. Malloy (Eds.) *Children´s Testimony: A Handbook of Psychological Research and Forensic Practice* (2nd Edition) (pp. 251-283). Chichester, UK: Wiley-Blackwell.

Hillman, C. H., Pontifex, M. B., Castelli, D. M., Khan, N. A., Raine, L. B., Scudder, M. R., Drollette, E. S., Moore, R. D., Wu, C. T., & Kamijo, K. (2014). Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics*, *134*(4), e1063-e1071. https://doi.org/10.1542/peds.2013-3219

Ho, W., Ahmed, M., D'Amico, R. L. D., Ramos, A., Ferreira, E. L., Ferreira, M. B. R., ... & Wong, B. (2018). Measuring the perception of quality physical education in Latin American professionals. *Revista Brasileira de Ciências do Esporte*, *40*, 361-369. https://doi.org/10.1016/j.rbce.2018.05.006

Hogan, D. P., Rogers, M. L., & Msall, M. E. (2000). Functional limitations and key indicators of well-being in children with disability. *Archives of pediatrics & adolescent medicine*, *154*(10), 1042-1048. https://doi.org/10.1001/archpedi.154.10.1042

Hooper, S. R., Hatton, D., Sideris, J., Sullivan, K., Hammer, J., Schaaf, J., Mirrett, P., Ornstein, P. A., & Bailey, D. B., Jr. (2008). Executive functions in young males with fragile X syndrome in comparison to mental age-matched controls: Baseline findings from a longitudinal study. *Neuropsychology, 22*(1), 36–47. https://doi.org/10.1037/0894-4105.22.1.36

Hsieh, K., Rimmer, J. H., & Heller, T. (2014). Obesity and associated factors in adults with intellectual disability. *Journal of Intellectual Disability Research*, *58*(9), 851-863. https://doi.org/10.1111/jir.12100

Hsu, P. J., Yeh, H. L., Tsai, C. L., Chu, C. H., Chen, F. C., & Pan, C. Y. (2021). Effects of a Floor Hockey Intervention on Motor Proficiency, Physical Fitness, and Adaptive Development in Youths with Mild Intellectual Disabilities. *International journal of environmental research and public health*, *18*(13), 7059. https://doi.org/10.3390/ijerph18137059

Huizinga, J. (1949). *Homo ludens: A study of the play-element in our culture*. Routledge & Kegan Paul.

Huizinga, J. (1972). Esencia y significación del juego como fenómeno cultural. *Homo ludens*, 11-44.

Ioanna, D. (2020). Independent living of individuals with intellectual disability: a combined study of the opinions of parents, educational staff, and individuals with intellectual disability in Greece. *International Journal of Developmental Disabilities*, *66*(2), 153-159. https://doi.org/10.1080/20473869.2018.1541560

Jäger, K., Schmidt, M., Conzelmann, A., & Roebers, C. M. (2015). The effects of qualitatively different acute physical activity interventions in real-world settings on executive functions in preadolescent children. *Mental Health and Physical Activity*, *9*, 1-9. https://doi.org/10.1016/j.mhpa.2015.05.002

Jakicic, J. M., Kraus, W. E., Powell, K. E., Campbell, W. W., Janz, K. F., Troiano, R. P., ... & 2018 Physical Activity Guidelines Advisory Committee. (2019). Association between bout duration of physical activity and health: systematic review. *Medicine and science in sports and exercise*, *51*(6), 1213. http://dx.doi.org/10.1249/MSS.0000000000001933

Japundza-Milisavljevic, M., Macesic-Petrovic, D. and Djuric-Zdravkovic, A. (2010). Attention and social behavior of children with intellectual developmental disabilities. *Procedia-Social and Behavioral Sciences*, 5, pp. 41-44. doi: 10.1016/j.sbspro.2010.07.047

Javan, A. T., Framarzi, S., Abedi, A., & Nattaj, F. H. (2014). Effectiveness of Rhythmic play on the Attention and Memory functioning in Children with Mild Intellectual Disability (MID). *International Letters of Social and Humanistic Sciences*, *6*, 9-21.

Juan, F. R., & Montes, M. E. G. (2001). *Desarrollo de la motricidad a través del juego: materiales convencionales y no convencionales [sic] como recursos metodológicos*. Gymnos.

Kamijo, K., Pontifex, M. B., O'Leary, K. C., Scudder, M. R., Wu, C. T., Castelli, D. M., & Hillman, C. H. (2011). The effects of an afterschool physical activity program on working memory in preadolescent children. *Developmental science*, *14*(5), 1046-1058. https://doi.org/10.1111/j.1467-7687.2011.01054.x

Kane, M. J., & Engle, R. W. (2000). Working-memory capacity, proactive interference, and divided attention: Limits on long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*(2), 336–358. https://doi.org/10.1037/0278-7393.26.2.336

Katkov, M., Romani, S., & Tsodyks, M. (2014). Word length effect in free recall of randomly assembled word lists. *Frontiers in Computational Neuroscience*, *8*, 129. https://doi.org/10.3389/fncom.2014.00129

Keogh, J. F. (1977). The study of movement skill development. *Quest*, *28*(1), 76-88. https://doi.org/10.1080/00336297.1977.10519902

Kessler, Y., & Oberauer, K. (2014). Working memory updating latency reflects the cost of switching between maintenance and updating modes of operation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40*(3), 738–754. https://doi.org/10.1037/a0035545

Ketcheson, L. R., Centeio, E. E., Snapp, E. E., McKown, H. B., & Martin, J. J. (2021). Physical activity and motor skill outcomes of a 10-week intervention for children with intellectual and developmental disabilities ages 4–13: A pilot study. *Disability and Health Journal*, *14*(1), 100952. https://doi.org/10.1016/j.dhjo.2020.100952

Kirk, H.E., Gray, K., Riby, D.M., Taffe, J. and Cornish, K.M. (2017). Visual attention and academic performance in children with developmental disabilities and behavioural attention deficits. *Developmental science*, 20 (6), p.e12468. doi: 10.1111/desc.12468

Kittler, P., Krinsky-McHale, S. J., & Devenny, D. A. (2006). Verbal intrusions precede memory decline in adults with Down syndrome. *Journal of Intellectual Disability Research*, *50*(1), 1-10. https://doi.org/10.1111/j.1365-2788.2005.00715.x

Klimkeit, E. I., Mattingley, J. B., Sheppard, D. M., Farrow, M., & Bradshaw, J. L. (2004). Examining the development of attention and executive functions in children with a novel paradigm. *Child Neuropsychology*, *10*(3), 201-211. https://doi.org/10.1080/09297040409609811

Kochinke, K., Zweier, C., Nijhof, B., Fenckova, M., Cizek, P., Honti, F., Keerthikumar, S., Oortveld, M., Kleefstra, T., Kramer, J., Webber, C., Huynen M., & Schenck, A. (2016). Systematic phenomics analysis deconvolutes genes mutated in intellectual disability into biologically coherent modules. *The American Journal of Human Genetics*, *98*(1), 149-164. https://doi.org/10.1016/j.ajhg.2015.11.024

Kohl III, H. W., & Cook, H. D. (Eds.). (2013). Educating the student body: Taking physical activity and physical education to school.

Koller, M. (2016). Robustlmm: an R package for robust estimation of linear mixed-effects models. *Journal of statistical software, 75*(1), 1-24. https://doi.org/10.18637/jss.v075.i06

Kosmidis, M. H., Vlahou, C. H., Panagiotaki, P., & Kiosseoglou, G. (2004). The verbal fluency task in the Greek population: Normative data, and clustering and switching strategies. *Journal of the International Neuropsychological Society*, *10*(2), 164-172. https://doi.org/10.1017/S1355617704102014

Kroes, M., Vissers, Y. L., Sleijpen, F. A., Feron, F. J., Kessels, A. G., Bakker, E., ... & Vles, J. S. (2004). Reliability and validity of a qualitative and quantitative motor test for 5-to 6-year-old children. *European Journal of Paediatric Neurology*, *8*(3), 135-143. https://doi.org/10.1016/j.ejpn.2004.01.007

Kurtz, L. A. (2007). *Understanding motor skills in children with dyspraxia, ADHD, autism, and other learning disabilities: A guide to improving coordination*. Jessica Kingsley Publishers.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. (2017). lmerTest package: tests in linear mixed effects models. *Journal of statistical software, 82*(13), 1-26. https://doi.org/10.18637/jss.v082.i13

Lakes, K. D., & Hoyt, W. T. (2004). Promoting self-regulation through school-based martial arts training. *Journal of Applied Developmental Psychology*, *25*(3), 283-302. https://doi.org/10.1016/j.appdev.2004.04.002

Lanfranchi, S., Jerman, O., Dal Pont, E., Alberti, A., & Vianello, R. (2010). Executive function in adolescents with Down syndrome. *Journal of intellectual disability research*, *54*(4), 308-319. https://doi.org/10.1111/j.1365-2788.2010.01262.x

Latash, M. L., Turvey, M. T., & Bernshteĭn, N. A. (1996). *Dexterity and its development*. Lawrence Erlbaum.

Lewandowski, A., Köster, V., & Wietfeld, C. (2009, March). A new dynamic co-channel interference model for simulation of heterogeneous wireless networks. In *Proceedings of the 2nd International Conference on Simulation Tools and Techniques* (pp. 1-7).

Lin J. K. (2004) *Sensory Integration Function Test for Children: User's Manual*. Psychological Corporation, Taipei.

Lotan, M., Henderson, C. M., & Merrick, J. (2006). Physical activity for adolescents with intellectual disability. *Minerva pediatrica*, *58*(3), 219-226.

Mackie, M. A., Van Dam, N. T., & Fan, J. (2013). Cognitive control and attentional functions. *Brain and cognition*, *82*(3), 301-312. https://doi.org/10.1016/j.bandc.2013.05.004

Maïano, C., Hue, O., & April, J. (2019). Effects of motor skill interventions on fundamental movement skills in children and adolescents with intellectual disabilities: A systematic review. *Journal of Intellectual Disability Research*, *63*(9), 1163-1179. https://doi.org/10.1111/jir.12618

Malagoli, C., & Usai, M. C. (2015). Inhibition and Working Memory: a latent variable analysis during adolescence. In *EAPCogSci*.

Malina, R. M. (1996). Tracking of physical activity and physical fitness across the lifespan. *Research quarterly for exercise and sport, 67* (sup3), S-48. https://doi.org/10.1080/02701367.1996.10608853

Marks, B., Sisirak, J., & Chang, Y. C. (2013). Efficacy of the HealthMatters program train-the-trainer model. *Journal of Applied Research in Intellectual Disabilities*, *26*(4), 319-334. https://doi.org/10.1111/jar.12045

Marques, A., Peralta, M., Sarmento, H., Martins, J., & González Valeiro, M. (2018). Associations between vigorous physical activity and chronic diseases in older adults: a study in 13 European countries. *European journal of public health*, *28*(5), 950-955. https://doi.org/10.1093/eurpub/cky086

Marton, K., Campanelli, L., Eichorn, N., Scheuer, J., & Yoon, J. 2014. Information processing and proactive interference in children with and without specific language impairment. *Journal of Speech Language and Hearing Research* **57**. 106– 119. https://doi.org/10.1111/lnc3.12189

Mason, L., & Zaccoletti, S. (2021). Inhibition and conceptual learning in science: a review of studies. *Educational Psychology Review*, *33*(1), 181-212. https://doi.org/10.1007/s10648-020-09529-x

Mazyn, L. I., Lenoir, M., Montagne, G., Delaey, C., & Savelsbergh, G. J. (2007). Stereo vision enhances the learning of a catching skill. *Experimental brain research*, *179*(4), 723-726. https://doi.org/10.1007/s00221-007-0957-5

McLennan, N., & Thompson, J. (2015). Educación física de calidad (EFC): guía para los responsables políticos. http://unescoittralee.com/wp-content/uploads/2017/11/QPE-for-policy-makers-Spanish.pdf

Medaglia, J. D. (2019). Clarifying cognitive control and the controllable connectome. *Wiley Interdisciplinary Reviews: Cognitive Science*, *10*(1), e1471. https://doi.org/10.1002/wcs.1471

Meiran, N., Pereg, M., Kessler, Y., Cole, M. W., & Braver, T. S. (2015). The power of instructions: Proactive configuration of stimulus–response translation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(3), 768–786.

Melville, C. A., Mitchell, F., Stalker, K., Matthews, L., McConnachie, A., Murray, H. M., Melling, C., & Mutrie, N. (2015). Effectiveness of a walking programme to support adults with intellectual disabilities to increase physical activity: walk well cluster-randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 1-11. https://doi.org/10.1186/s12966-015-0290-5

Memisevic, H., & Sinanovic, O. (2014). Executive function in children with intellectual disability–the effects of sex, level and aetiology of intellectual disability. *Journal of intellectual disability research*, *58*(9), 830-837. https://doi.org/10.1111/jir.12098

Menghini, D., Addona, F., Costanzo, F., & Vicari, S. (2010). Executive functions in individuals with Williams syndrome. *Journal of Intellectual Disability Research*, *54*(5), 418-432. https://doi.org/10.1111/j.1365-2788.2010.01287.x

Mento, G., Scerif, G., Granziol, U., Franzoi, M., & Lanfranchi, S. (2019). Dissociating top-down and bottom-up temporal attention in Down syndrome: A neurocostructive perspective. *Cognitive Development*, *49*, 81-93. https://doi.org/10.1016/j.cogdev.2018.12.004

Meral, T., & Yalnizoğlu, D. (2013). Developmental abnormalities and mental retardation: Diagnostic strategy. *Handbook of clinical neurology*, *111*, 211-217. https://doi.org/10.1016/B978-0-444-52891-9.00021-X

Mero Piedra, A. L. (2020a). Gross motor skills in young populations with mild intellectual disabilities. In E. Bihari, D. Molnár, & K. Szikszai-Németh (Eds.), *Psychology and education section: Spring Wind 2019 Conference Handbook* (pp. 409-418). Debrecen, Hungary: National Association of Doctoral Students. Retrieved from http://dosz.hu/__doc/dokumentumfile/2019/11/Tavaszi_Szel_-_Spring_Wind_2019_Tanulmanykotet_-_III._kotet_1.pdf

Mero Piedra, A. L. (2020b). Playful practices with children with intellectual disabilities. *West East Journal of Social Sciences*, *9*(1), 9-22. https://doi.org/10.36739/wejss.2020.v9.i1.38

Mero Piedra, A. L., Pesthy, O., & Marton, K. (2023). Effects of a physical education intervention on attention and inhibitory control in Ecuadorian children with intellectual disabilities. *Journal of Intellectual Disabilities*, *0*(0), 1-14. https://doi.org/10.1177/17446295231189018

Merrell, K. W. (1993). Using behavior rating scales to assess social skills and antisocial behavior in school settings: Development of the school social behavior scales. *School Psychology Review*, *22*(1), 115-133.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*, 167–202

Ministerio de Educación de Ecuador. (2011). *Curso de Inclusión Educativa: Programa de Formación.* Quito, Ecuador. Retrieved from https://educacion.gob.ec/wp-content/uploads/downloads/2013/03/SiProfe-Inclusi%C3%B3n-Educativa.pdf

Ministerio de Educación de Ecuador. (2013). *Guía de Trabajo Adaptaciones Curriculares para la Educación Especial e Inclusiva.* Quito, Ecuador. Retrieved from https://educacion.gob.ec/wp-content/uploads/downloads/2019/05/Guia-de-adaptaciones-curriculares-para-educacion-inclusiva.pdf

Ministerio de Educación de Ecuador (2014). Acuerdo Ministerial 0041-014. Quito, Ecuador. https://educacion.gob.ec/wp-content/uploads/downloads/2014/03/ACUERDO-041-14.pdf

Ministerio de Educación de Ecuador. (2016a). *Currículo EGU y BGU Educación Física*. Quito, Ecuador. Retrieved from https://educacion.gob.ec/wp-content/uploads/downloads/2016/08/EF-completo.pdf

Ministerio de Educación de Ecuador. (2016b). *Currículo de los niveles de educación obligatoria*. Quito, Ecuador. Retrieved from https://educacion.gob.ec/wp-content/uploads/downloads/2016/03/Curriculo1.pdf

Ministerio de Educación de Ecuador. (2018). *Modelo Nacional de Gestión y Atención para Estudiantes con Necesidades Educativas Especiales Asociadas a la Discapacidad de las Instituciones De Educación Especializadas*. Quito, Ecuador. Retrieved from https://educacion.gob.ec/wp-content/uploads/downloads/2018/07/Modelo-IEE.pdf

Ministerio de Salud Pública. (2018). *Manual de calificación de la discapacidad.* Retrieved from https://www.salud.gob.ec/wp-content/uploads/downloads/2018/12/Manual_Calificaci%C3%B3n-de_Discapacidad_2018.pdf

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive psychology*, *41*(1), 49-100. https://doi.org/10.1006/cogp.1999.0734

Monsell, S. (2003). Task switching. *Trends in cognitive sciences*, *7*(3), 134-140. https://doi.org/10.1016/S1364-6613(03)00028-7.

Naeem, K., Filippi, R., Periche-Tomas, E., Papageorgiou, A., & Bright, P. (2018). The importance of socioeconomic status as a modulator of the bilingual advantage in cognitive ability. *Frontiers in psychology*, *9*, 1818. https://doi.org/10.3389/fpsyg.2018.01818

Naglieri, J. A., & Das, J. P. (1997). Cognitive Assessment System.

Nakayama, L. (2018). *El juego como contenido de la Educación Física. Construcción y resignificación en la práctica docente* (Master's thesis, Universidad Nacional de La Plata. Facultad de Humanidades y Ciencias de la Educación. Secretaría de Posgrado). Retrieved from http://www.memoria.fahce.unlp.edu.ar/tesis/te.1627/te.1627.pdf

Nayfeld, I., Fuccillo, J., & Greenfield, D. B. (2013). Executive functions in early learning: Extending the relationship between executive functions and school readiness to science. *Learning and Individual Differences*, *26*, 81-88. https://doi.org/10.1016/j.lindif.2013.04.011

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126*(2), 220–246. https://doi.org/10.1037/0033-2909.126.2.220

Oberauer, K. (2009). Design for a working memory. In B. H. Ross (Ed.), *The psychology of learning and motivation* (pp. 45–100). Elsevier Academic Press. https://doi.org/10.1016/S0079-7421(09)51002-X

Okely, A. D., Booth, M. L., & Patterson, J. W. (2001). Relationship of cardiorespiratory endurance to fundamental movement skill proficiency among adolescents. *Pediatric exercise science*, *13*(4), 380-391. https://doi.org/10.1123/pes.13.4.380

Palmqvist, L., Danielsson, H., Jönsson, A., & Rönnberg, J. (2020). Cognitive abilities and life experience in everyday planning in adolescents with intellectual disabilities: Support for the difference model. *Journal of Intellectual Disability Research*, *64*(3), 209-220. https://doi.org/10.1111/jir.12710

Pan, C. Y., Chu, C. H., Tsai, C. L., Lo, S. Y., Cheng, Y. W., & Liu, Y. J. (2016). A racket-sport intervention improves behavioral and cognitive performance in children with attention-deficit/hyperactivity disorder. *Research in developmental disabilities*, *57*, 1-10. https://doi.org/10.1016/j.ridd.2016.06.009

Pan, C. Y., Chu, C. H., Tsai, C. L., Sung, M. C., Huang, C. Y., & Ma, W. Y. (2017). The impacts of physical activity intervention on physical and cognitive outcomes in children with autism spectrum disorder. *Autism*, *21*(2), 190-202. https://doi.org/10.1177/1362361316633562

Pan, C. Y., Tsai, C. L., Chu, C. H., Sung, M. C., Huang, C. Y., & Ma, W. Y. (2019). Effects of physical exercise intervention on motor skills and executive functions in children with ADHD: A pilot study. *Journal of attention disorders*, *23*(4), 384-397.

Pangrazi, R. P., & Beighle, A. (2012). *Dynamic physical education for elementary school children*. Pearson Higher Ed.

Papalia, D., & Duskin, R. (2012). Desarrollo Humano. Séptima ed. Obregón Á, editor.

Pastor-Cerezuela, G., Fernández-Andrés, M. I., Feo-Álvarez, M., & González-Sala, F. (2016). Semantic verbal fluency in children with and without autism spectrum

disorder: Relationship with chronological age and IQ. *Frontiers in psychology, 7*, 921. https://doi.org/10.3389/fpsyg.2016.00921
Patel, D. R., Neelakantan, M., Pandher, K., & Merrick, J. (2020). Cerebral palsy in children: a clinical overview. *Translational pediatrics, 9*(Suppl 1), S125. https://doi.org/10.21037/tp.2020.01.01
Payne, V. G., & Isaacs, L. D. (2012). *Human motor development: A lifespan approach*. New York: McGraw-Hill.
Payne, V. G., Yan, J. H., & Block, M. E. (2010). *Human Motor Development in Individuals with and Without Disabilities*. Nova Science Publishers.
Pellegrino, L. (2007). Patterns of development and disability. In M. L. Batshaw, L. Pellegrino, & N. J. Roizen (Eds.), *Children with disabilities.* 6th ed. Baltimore: Paul H. Brookes.
Peredo Videa R. D. L. A. (2016). Comprendiendo la discapacidad intelectual: datos, criterios y reflexiones. *Revista de investigación psicológica*, (15), 101-122. Retrieved from http://www.scielo.org.bo/pdf/rip/n15/n15_a07.pdf
Pérez, L. M. R., Iglesias, J. L. L., & Mendes, R. P. (2008). El estudio del desarrollo motor: entre la tradición y el futuro. *Revista fuentes*, (8), 243-258.
Pesce, C., Croce, R., Ben-Soussan, T. D., Vazou, S., McCullick, B., Tomporowski, P. D., & Horvat, M. (2019). Variability of practice as an interface between motor and cognitive development. *International Journal of Sport and Exercise Psychology*, *17*(2), 133-152. https://doi.org/10.1080/1612197X.2016.1223421
Pesce, C., Crova, C., Marchetti, R., Struzzolino, I., Masci, I., Vannozzi, G., & Forte, R. (2013). Searching for cognitively optimal challenge point in physical activity for children with typical and atypical motor development. *Mental Health and Physical Activity*, *6*(3), 172-180. https://doi.org/10.1016/j.mhpa.2013.07.001
Pesce, C., Masci, I., Marchetti, R., Vazou, S., Sääkslahti, A., & Tomporowski, P. D. (2016). Deliberate play and preparation jointly benefit motor and cognitive development: mediated and moderated effects. *Frontiers in psychology*, *7*, 349. https://doi.org/10.3389/fpsyg.2016.00349
Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual review of neuroscience, 35*, 73-89. https://doi.org/10.1146/annurev-neuro-062111-150525
Populin, L., Rose, D. J., & Heath, K. (1990). The role of attention in one-handed catching. *Journal of motor behavior*, *22*(1), 6-18.
Posner, M. I., & Fan, J. (2008). Attention as an organ system. In J. R. Pomerantz (Ed.), *Topics in integrative neuroscience: From cells to cognition* (pp. 31-61).
Posner, M. I., & Rothbart, M. K. (2005). Influencing brain networks: implications for education. *Trends in cognitive sciences*, *9*(3), 99-103. https://doi.org/10.1016/j.tics.2005.01.007
Posner, M. I., & Rothbart, M. K. (2014). Attention to learning of school subjects. *Trends in Neuroscience and Education*, *3*(1), 14-17. https://doi.org/10.1016/j.tine.2014.02.003
Posner, M. I., & Snyder, C. R. R. (1975). In R. L. Solso (Ed.), *Information processing and cognition: The Loyola symposium*. New York: Lawrence Erlbaum.
Rarick, G. L. (1980). Cognitive-motor relationships in the growing years. *Research Quarterly for Exercise and Sport*, *51*(1), 174-192. https://doi.org/10.1080/02701367.1980.10609282
Rasberry, C. N., Lee, S. M., Robin, L., Laris, B. A., Russell, L. A., Coyle, K. K., & Nihiser, A. J. (2011). The association between school-based physical activity,

including physical education, and academic performance: a systematic review of the literature. *Preventive medicine*, *52*, S10-S20. https://doi.org/10.1016/j.ypmed.2011.01.027

Razza, R. A., Bergen-Cico, D., & Raymond, K. (2015). Enhancing preschoolers' self-regulation via mindful yoga. *Journal of Child and Family Studies*, *24*(2), 372-385. https://doi.org/10.1007/s10826-013-9847-6

Reynolds, T., Zupanick, D. M., & Dombeck, M. (2013). Intellectual disability and severity codes. *Mentalhelp. net*.

Ridderinkhof K. R., van der Molen M. W. (1995). A psychophysiological analysis of developmental differences in the ability to resist interference. *Child Dev.* 66, 1040–1056. 10.2307/1131797

Riggs, N. R., Spruijt-Metz, D., Sakuma, K. L., Chou, C. P., & Pentz, M. A. (2010). Executive cognitive function and food intake in children. *Journal of nutrition education and behavior*, *42*(6), 398-403. https://doi.org/10.1016/j.jneb.2009.11.003

Rintala, P., & Loovis, E. M. (2013). Measuring motor skills in Finnish children with intellectual disabilities. *Perceptual and motor skills*, *116*(1), 294-303. https://doi.org/10.2466/25.10.PMS.116.1.294-303

Rogers, R. D., & Monsell, S. (1995). Costs of a predictible switch between simple cognitive tasks. *Journal of experimental psychology: General*, *124*(2), 207.

Röthlisberger, M., Neuenschwander, R., Cimeli, P., Michel, E., & Roebers, C. M. (2012). Improving executive functions in 5-and 6-year-olds: Evaluation of a small group intervention in prekindergarten and kindergarten children. *Infant and Child Development*, *21*(4), 411-429. https://doi.org/10.1002/icd.752

Rougier, N. P., Noelle, D. C., Braver, T. S., Cohen, J. D., & O'Reilly, R. C. (2005). Prefrontal cortex and flexible cognitive control: Rules without symbols. *Proceedings of the National Academy of Sciences*, *102*(20), 7338-7343. https://doi.org/10.1073/pnas.0502455102

Ruiz Pérez, L. M., Linaza Iglesias, J. L., & Peñaloza Mendes, R. (2008). El estudio del desarrollo motor: entre la tradición y el futuro. *Revista Fuentes, 8, 243-258*.

Runhaar, J., Collard, D. C. M., Singh, A. S., Kemper, H. C. G., Van Mechelen, W., & Chinapaw, M. (2010). Motor fitness in Dutch youth: differences over a 26-year period (1980–2006). *Journal of Science and Medicine in Sport*, *13*(3), 323-328. https://doi.org/10.1016/j.jsams.2009.04.006

Sadowska, M., Sarecka-Hujar, B., & Kopyta, I. (2020). Cerebral palsy: current opinions on definition, epidemiology, risk factors, classification and treatment options. *Neuropsychiatric disease and treatment*, 1505-1518.

Salse-Batán, J., Suárez-Iglesias, D., Sanchez-Lastra, M. A., & Ayán Pérez, C. (2021). Aquatic exercise for people with intellectual disabilities: findings from a systematic review. *International Journal of Developmental Disabilities*, 1-13. https://doi.org/10.1080/20473869.2021.1924033

Schalick, W., Westbrook, C., & Young, B. (2012). Communication with Individuals with Intellectual Disabilities and Psychiatric Disabilities: A summary of the literature. *Michigan Retirement Research Center Research Paper*, (2012-264). http://dx.doi.org/10.2139/ssrn.2159227

Schmidt, F. L., & Hunter, J. (2004). General mental ability in the world of work: occupational attainment and job performance. *Journal of personality and social psychology*, *86*(1), 162

Schmidt, M., Jäger, K., Egger, F., Roebers, C. M., & Conzelmann, A. (2015). Cognitively engaging chronic physical activity, but not aerobic exercise, affects executive functions in primary school children: a group-randomized controlled trial. *Journal of Sport and Exercise Psychology*, *37*(6), 575-591. https://doi.org/10.1123/jsep.2015-0069

Schmidt, R. A., & Wrisberg, C. A. (2000). Motor learning and performance: A problem-based learning approach. Champaign. *IL: Human Kinetics*.

Schmidt, R. A., & Wrisberg, C. A. (2008). *Motor learning and performance.* 4th ed. Champaign, IL: Human Kinetics.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: 1. Detection, search, and attention. *Psychological Review*, *84*(2), 1–66. https://doi.org/10.1037/0033-295X.84.1.1

Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *Journal of Pharmacology and pharmacotherapeutics*, *1*(2), 100-107. https://doi.org/10.1136/bmj.c332

Seifert, K., & Sutton, R. (2009). Intellectual Disabilities. *Educational Psychology*, 96-99. Kelvin Seifert. Retrieved from https://home.cc.umanitoba.ca/~seifert/EdPsy2009.pdf

Serdar, C. C., Cihan, M., Yücel, D., & Serdar, M. A. (2021). Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies. *Biochemia medica*, *31*(1), 27-53. https://doi.org/10.11613/BM.2021.010502

Seroyer, S. T., Nho, S. J., Bach, B. R., Bush-Joseph, C. A., Nicholson, G. P., & Romeo, A. A. (2010). The kinetic chain in overhand pitching: its potential role for performance enhancement and injury prevention. *Sports health*, *2*(2), 135-146. https://doi.org/10.1177/1941738110362

Shallice, T. (1982). Specific impairments of planning. *Phil. Trans. R. Soc. Lond. B*, *298*(1089), 199-209.

Shenhav, A., Botvinick, M. M., & Cohen, J. D. (2013). The expected value of control: an integrative theory of anterior cingulate cortex function. *Neuron*, *79*(2), 217-240. https://doi.org/10.1016/j.neuron.2013.07.007

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review*, *84*(2), 127–190. https://doi.org/10.1037/0033-295X.84.2.127

Shields, N., & Synnot, A. (2016). Perceived barriers and facilitators to participation in physical activity for children with disability: a qualitative study. *BMC pediatrics*, *16*(1), 9. https://doi.org/10.1186/s12887-016-0544-7

Simons, J., Daly, D., Theodorou, F., Caron, C., Simons, J., & Andoniadou, E. (2008). Validity and reliability of the TGMD-2 in 7–10-year-old Flemish children with intellectual disability. *Adapted physical activity quarterly*, *25*(1), 71-82. https://doi.org/10.1123/apaq.25.1.71

Slevin, E., Truesdale-Kennedy, M., McConkey, R., Livingstone, B., & Fleming, P. (2014). Obesity and overweight in intellectual and non-intellectually disabled children. *Journal of Intellectual Disability Research*, *58*(3), 211-220. https://doi.org/10.1111/j.1365-2788.2012.01615.x

Snyder, H. R., Miyake, A., & Hankin, B. L. (2015). Advancing understanding of executive function impairments and psychopathology: bridging the gap between clinical and cognitive approaches. *Frontiers in psychology*, *6*, 328. https://doi.org/10.3389/fpsyg.2015.00328

Spaniol, M., & Danielsson, H. (2022). A meta-analysis of the executive function components inhibition, shifting, and attention in intellectual disabilities. *Journal of Intellectual Disability Research*, *66*(1-2), 9-31. https://doi.org/10.1111/jir.12878

St. John, L., Borschneck, G., & Cairney, J. (2020). A systematic review and meta-analysis examining the effect of exercise on individuals with intellectual disability. *American Journal on Intellectual and Developmental Disabilities*, *125*(4), 274-286. https://doi.org/10.1352/1944-7558-125.4.274

Stad, F. E., Wiedl, K. H., Vogelaar, B., Bakker, M., & Resing, W. C. (2019). The role of cognitive flexibility in young children's potential for learning under dynamic testing conditions. *European Journal of Psychology of Education*, *34*, 123-146. https://doi.org/10.1007/s10212-018-0379-8

Stahmer, A. C., Suhrheinrich, J., Reed, S., Schreibman, L., & Bolduc, C. (2011). *Classroom Pivotal Response Teaching for Children with Autism*. Guilford Press. 72 Spring Street, New York, NY 10012.

Staples, K. L., & Reid, G. (2010). Fundamental movement skills and autism spectrum disorders. *Journal of autism and developmental disorders*, *40*(2), 209-217. https://doi.org/10.1007/s10803-009-0854-9

Staples, K. L., MacDonald, M., & Zimmer, C. (2012). Assessment of motor behavior among children and adolescents with autism spectrum disorder. In *International Review of Research in Developmental Disabilities* (Vol. 42, pp. 179-214). Academic Press. https://doi.org/10.1016/B978-0-12-394284-5.00007-3

Sterne, J. A. C., Egger, M., Moher, D., Higgins, J. P. T., & Green, S. (2011). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1. 0 [updated March 2011]. *The Cochrane Collaboration*. https://www.handbook.cochrane.org

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, *60*(2), 290-306. https://doi.org/10.1080/00336297.2008.10483582

Strobach, T., Liepelt, R., Schubert, T., & Kiesel, A. (2012). Task switching: effects of practice on switch and mixing costs. *Psychological research*, *76*(1), 74-83. https://doi.org/10.1007/s00426-011-0323-x

Stroop, J. R. (1935). Studies of inference in serial verbal reactions. Journal of Experimental Psychology, 18, 643–662.

Sulton, K., & Jajat, J. (2019, September). Relationship between gross motor skills and body mass index of children with intellectual disability. In *Proceedings of the 3rd International Conference on Sport Science, Health, and Physical Education (ICSSHPE 2018), Bandung, Indonesia: Atlantis Press*.

Sweeney, M. (2015). Stop skipping class: Why socioeconomic status (SES) matters. *American Psychological Association*. Retrieved from https://www.apa.org/pi/ses/resources/indicator/2015/09/socioeconomic-status-research

Szöllősi, I., & Marton, K. (2016). Interference control in aphasia. *Psychologia Hungarica Caroliensis*, 169-187. http://www.kre.hu/portal/images/doc/Szollosi_et_al.pdf

Tan, C. A., Topper, S., Del Gaudio, D., Nelakuditi, V., Shchelochkov, O., Nowaczyk, M. J. M., ... & Sastry, S. (2016). Characterization of patients referred for non-specific intellectual disability testing: the importance of autosomal genes for diagnosis. *Clinical genetics*, *89*(4), 478-483. https://doi.org/10.1111/cge.12575

Tavares, J. V. T., Clark, L., Cannon, D. M., Erickson, K., Drevets, W. C., & Sahakian, B. J. (2007). Distinct profiles of neurocognitive function in unmedicated unipolar depression and bipolar II depression. *Biological psychiatry*, *62*(8), 917-924. https://doi.org/10.1016/j.biopsych.2007.05.034

Tomporowski, P. D., Lambourne, K., & Okumura, M. S. (2011). Physical activity interventions and children's mental function: an introduction and overview. *Preventive medicine*, *52*, S3-S9. https://doi.org/10.1016/j.ypmed.2011.01.028

Tomporowski, P. D., McCullick, B. A., & Pesce, C. (2015a). *Enhancing children's cognition with physical activity games*. Human Kinetics.

Tomporowski, P. D., McCullick, B., Pendleton, D. M., & Pesce, C. (2015b). Exercise and children's cognition: The role of exercise characteristics and a place for metacognition. *Journal of Sport and Health Science*, *4*(1), 47-55. https://doi.org/10.1016/j.jshs.2014.09.003

Towse, J. N., & Neil, D. (1998). Analyzing human random generation behavior: A review of methods used and a computer program for describing performance. *Behavior Research Methods, Instruments, & Computers*, *30*(4), 583-591. https://doi.org/10.3758/BF03209475

Traverso, L., Fontana, M., Usai, M. C., & Passolunghi, M. C. (2018). Response inhibition and interference suppression in individuals with down syndrome compared to typically developing children. *Frontiers in Psychology*, *9*, 660. https://doi.org/10.3389/fpsyg.2018.00660

Troncoso, M. V., & Del Cerro, M. M. (1999). *Síndrome de Down: lectura y escritura*. Barcelona: Masson. Retrieved from http://biblioteca.univalle.edu.ni/files/original/a28ad637926a57f2891ae0f9f1e55a84f0c3bd23.pdf

Tsai, C. L. (2009). The effectiveness of exercise intervention on inhibitory control in children with developmental coordination disorder: using a visuospatial attention paradigm as a model. *Research in developmental disabilities*, *30*(6), 1268-1280. https://doi.org/10.1016/j.ridd.2009.05.001

Tsai, C. L., Chang, Y. K., Chen, F. C., Hung, T. M., Pan, C. Y., & Wang, C. H. (2014). Effects of cardiorespiratory fitness enhancement on deficits in visuospatial working memory in children with developmental coordination disorder: a cognitive electrophysiological study. *Archives of clinical neuropsychology*, *29*(2), 173-185. https://doi.org/10.1093/arclin/act081

Tsai, C. L., Wang, C. H., & Tseng, Y. T. (2012). Effects of exercise intervention on event-related potential and task performance indices of attention networks in children with developmental coordination disorder. *Brain and cognition*, *79*(1), 12-22. https://doi.org/10.1016/j.bandc.2012.02.004

Tsai, C. Y., Tsai, C. L., Chu, C. H., Sung, M. C., Huang, C. Y., & Ma, W. Y. (2015). Effects of physical exercise intervention on motor skills and executive functions in children with ADHD: A pilot study. *Journal of attention disorders*, *23*(4), 384-397. https://doi.org/10.1177/1087054715569282

Tucker, P. (2008). The physical activity levels of preschool-aged children: A systematic review. *Early Childhood Research Quarterly*, *23*(4), 547-558. https://doi.org/10.1016/j.ecresq.2008.08.005

Ulrich, D. A. (2000). Test of Gross Motor Development, Examiner's manual. Pro-ED. *Inc., Austin, Texas*. Retrieved from https://33202576.weebly.com/uploads/1/4/6/8/14680198/tgmd-2-2.pdf

Ulrich, D.A. (1985). *Test of Gross Motor Development*. Pro-ED. Inc., Austin, Texas.

United Nations Children's Fund. (1989). Convention on the Rights of the Child. Retrieved from www.unicef.org/sites/default/files/2019-04/UN-Convention-Rights-Child-text.pdf

United Nations Educational, Scientific and Cultural Organization. (2023). *Promoting Quality Physical Education Policy.* Retrieved from https://www.unesco.org/en/quality-physical-education

United Nations Educational, Scientific and Cultural Organization. (1981). Carta Internacional de la Educación Física y el Deporte. *Educación Física y Deporte*, *3*(1), 3-6. Retrieved from http://portal.unesco.org/es/ev.php-URL_ID=13150&URL_DO=DO_TOPIC&URL_SECTION=201.html

Unuzungo, M. I. B., & Carvajal, W. B. M. (2018). Visibilización de las personas con discapacidad en el Ecuador: Un enfoque desde los derechos de participación ciudadana. *Revista Latinoamericana en Discapacidad, Sociedad y Derechos Humanos*, *2*(1).

Van der Meere, J. J., Marzocchi, G. M., & De Meo, T. (2005). A response inhibition experiment in ADHD children plus or minus ODD. Developmental Neuropsychology, 28, 459–472.

van Schijndel-Speet, M., Evenhuis, H. M., van Wijck, R., & Echteld, M. A. (2014). Implementation of a group-based physical activity programme for ageing adults with ID: A process evaluation. *Journal of evaluation in clinical practice*, *20*(4), 401-407. https://doi.org/10.1111/jep.12145

Vandierendonck, A., Liefooghe, B., & Verbruggen, F. (2010). Task switching: interplay of reconfiguration and interference control. *Psychological bulletin*, *136*(4), 601. https://doi.org/10.1037/a0019791

Vásconez, A. C., Figueroa, G. F., Gavilánez, F. J., & Morejón, D. A. (2013). Política de atención a personas con discapacidad en el Ecuador: hacia un modelo de exportación. *Línea Sur*, *6*, 100.

Verret, C., Guay, M. C., Berthiaume, C., Gardiner, P., & Béliveau, L. (2012). A physical activity program improves behavior and cognitive functions in children with ADHD: an exploratory study. *Journal of attention disorders*, *16*(1), 71-80. https://doi.org/10.1177/1087054710379735

Vickerstaff, V., Omar, R. Z., & Ambler, G. (2019). Methods to adjust for multiple comparisons in the analysis and sample size calculation of randomised controlled trials with multiple primary outcomes. *BMC medical research methodology*, *19*(1), 1-13. https://doi.org/10.1186/s12874-019-0754-4

Visu-Petra, L., Stanciu, O., Benga, O., Miclea, M., & Cheie, L. (2014). Longitudinal and concurrent links between memory span, anxiety symptoms, and subsequent executive functioning in young children. *Frontiers in Psychology*, *5*, 443. https://doi.org/10.3389/fpsyg.2014.00443

Vuijk, P. J., Hartman, E., Scherder, E., & Visscher, C. (2010). Motor performance of children with mild intellectual disability and borderline intellectual functioning. *Journal of intellectual disability research*, *54*(11), 955-965.

Wall, A. E. T. (2004). The developmental skill-learning gap hypothesis: Implications for children with movement difficulties. *Adapted Physical Activity Quarterly, 21,* 197–218. https://doi.org/10.1123/apaq.21.3.197

Wechsler D. (1991). *Manual for the Wechsler Intelligence Scale for Children-Third Edition*. Psychological Corporation

Wentworth, N., Benson, J. B., & Haith, M. M. (2000). The development of infants' reaches for stationary and moving targets. *Child Development*, *71*(3), 576-601.

Westendorp, M., Houwen, S., Hartman, E., & Visscher, C. (2011). Are gross motor skills and sports participation related in children with intellectual disabilities?. *Research in developmental disabilities*, *32*(3), 1147-1153. https://doi.org/10.1016/j.ridd.2011.01.009

Wieland, J., & Zitman, F. G. (2016). It is time to bring borderline intellectual functioning back into the main fold of classification systems. *BJPsych Bulletin*, *40*(4), 204-206. https://doi.org/10.1192/pb.bp.115.051490

Williams, H. G., Pfeiffer, K. A., O'neill, J. R., Dowda, M., McIver, K. L., Brown, W. H., & Pate, R. R. (2008). Motor skill performance and physical activity in preschool children. *Obesity*, *16*(6), 1421-1426. https://doi.org/10.1038/oby.2008.214

Winter, R., & Hartmann, C. (2007). Die motorische Entwicklung (Ontogenese) des Menschen (Überblick). *K. Meinel, G. Schnabel & J. Krug, Bewegungslehre-Sportmotorik. Aachen [ua]: Meyer & Meyer*.

Worden, M. S. (2011). Attention Network Test (ANT). In J. S. Kreutzer, J. DeLuca, B. Caplan (Eds.), *Encyclopedia of Clinical Neuropsychology*. Springer, New York, NY. https://doi.org/10.1007/978-0-387-79948-3_1268

World Health Organization. (2011). World report on disability. Geneva, Switzerland: World Health Organization. Retrieved from https://www.who.int/teams/noncommunicable-diseases/sensory-functions-disability-and-rehabilitation/world-report-on-disability

World Health Organization (2020). *Physical activity: What is physical activity?* Retrieved from https://www.who.int/news-room/fact-sheets/detail/physical-activity

World Health Organization (2023). *Disability*. Retrieved from https://www.who.int/health-topics/disability#tab=tab_1

Wuang, Y. P., Wang, C. C., Huang, M. H., & Su, C. Y. (2008). Profiles and cognitive predictors of motor functions among early school-age children with mild intellectual disabilities. *Journal of Intellectual Disability Research*, *52*(12), 1048-1060. https://doi.org/10.1111/j.1365-2788.2008.01096.x

Wylie, G., & Allport, A. (2000). Task switching and the measurement of “switch costs”. *Psychological research*, *63,* 212-233. https://doi.org/10.1007/s004269900003

Yeniad, N., Malda, M., Mesman, J., van IJzendoorn, M. H., Emmen, R. A., & Prevoo, M. J. (2014). Cognitive flexibility children across the transition to school: A longitudinal study. *Cognitive Development*, *31,* 35-47. https://doi.org/10.1016/j.cogdev.2014.02.004

Yılmaz, A., & Soyer, F. (2018). Effect of physical education and play applications on school social behaviors of mild-level intellectually disabled children. *Education Sciences*, *8*(2), 89.

Zeichner, K. M. (1987). Preparing reflective teachers: An overview of instructional strategies which have been employed in preservice teacher education. *International journal of educational research*, *11*(5), 565-575. https://doi.org/10.1016/0883-0355(87)90016-4

Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. *Nature protocols*, *1*(1), 297-301. https://doi.org/10.1038/nprot.2006.46

Zhang, J. B., & Chen, S. (2004). A quantitative analysis of motor developmental delay by adolescents with intellectual disabilities. *Research Quarterly for Exercise and Sport*, 75(1), A114-A114

Zhang, L., Zhu, X., Haegele, J. A., Wang, D., & Wu, X. (2021). Effects of a one-year physical activity intervention on fundamental movement skills of boys with severe intellectual disabilities. *Research in Developmental Disabilities*, *114*, 103980. https://doi.org/10.1016/j.ridd.2021.103980

9 APPENDICES

Appendix 1

MEDICAL HISTORY SURVEY

Thank you for agreeing to answer our questions. Your answers are confidential and will not be disclosed to anyone apart from the research team. Please try and help us with all the information you can. If you don't understand any questions, please feel free to ask.

Name: __________________________ Date: __________________________________

Address: _______________________ Phone number: ___________________________

1) Please complete the following general information about your child:

Birthdate _______________________ Education level (grade)______________________

Gender _____________________________ Ethnicity____________________________

2) Does your child have any diagnosed congenital syndrome? (Such as Down syndrome, Fragile X syndrome, or Prader-Willi syndrome)

Yes	No	I do not know

If the answer is yes: Which syndrome?____

____

3) Does your child have any other diagnosed developmental disorder (in addition to the intellectual disability)? (Such as motor disorders, autism spectrum disorders, or schizophrenia)

Yes	No	I do not know

If the answer is yes: Which developmental disorders?______________________________

____

4) Does your child have any important physical or sensory limitations? (Such as visual impairment, hearing impairment, or limb amputation)

Yes	No	I do not know

If the answer is yes: Which limitation/s? ______________________________________

____

5) Are there any health conditions worth mentioning for your child's participation in the physical education program? (Such as asthma, heart disease, or high blood pressure)

Yes	No	I do not know

If the answer is yes: Which health conditions? __________________________________

____

6) How do you consider your child's general health status?

Very Good	Good	Acceptable	Poor	Very Poor

7) Do you think your child is in good physical condition to participate in a physical education program for six weeks (1 hour 2 times per week)?

Yes	No

8) Do you want to add some important information about your child's health status?

____

____

____

____

The research team may contact you for more information on your child's health status.

Thank you very much for your help.

Appendix 2

VOLUNTEERS NEEDED

We are seeking children aged between 10 and 14 years old with mild intellectual disability for participation in research focused on examining whether an enriched physical education program contributes to cognitive and motor performance.

This study might highlight the importance of a quality physical activity planned according to the features and needs of children with intellectual disabilities. In addition, the outcomes could serve as guidelines for educators and schools for possible modifications in current practices, and you can help us achieve it!

Children who participate in this study will be able to take part in a 6-week physical education program for one hour two times a week, with a total of 12 sessions. Children will also be tested (cognitive and motor measurements) to compare the effects of the intervention. There are potential benefits to the children participating in this study, such as improved motor skills performance and some cognitive control capacities.

FOR FURTHER INFORMATION:

Liseth Mero Piedra- 0997708707
lisethmero@student.elte.hu

Appendix 3

INFORMED PARENTAL CONSENT FORM

We invite you and your child to participate in a research study conducted by Angélica Liseth Mero Piedra. She is a doctoral student at the Special Education Doctoral Programme at Eötvös Loránd University, as part of her project "Effects of an enriched physical education program on cognitive and motor performance in children with intellectual disabilities".

The study aims to examine whether the effects of a 6-week enriched physical education program contribute to cognitive control (attention, inhibitory control, and cognitive flexibility) and gross motor skills (locomotor and object control) in children with mild intellectual disabilities. The program will be based on playful practices because they provide a substantial educational resource of quality physical education and are the first block in the Ecuadorian physical education school curriculum, called "Playful practices: games and playing". There are potential benefits to the children participating in this study, such as improved motor skills performance and cognitive control capacities. This study might highlight the importance of quality physical activity, planned according to the features and needs of children with intellectual disabilities. The outcomes could serve as guidelines for educators and schools for possible modifications in current practices. Description of the study design and methods, as well as your children's rights as participants, are described below:

Design and methods description: The children will be randomly assigned to 2 groups; both groups will participate in a 6-week physical education program for one hour two times a week, with a total of 12 sessions. The difference is that one group will be part of the intervention in the first six weeks (intervention group), and the second group will also have the opportunity to participate later, after completing the study's measurements (wait-list control group). This is to evaluate the real effects of the intervention by comparing the results of the two groups. We will also require the children an oral consent to participate, and short-term memory and verbal-fluency tests will be administered to verify that the groups are not significantly different in basic memory and language skills. We will also ask the parents (or legal representative) to complete a general medical history survey about the children.

After that, participants will be asked to perform two computer-based cognitive tests and one motor skill test. These tasks will be performed twice, before and after the intervention. Your child's motor skill test will be videotaped for use in standard research procedures (analysis of qualitative motor skill scores). Data collection will be completed over four days per child (2 pre-tests - 2 post-tests). There will be breaks between tasks, and each test will take about 15-25 minutes per child.

Confidentiality: Children's answers and performance scores will not be associated with their names. Instead, each child will be given an identification number (1-30). All data will be stored in password-protected files. Upon completing the study, all identifiable data will be immediately destroyed, such as the general medical history survey and videotape of your child's participation (motor skills). Researchers retain the right to use and publish non-identifiable data. The data collected will be used only for this investigation, and the findings will be presented to people involved and key stakeholder organizations in appropriate scientific publications, a doctoral thesis, and scientific conferences. When the results of this research are published or discussed at conferences, no information will be included that would reveal the children's identity.

Risks: There are minimal risks to children's safety (no greater than those typically encountered in physical education), such as physical or mental fatigue. However, all pertinent measures will be taken to reduce these risks, such as good communication and instructions or the possibility of stopping and resting when children consider it appropriate. The literature raises no sensitive or controversial issues in similar programs and does not contain elements typically frightening to children.

Freedom to withdraw or refuse participation: Children's participation is voluntary, and they might withdraw from or refuse to participate in the study at any time, without any punishment. Your decision or your child's withdrawal will not affect in any way his/her current services.

Grievance procedure: If you have any concerns or are dissatisfied with any aspect of this study, you may report the grievances if desired to the researcher; these will be recorded and be considered later in the analysis process.

Questions: Please feel free to ask the principal investigator any questions before signing the consent form or at any time during or after the study.

Investigator: Angélica Liseth Mero Piedra. Doctoral student at the Special Education Doctoral Programme at Eötvös Loránd University, Hungary. E-mail: lisethmero@student.elte.hu, cell phone (+593) 0997708707.

Faculty supervisor: Klára Marton, Ph.D., habil. dr. Special Education Faculty at Eötvös Loránd University, Hungary. E-mail: klara.marton@barczi.elte.hu.

INFORMED CONSENT STATEMENT

Please let us know whether you agree to allow us to video-record your child's motor skill test performance:

_____ Yes, I agree to have my child's motor skill test performance video-recorded and used for data analysis purposes.

_____ No, I do not agree to have my child's motor skill test performance video-recorded.

I, ______________________________*(parent/legal representative's name)*, give permission for my child __________________________*(child's name)*, to participate in the research project entitled, "Effects of an enriched physical education program on cognitive and motor performance in children with intellectual disabilities". The study has been explained to me and my questions answered to my satisfaction. I understand that my child's right to withdraw from participating or refuse to participate will be respected and that his/her responses and identity will be kept confidential. Therefore, I give this consent voluntarily.

Parent/Legal representative Signature:

______________________________ ______________________

Signature *Date*

Principal investigator Signature:

______________________________ ______________________

Signature *Date*

Appendix 4

CHILDREN ASSENT TO PARTICIPATE

Project Title: Effects of an enriched physical education program on cognitive and motor performance in children with intellectual disabilities

Principal Investigador: Angélica Liseth Mero Piedra

Child's Name:______________________________

Hello, my name is___________________________ *(examiner's name)*. We are studying how physical games can help children's mental capacities, like paying attention, for example. If we pay attention, we can be alert and ready to take all the information teachers gives us during our classes without getting distracted by our friends.

We are asking you to help us. If you agree to participate, all you have to do is come and have fun playing games during six weeks in a physical education program. You will also help us a lot by making some simple judgments about some pictures and shapes on a computer. But don't worry! We will explain everything very well, and you will have time to practice. We also want to know how you move! So, you will have to show us how good are you at that, by showing how you jump or throw, for example.

We will meet two times per week during the program, and we will be together for 1 hour. And also, we will meet two times at the beginning and two times at the end of the program so you can show us those movements and judgments about the pictures and shapes we mentioned. It is very important that you know that if you agree to participate, you will be free to ask about everything and also to take as many breaks as you want if you feel tired.

What we will learn from you may also help other children and teachers. But you don't have to be in this study. No one will be mad at you if you don't want to do this. If you don't want to be in this study, just tell us. If you want to be in this study, just tell us. Remember, it is ok to say yes now and change your mind later. Nothing will happen to you if you decide to stop.

We will not tell anyone your name and that you are in this study.

You can ask any question. You can ask me now. You can ask me later. You can talk to me or your mom/dad/guardian.

Do you want to participate in this study? Yes _______ No _______

INVESTIGATOR ASSENT

I have explained the study to ____ (*name of child*) in language he/she understands, and he/she has agreed to be in the study.

Investigator Signature:

________________________________ ______________________

Signature *Date*

Appendix 5

TGMD–2

Test of Gross Motor Development–Second Edition

Profile/Examiner Record Form

Section I. Identifying Information

Name ______________________

Male ☐ Female ☐ Grade ______________________

Date of Testing ______ ______ ______

Date of Birth ______ ______ ______

Age ______ ______ ______

School ______________________

Referred by ______________________

Reason for Referral ______________________

Examiner ______________________

Examiner's Title ______________________

Section II. Record of Scores

First Testing

	Raw Score	Standard Score	Percentile	Age Equivalent
Locomotor	____	____	____	____
Object Control	____	____	____	____

Sum of Standard Scores ____

Gross Motor Quotient ____ ____

Second Testing

	Raw Score	Standard Score	Percentile	Age Equivalent
Locomotor	____	____	____	____
Object Control	____	____	____	____

Sum of Standard Scores ____

Gross Motor Quotient ____ ____

Section III. Testing Conditions

A. Place Tested ______________________

	Interfering				Not Interfering
B. Noise Level	1	2	3	4	5
C. Interruptions	1	2	3	4	5
D. Distractions	1	2	3	4	5
E. Light	1	2	3	4	5
F. Temperature	1	2	3	4	5

G. Notes and other considerations ______________________

Section IV. Other Test Data

Name of Test	Date	Standard Score	TGMD–2 Equivalent

Section V. Profile of Standard Scores

Standard Scores	Locomotor	Object Control	Standard Scores	Quotients	Gross Motor Quotient	Quotients
20			20	150		150
19			19	145		145
18			18	140		140
17			17	135		135
16			16	130		130
15			15	125		125
14			14	120		120
13			13	115		115
12			12	110		110
11			11	105		105
10			10	100		100
9			9	95		95
8			8	90		90
7			7	85		85
6			6	80		80
5			5	75		75
4			4	70		70
3			3	65		65
2			2	60		60
1			1	55		55

Additional copies of this form (#9262) may be purchased from
PRO-ED, 8700 Shoal Creek Blvd., Austin, TX 78757-6897
800/897-3202 Fax 800/397-7633 www.proedinc.com

8 9 10 11 12 13 12 11 10 09

1

Section VI. Subtest Performance Record

Preferred Hand: Right ☐ Left ☐ Not Established ☐
Preferred Foot: Right ☐ Left ☐ Not Established ☐

Locomotor Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Run	60 feet of clear space, and two cones	Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "Go." Repeat a second trial.	1. Arms move in opposition to legs, elbows bent			
			2. Brief period where both feet are off the ground			
			3. Narrow foot placement landing on heel or toe (i.e., not flat footed)			
			4. Nonsupport leg bent approximately 90 degrees (i.e., close to buttocks)			
					Skill Score	
2. Gallop	25 feet of clear space, and tape or two cones	Mark off a distance of 25 feet with two cones or tape. Tell the child to gallop from one cone to the other. Repeat a second trial by galloping back to the original cone.	1. Arms bent and lifted to waist level at takeoff			
			2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot			
			3. Brief period when both feet are off the floor			
			4. Maintains a rhythmic pattern for four consecutive gallops			
					Skill Score	
3. Hop	A minimum of 15 feet of clear space	Tell the child to hop three times on his or her preferred foot (established before testing) and then three times on the other foot. Repeat a second trial.	1. Nonsupport leg swings forward in pendular fashion to produce force			
			2. Foot of nonsupport leg remains behind body			
			3. Arms flexed and swing forward to produce force			
			4. Takes off and lands three consecutive times on preferred foot			
			5. Takes off and lands three consecutive times on nonpreferred foot			
					Skill Score	
4. Leap	A minimum of 20 feet of clear space, a beanbag, and tape	Place a beanbag on the floor. Attach a piece of tape on the floor so it is parallel to and 10 feet away from the beanbag. Have the child stand on the tape and run up and leap over the beanbag. Repeat a second trial.	1. Take off on one foot and land on the opposite foot			
			2. A period where both feet are off the ground longer than running			
			3. Forward reach with the arm opposite the lead foot			
					Skill Score	

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
5. Horizontal Jump	A minimum of 10 feet of clear space and tape	Mark off a starting line on the floor. Have the child start behind the line. Tell the child to jump as far as he or she can. Repeat a second trial.	1. Preparatory movement includes flexion of both knees with arms extended behind body			
			2. Arms extend forcefully forward and upward reaching full extension above the head			
			3. Take off and land on both feet simultaneously			
			4. Arms are thrust downward during landing			
					Skill Score	
6. Slide	A minimum of 25 feet of clear space, a straight line, and two cones	Place the cones 25 feet apart on top of a line on the floor. Tell the child to slide from one cone to the other and back. Repeat a second trial.	1. Body turned sideways so shoulders are aligned with the line on the floor			
			2. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot			
			3. A minimum of four continuous step–slide cycles to the right			
			4. A minimum of four continuous step–slide cycles to the left			
					Skill Score	
			Locomotor Subtest Raw Score (sum of the 6 skill scores)			

Object Control Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Striking a Stationary Ball	A 4-inch lightweight ball, a plastic bat, and a batting tee	Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball hard. Repeat a second trial.	1. Dominant hand grips bat above nondominant hand			
			2. Nonpreferred side of body faces the imaginary tosser with feet parallel			
			3. Hip and shoulder rotation during swing			
			4. Transfers body weight to front foot			
			5. Bat contacts ball			
					Skill Score	
2. Stationary Dribble	An 8- to 10-inch playground ball for children ages 3 to 5; a basketball for children ages 6 to 10; and a flat, hard surface	Tell the child to dribble the ball four times without moving his or her feet, using one hand, and then stop by catching the ball. Repeat a second trial.	1. Contacts ball with one hand at about belt level			
			2. Pushes ball with fingertips (not a slap)			
			3. Ball contacts surface in front of or to the outside of foot on the preferred side			
			4. Maintains control of ball for four consecutive bounces without having to move the feet to retrieve it			
					Skill Score	

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
3. Catch	A 4-inch plastic ball, 15 feet of clear space, and tape	Mark off two lines 15 feet apart. The child stands on one line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his or her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the child's shoulders and belt. Repeat a second trial.	1. Preparation phase where hands are in front of the body and elbows are flexed			
			2. Arms extend while reaching for the ball as it arrives			
			3. Ball is caught by hands only			
					Skill Score	
4. Kick	An 8- to 10-inch plastic, playground, or soccer ball; a beanbag; 30 feet of clear space; and tape	Mark off one line 30 feet away from a wall and another line 20 feet from the wall. Place the ball on top of the bean-bag on the line nearest the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.	1. Rapid continuous approach to the ball			
			2. An elongated stride or leap immediately prior to ball contact			
			3. Nonkicking foot placed even with or slightly in back of the ball			
			4. Kicks ball with instep of preferred foot (shoe-laces) or toe			
					Skill Score	
5. Overhand Throw	A tennis ball, a wall, tape, and 20 feet of clear space	Attach a piece of tape on the floor 20 feet from a wall. Have the child stand behind the 20-foot line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.	1. Windup is initiated with downward movement of hand/arm			
			2. Rotates hip and shoulders to a point where the nonthrowing side faces the wall			
			3. Weight is transferred by stepping with the foot opposite the throwing hand			
			4. Follow-through beyond ball release diagonally across the body toward the nonpreferred side			
					Skill Score	
6. Underhand Roll	A tennis ball for children ages 3 to 6; a softball for children ages 7 to 10; two cones; tape; and 25 feet of clear space	Place the two cones against a wall so they are 4 feet apart. Attach a piece of tape on the floor 20 feet from the wall. Tell the child to roll the ball hard so that it goes between the cones. Repeat a second trial.	1. Preferred hand swings down and back, reaching behind the trunk while chest faces cones			
			2. Strides forward with foot opposite the preferred hand toward the cones			
			3. Bends knees to lower body			
			4. Releases ball close to the floor so ball does not bounce more than 4 inches high			
					Skill Score	
				Object Control Subtest Raw Score (sum of the 6 skill scores)		

Appendix 6

EÖTVÖS LORÁND UNIVERSITY

DECLARATION FORM for disclosure of a doctoral dissertation

I. **The data of the doctoral dissertation:**

Name of the author: Angélica Liseth Mero Piedra

MTMT-identifier: 10072042

Title and subtitle of the doctoral dissertation: Effects of an Enriched Physical Education Program on Cognitive and Motor Performance in Children with Mild Intellectual Disabilities.

DOI-identifier[87]: 10.15476/ELTE.2023.199

Name of the doctoral school: Doctoral School of Education

Name of the doctoral programme: Special Education Programme

Name and scientific degree of the supervisor: Dr. Klára Marton, Ph.D., Professor

Workplace of the supervisor: -Bárczi Gusztáv Faculty of Special Needs Education, Eötvös Loránd University.
-Brooklyn College, City University of New York, Brooklyn, NY, USA.
-Graduate School and University Center, City University of New York, USA.

II. Declarations

1. As the author of the doctoral dissertation,[88]

a) I agree to public disclosure of my doctoral dissertation after obtaining a doctoral degree in the storage of ELTE Digital Institutional Repository. I authorize ………………………………. the administrator of the …………………………..…………..…… Office of the Doctoral School to upload the dissertation and the abstract to ELTE Digital Institutional Repository, and I authorize the administrator to fill all the declarations that are required in this procedure.

b) I request to defer public disclosure to the University Library and the ELTE Digital Institutional Repository until the date of announcement of the patent or protection. For details, see the attached application form;[89]

c) I request in case the doctoral dissertation contains qualified data pertaining to national security, to disclose the doctoral dissertation publicly to the University Library and the ELTE Digital Institutional Repository ensuing the lapse of the period of the qualification process.;[90]

[87] Filled by the administrator of the faculty offices.
[88] The relevant part shall be underlined.
[89] Submitting the doctoral dissertation to the Disciplinary Doctoral Council, the patent or protection application form and the request for deferment of public disclosure shall also be attached.
[90] Submitting the doctoral dissertation, the notarial deed pertaining to the qualified data shall also be attached.

d) I request to defer public disclosure to the University Library and the ELTE Digital Institutional Repository, in case there is a publishing contract concluded during the doctoral procedure or up until the award of the degree. However, the bibliographical data of the work shall be accessible to the public. If the publication of the doctoral dissertation will not be carried out within a year from the award of the degree subject to the publishing contract, I agree to the public disclosure of the doctoral dissertation and abstract to the University Library and the ELTE Digital Institutional Repository.[91]

2. As the author of the doctoral dissertation, I declare that
a) the doctoral dissertation and abstract uploaded to the ELTE Digital Institutional Repository are entirely the result of my own intellectual work and as far as I know, I did not infringe anyone's intellectual property rights.;
b) the printed version of the doctoral dissertation and the abstract are identical with the doctoral dissertation files (texts and diagrams) submitted on electronic device.

3. As the author of the doctoral dissertation, I agree to the inspection of the dissertation and the abstract by uploading them to a plagiarism checker software.

Budapest, 23 July, 2023

Signature of dissertation author

[91] Submitting the doctoral dissertation, the publishing contract shall also be attached.