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Assessment of Executive Functions in School Considering Motor and Sociodemographic Factors: A Joint Vision for School-Based Occupational Therapists and School Staff

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Abstract: Executive functions (EFs) and motor skills are essential for many school and daily tasks. Many school-based occupational therapists need help addressing EFs. The current study aims to provide new insights into the relationship between executive functions and motor development by considering confounding factors. Ninety-six second-grade children were tested in one state-funded (public) school and another state-subsidised private school. Children were assessed with the Movement Assessment Battery for Children-2 (MABC-2), Neuropsychological Assessment of Executive Functions in Children, and Test of Perception of Differences–R. Families completed a sociodemographic questionnaire, and teachers completed a previous questionnaire and subsequently evaluated the information the occupational therapist provided. Mixed results were obtained regarding the correlation between motor and executive skills. Furthermore, children who received worse scores on the MABC-2 had more difficulties on the EFs tests. The Impulsivity Control Index was not correlated with any motor variable. Our results show that sociodemographic variables (except gender) correlate more with EFs than motor skills. The teachers showed a high degree of agreement with the occupational therapist (4.0 ± 0.8), even in children with good academic performance. They expressed the need for additional training and classroom interventions. A joint vision of motor-executive functioning can facilitate the design of effective interventions, especially in schools with more disadvantaged populations.

Keywords: child development; assessment; sociodemographic factors; executive functions; motor skills; occupational therapy; school-based practice

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1. Introduction

Occupational therapists and physiotherapists have a primary role in detecting motor difficulties in childhood [1,2]. However, the presence of these professionals in Spanish mainstream schools is scarce and may prevent an adequate evaluation of this critical development area [2]. Motor development can affect areas other than motor performance, such as cognition and social or academic skills [1,3]. In this way, motor and cognitive skills appear to be interrelated at the level of underlying brain structures and can influence each other [4]. This connection is more significant at early ages [5,6]. Specifically, acquiring new motor skills requires, among other things, planning and problem-solving [3], enabling new learning opportunities.

On the other hand, executive functions (EFs) are a set of complex cognitive processes essential for adaptative behaviour and everyday life. Basic EFs are inhibitory control, working memory, and cognitive flexibility; higher-level EFs are planning, reasoning, and problem-solving [7]. Therefore, these functions include the individual's ability to formulate goals, focus on relevant information, plan strategies, start, maintain, and stop complex sequences, and regulate behaviour [8]. These functions are essential to success in school, work, and personal relationships [9] and mainly affect occupational performance and engagement [10].

EF deficits are common among children with developmental disorders, such as attention-deficit hyperactivity disorder (ADHD) or autism spectrum disorders (ASD), and learning disabilities; they may also be present in children who have experienced chronic stress, poverty, or other adverse life experiences [11–13]. The study of EFs has gained increasing attention in recent years as school-based occupational therapists seek to understand how these functions are related to daily occupational performance [14]. So, understanding EFs and their development is crucial for occupational therapists, educators, and researchers to avoid adverse long-term effects.

Children in school use EFs when they focus on a school task, remember the steps and teacher's instructions, and continue the activity until completion. Children also used EFs in school when they demonstrate inhibitory control to stop an action or change the focus of their attention when their teacher tells them to do something else. These small examples illustrate how EFs are needed daily in the classroom [12]. Hence, poor EF skills may interfere with children's learning and cause behavioural problems. Children with EF deficits may struggle with paying attention in class, initiating tasks, making decisions, and inhibiting impulsive responses. For this reason, school-based occupational therapists should consider systematically evaluating these functions to detect children with issues in this area and to improve occupational performance.

There is a consensus that occupational therapists should pay attention to problems derived from EFs due to their impact on occupational performance [15–17]. However, school-based occupational therapists prefer to assess motor and sensory skills [14,18]. Therefore, professionals may attribute performance issues to sensory and motor difficulties and overlook the influence of EFs on occupational performance [19].

In this way, recent research indicates that EFs are a more difficult predictor of academic performance than fine motor skills [20], so educational professionals should consider this. Furthermore, although motor development and FEs have stronger relationships in preschool age, they exhibit a weaker association from adolescence onwards [5,6]. Thus, if children do not have sensorimotor difficulties but have performance issues associated with poor executive functioning, they may not receive occupational therapy services at school [19]. Therefore, simultaneously assessing EFs and motor development can be crucial to facilitating success in school [21]. Such research is essential to help school-based occupational therapists identify factors related to EFs. Differentiating and comparing motor performance and EFs can facilitate the implementation of specific programmes to address children's participation challenges in school.

Occupational therapists should assess EFs by choosing the available tools [22] since, as the American Occupational Therapy Association (AOTA) points out, standardised assessments allow for obtaining objective data from the domains influencing performance [23]. In a recent Tanis (2022) study, the surveyed occupational therapists reported using non-standardised measures and approaching EF issues informally. Furthermore, some therapists must consider EFs in evaluating or planning individualised goals, which may divert from the best practice recommendations [14].

School-based occupational therapists appear to have difficulty addressing EFs related to occupational performance challenges at school [10,14]. For this reason, professionals must understand the relevance of assessing these functions at school to detect children with difficulties and to include goals in individualised intervention plans. As Tanis and Erb point out, the occupational therapy process for EFs differs from the most typical performance skill areas despite being a comparable need [14]. This may be the first step for therapists to learn about this and be able to apply it in school.

Most teachers recognise that EFs are essential in school, especially those with more experience, even if they have never heard of this term [24]. However, teachers also need more comprehension of EFs [24,25]. In addition, teachers have reported difficulties in understanding the reports due to the lack of face-to-face explanations, inaccessible language, and unclear terminology [25]. Both research and reports may focus on abstract tasks rather than how these skills translate into classroom behaviours [24,25]. Therefore, teachers need easy and accessible information to understand children's performance.

Finally, various sociodemographic factors have been associated with motor [2,26] and cognitive development [11]. Recent studies have pointed out the need to further explore the relationship between sociodemographic factors and the development of executive and motor functions [5,6] because they can act as confounding variables [5,6,13]. In this way, multiple factors influence development [3], making it a relevant topic for education and health professionals. This study includes several sociodemographic variables to address this gap.

This study aimed to examine the relationships between executive function and motor performance in second-grade students and analyse the moderating effects of sociodemographic factors. The secondary aim was to explore whether qualitative and quantitative information obtained during assessment was helpful for teachers and mirroring children's performance in the classroom.

We hypothesised that children with better motor performance would obtain better results on EF tests and vice-versa. On the other hand, families' sociodemographic characteristics, as confounding variables, could impact both areas of development. We also hypothesised that an experienced paediatric occupational therapist could provide teachers with relevant information about children's performance in the classroom based on data obtained from standardised tests and observations collected during testing. A better understanding of the specific relationships between motor and executive skills, considering confounding variables, may help detect children with difficulties in either of the two developmental domains and implement interventions at school.

2. Materials and Methods

2.1. Participants and Settings

The participants were recruited from two schools in Zaragoza, Autonomous Community of Aragon (Spain): one state-funded school and another state-subsidised private school. The inclusion criteria were to have informed consent signed by parents or legal tutors and to complete all tests regardless of the degree or kind of disability.

Ninety-eight second-grade students voluntarily participated after the informed consent form was signed by their parents or guardians. However, the results of two children were excluded from the analysis because they could not complete all the tests. The final sample comprised 96 children, 44 female and 52 males, with an average age of 90.1 months $\pm$4.2. This study was conducted following the standards of the Declaration of Helsinki and approved by the Research Ethics Committee of Aragon (CEICA) in November 2022 (CP-CI PI22/459).

There were five teachers (four female and one male). They ranged in age from 29 to 49 years old and had an average teaching experience of 16 years. Only one of them had had previous contact with an occupational therapist.

2.2. Measures

Demographic Questionnaire. Demographic features of the child and parents, including age, country of origin, socioeconomic status, and parental education. Families completed demographic questions addressing children's age and sex, parents' education, economic status, and country of origin.

Neuropsychological Assessment of Executive Functions in Children (ENFEN-Spanish acronym) [27]. The ENFEN is a standardised test to assess EFs in children aged 6 to 12 years old, which occupational therapists can use. The ENFEN is made up of four tests. In the verbal fluency task, the child has one minute to produce as many words as possible, and the task has two parts: phonological fluency (words beginning with "m") and semantic fluency (animal names). The trail construction tests are based on the "Trail Making Test" and have two parts. The subject must quickly connect a set of dots from 20 to 1 in the grey path and connect dots from 1 to 21, changing the colour at each number in the colour path. The Tower of Hanoi inspires the rings test and requires completing 14 models of increasing difficulty with washers of six colours. Finally, the Interference test is a Stroop-type task where the subject must instead name the colour of the printed ink, not read the word. The four tasks provide six measures, and direct scores are transformed into sten scores (mean 5.5; SD $\pm$ 2). The ENFEN is a suitable psychometric instrument in the educational field [28].

Test of Perception of Differences–Revised (R-FACES) [29]. The R-FACES is an easy and quick test to assess the subject's visual perception, attention, and impulsiveness in executing a task. It consists of 60 graphic elements, and each one of them is made up of three schematic drawings of faces. The subject must cross out the different figures from a group of three faces. The number of hits and errors allows for obtaining the Net Hits (correct Answers minus Errors), which measures attentional efficacy and the Impulsivity Control Index [(A $-$ E/A + E) $\times$ 100], which is an indicator of inhibitory control. Direct scores are transformed into the stanine scores (mean 5; SD $\pm$ 2) and percentiles. Regarding reliability, Cronbach's alpha levels (α) ranged from .82 to .92 in the original study.

The Spanish version of the Movement Assessment Battery for Children-2 (MABC-2) assessed motor development [30,31]. The MABC-2 allows you to evaluate three dimensions: manual dexterity (three tasks), aiming and catching (two tasks), and balance (three tasks). Eight items differ for the three age ranges. Only materials for age bands 1 and 2 tasks were used in this study. For age band 1, these tasks are as follows: manual dexterity (MD), including posting coins (MD1), threading beads (MD2), and drawing a trail (MD3); aiming and catching (A&C), including catching a beanbag (A&C1) and throwing a beanbag onto a mat (A&C2); and balance (B), including one-leg balance (B1), walking heels raised (B2), and jumping on mats with feet together (B3). For age band 2, these tasks are as follows: manual dexterity (MD), including placing pegs (MD1), threading lace (MD2), and drawing a trail (MD3); aiming and catching (A&C), including catching with two hands (A&C1) and throwing a bean bag onto a mat (A&C2); and balance (B), including one-board balance (B1), walking heel to toe forward (B2), and hopping on mats on one leg (B3). Direct scores are converted into scaled scores (ranging from 1 to 19) with a mean of 10 and SD of 3 and percentiles. The 5th and lower percentiles indicate that the child has severe movement difficulties, and scores between the 6th and 15th percentiles represent children with borderline motor impairment. The often-standard cut-off value of 15% is unavailable in the MABC-2 [32]. However, the authors show that the 5th and 15th percentiles correspond to the total test scores of 59 and 68 points, respectively.

Questionnaires from teachers and ecological validity. Before starting the study, teachers completed a short questionnaire for each child with the following questions: (1) difficulty following and maintaining verbal instructions; (2) impulsivity; (3) attention problems; and (4) difficulties organising and solving complex problems. They rated each item on a 3-point Likert-type scale (1 = very often/often, 2 = sometimes, 3 = never/rarely). These data were only available to the evaluators once the reports were given to teachers and families.

At the end of the study, teachers received reports from each child (except two whose families had not given express consent to share the information with school staff). The teachers completed a questionnaire to assess the points of the therapist's information about the children's performance that corresponded with their daily observations in the classroom. They also evaluated the degree of satisfaction with the information received and whether they saw it necessary to conduct school evaluations regularly. Each question was rated on a 5-point Likert-type scale (from 1 Strongly Disagree/Very dissatisfied/Not Important to 5 Strongly Agree/Very Satisfied/Essential). Additional comments were also collected.

2.3. Procedure

In each school, a previous meeting was held with the principals, the teachers, and the families. The principal investigator explained the objectives of the study and facilitated informed consent. Families who could not attend the meeting received the information through their teachers. This research is part of a larger project by occupational therapists and optometrists of Zaragoza University in the school setting.

This research project was carried out during the 2022–2023 school year. Informed consent forms for families were collected in December 2022. Five occupational therapists performed the motor assessment. Evaluators received additional training, had the opportunity to practice under simulated conditions and via videos, and received feedback on their performance. However, only a paediatric occupational therapist with more than 20 years of experience collaborating with schools carried out the EF assessment, prepared reports and gave information to teachers. Teachers completed the initial questionnaire on each child before concluding the evaluations. Data collection took place between December 2022 and March 2023 during school hours. Each school provided appropriate rooms to test children. Children completed the tasks in two sessions. The first session was held in a separate room per the ENFEN norms and was used to evaluate the R-FACES Test. The second session was used to assess motor development through the MABC-2. The first session lasted approximately 20 to 30 min. The second session lasted about 20 to 40 min since the MABC-2 does require a second trial on some tasks if the child still needs to obtain the maximum score.

After completing the data collection, the teachers and families were informed about the children's results in the test and other qualitative data collected by the therapists. These were compared with their performance in the classroom through the teacher's perception to ensure ecological validity.

2.4. Data Analysis

Data analysis was conducted using the R programming language, which is specialised for statistical purposes. Descriptive categorical variables were analysed by calculating their absolute and relative frequencies. In contrast, the descriptive analysis of numerical variables involved computing their mean, standard deviation, and range (minimum and maximum values). We applied an appropriate normality test to all numerical variables based on their sample size. To make inferences regarding location and determine differences between groups of normally distributed variables, we employed the Student's t-test. For non-normally distributed variables, we utilised the non-parametric Mann–Whitney–Wilcoxon test.

Sociodemographic variables in this study comprised gender, income, educational level, and mother tongue. Gender was treated as a dichotomous categorical variable. Income level was defined as total household income and categorised as ordinal multi-categorical. The highest educational level of one of the parents has been selected as the ordinal multi-categorical. The mother tongue has been established as follows depending on the parent's country of origin: a parent of Spanish origin = 2; at least one parent from a Spanish-speaking Latin American country = 1; no parent whose native language is Spanish = 0.

To examine the relationship between numerical variables, we employed Spearman's rank correlation test, which is suitable for assessing correlations between non-normally distributed variables. In this test, categorical variables were also included by sorting them and assigning them a numerical value. To express the degree of correlation, we used the Spearman correlation coefficient (Rho) and considered the following ranges: weak correlation up to $\rho \leq 0.2$, moderate $0.2 < \rho < 0.5$, strong $0.5 \leq \rho \leq 0.8$, and very strong $\rho > 0.8$. For all the tests mentioned above, we applied a significance level of 95% and ensured a statistical power of 80% to guarantee that the sample size was adequate for detecting the expected effect.

3. Results

After applying the Mann–Whitney–Wilcoxon test, we observed statistically significant differences in terms of educational level, professional category, and nationality of the parents, as well as the income of the family unit, even though the two schools are located in the same school district (Table 1).

Table 1. Descriptive statistics of demographic variables.

	School 1				School 2					
	Mother		Father		Mother		Father		Mother	Father
	n	%	*n*	%	*n*	%	*n*	%	*p*-Value	*p*-Value
Education										
Primary or less	5	16.6	4	16.0	1	1.6	0	0		
Middle school	8	26.6	11	44.0	7	11.5	8	13.6	<0.001	<0.001
High or trade school	14	46.6	8	32.0	27	44.3	37	62.7		
University	3	10.0	2	78.0	26	42.6	14	23.7		
Occupational category										
Unemployed/homeworker	9	30.0	6	23.1	4	7.5	0	0.0		
Unskilled employed	15	50.0	15	57.7	24	45,3	27	51.9	0.001	0.002
Skilled employed	5	16.6	3	11.5	11	20.8	7	13.5		
Managerial employed	1	3.3	2	7.7	14	26.4	18	34.6		
Nacionality										
Spain	4	12.9	5	18.5	49	81.7	51	86.4		
Sub-Saharan Africa	8	25.8	7	25.9	0	0.0	0	0		
Arabian countries	3	9.7	3	11.1	0	0.0	0	0	<0.001	<0.001
Eastern Europe	2	6.4	1	3.7	6	10.0	2	3.4		
Latin America	14	45.2	10	37.0	5	8.3	6	10.2		
Other	0	0	1	3.7	0	0.0	0	0		
	n		%		*n*		%		*p*-Value	
Income										
Less than 1000 €	6		20.7		1		1.9			
1000–2000 €	17		58.6		11		21.1		<0.001	
2000–3000 €	4		13.8		23		44.2			
More than 3000 €	2		6.9		17		32.7			
Gender										
Female	18		53.0		26		41.9		0.305	
Male	16		47.0		36		58.1			
	Mean		SD		Mean		SD			
Age	90.2		5.3		90.1		3.6		0.889	

The families in School 1 have a larger immigrant population and a lower socioeconomic and educational level. Not all families completed all the data on the sociodemographic form. Therefore, many of the variables do not contain the complete sample.

The participants' mean scores, standard deviation, and range (minimum-maximum) on all the study variables are presented in Table 2. The last column shows the *p*-value of a non-parametric test (Mann–Whitney–Wilcoxon test), which compares the position of each variable with the standardised results. A non-parametric test was used because most variables did not meet the normality criterion. A test was also performed to check the homoscedasticity concerning the standardised results of each of the tests. The results show that most of the variables in our study are below expectations.

Table 2. Descriptive statistics of motor and executive function variables.

	Mean	SD	Min	Max	N	*p*-Value
ENFEN						
Phonological fluency	4.16	1.77	1	8	96	<0.001
Semantic fluency	5.37	2.38	1	10	96	0.743
Grey path	5.35	2.30	1	10	96	0.495
Colour path	3.24	2.29	1	10	96	<0.001
Rings	3.83	2.07	1	9	96	<0.001
Interference	4.72	2.13	1	10	96	0.165
R-FACES						
Net Hits	5.27	2.31	1	9	96	0.298
Impulsivity Control Index	4.05	1.75	1	6	96	<0.001
MABC						
MABC Total	7.52	3.75	1	14	96	<0.001
Manual Dexterity (MD)	7.93	3.39	1	13	96	<0.001
MD1	7.38	3.14	1	13	96	<0.001
MD2	8.01	3.48	1	14	96	<0.001
MD3	9.95	2.90	1	12	96	0.947
Aiming and Catching (A&C)	7.75	3.08	1	15	96	<0.001
A&C1	8.47	3.11	1	15	96	<0.001
A&C2	7.67	2.58	1	14	96	<0.001
Balance (B)	8.74	4.35	1	16	96	0.019
B1	9.08	2.75	5	16	96	<0.001
B2	8.81	3.90	1	12	96	0.013
B3	9.93	2.33	3	12	96	0.951

The sample was divided into three subgroups to establish a relationship between motor functions and EFs. The criteria to form the subgroups were the total motor cut-off scores in the MABC-2: G1-significant motor difficulty (Raw Score < 59); G2-"at risk"; careful monitoring suggested (Raw Score $\leq$ 68); and G3-no movement difficulty (Raw Score > 68). Their sample sizes are G1n = 26, G2n = 17, and G3n = 53.

Significant differences were found between G1 and G3 in all the ENFEN and R-FACES variables, except for semantic fluency, interference and Impulsivity Control Index. Statistically significant differences were also observed between G1 and G2 in colour path and between G2 and G3 for grey path and rings (Table 3).

Table 3. Differences between the executive function variables of subgroups G1, G2, and G3.

	G1 vs. G2	G2 vs. G3	G1 vs. G3
	p-Value	*p*-Value	*p*-Value
ENFEN			
Phonological fluency	0.232	0.166	0.002
Semantic fluency	0.229	0.629	0.288
Grey path	0.478	0.040	0.001
Colour path	0.018	0.069	<0.001
Rings	0.194	<0.001	<0.001
Interference	0.646	0.249	0.069
R-FACES			
Net Hits	0.475	0.176	0.013
Impulsivity Control Index	0.990	0.342	0.165

G1 = significant motor difficulty; G2 = "at risk"; G3 = no movement difficulty.

An analysis of the size of the effect on differences and the power of the sample size between the subgroups was performed. The variables with statistically significant differences between G1 and G3 obtained powers greater than 80%, so these results are accepted as statistically significant. In comparison, the effects of differences between groups

G2 and G3 or G1 had powers less than 80% and should, therefore, be discarded. This is likely related to the small size of the G2.

Table 4 shows the Spearman correlation coefficients between the sociodemographic and motor-executive functioning variables. To simplify the visualisation, only the correlation coefficient of those variables with a level of statistical significance $p < 0.05$ in the Spearman correlation test is shown.

Table 4. Correlation coefficients between sociodemographic and study variables.

	Gender	Income	Parents Study Level	Mother Tongue
ENFEN				
Phonological fluency	ns	ns	ns	ns
Semantic fluency	ns	ns	ns	ns
Grey path	ns	ns	0.18 *	ns
Colour path	ns	0.28 **	0.39 **	0.37 **
Rings	ns	0.23 **	0.41 **	0.37 **
Interference	ns	ns	0.32 **	ns
R-FACES				
Net Hits	ns	0.32 **	0.24 **	0.33 **
Impulsivity Control Index	ns	0.34 **	0.23 *	0.25 **
MABC-2				
MABC total	ns	ns	0.24 *	ns
Manual Dexterity (MD)	−0.29 **	ns	ns	ns
MD1	ns	ns	ns	0.27 *
MD2	−0.26 **	ns	ns	ns
MD3	−0.33 **	ns	ns	ns
Aiming and Catching (A&C)	ns	0.19 *	0.17 *	ns
A&C1	ns	ns	0.20 *	ns
A&C2	ns	ns	ns	ns
Balance (B)	ns	ns	ns	ns
B1	ns	ns	ns	ns
B2	ns	ns	0.23 *	ns
B3	ns	ns	0.21 *	ns

ns: $p > 0.05$; * $p < 0.05$; ** $p < 0.01$.

Gender did not present a correlation with any of the EF variables. However, we found moderate negative correlations, specifically in manual dexterity tasks, where girls obtained better results than boys (ρMD = −0.29 y ρMD2 = −0.26 y ρMD3 = −0.33). Both income level and mother tongue presented moderate positive correlations with the colour path and rings of the ENFEN and in the variables Net Hits and Impulsivity Control Index of the R-FACES. The variable educational level of the parents correlated with a more significant number of executive and motor skills (Table 4). Mother tongue did not correlate with phonological or semantic fluency variables.

Table 5 shows the correlation between the motor and executive function variables. Only correlation coefficients with statistical significance ($p < 0.05$) are shown.

Mixed results were obtained. No relationships were detected between the variables semantic fluency and Impulsivity Control Index with motor functions, and variable interference was only related to B2 (walking with heels raised or tandem walking). The Net Hits variable only correlated positively and weakly with some manual tasks and B3 (hopping on mats). The grey path variable correlates moderately with aiming and catching tasks. The phonological fluency variable correlated with almost all motor function variables (except for drawing a trail-MD3) with intensities that ranged from weak to moderate and positive. The variables' colour path and rings have positive correlations with all the motor variables, except for A&C2 (throwing a bean bag onto a mat), with intensities ranging from moderate to strong, being almost always more intense in variable rings than in colour path (Table 5).

Table 5. Correlation coefficients between executive and movement function variables.

	ENFEN						R-FACES	
	Phonological Fluency	**Semantic Fluency**	**Grey Path**	**Colour Path**	**Rings**	**Interference**	**Net Hits**	**ICI**
MABC-2								
MABC total	0.30 **	ns	0.14 **	0.37 **	0.53 **	ns	0.27 *	ns
Manual Dexterity (MD)	0.18 **	ns	0.12 *	0.30 **	0.37 **	ns	0.25 *	ns
MD1	0.22 **	ns	0.14 *	0.23 **	0.39 **	ns	0.30 *	ns
MD2	0.14 *	ns	0.06 **	0.27 **	0.25 **	ns	ns	ns
MD3	ns	ns	ns	0.23 **	0.29 **	ns	ns	ns
Aiming and Catching	0.23 *	ns	0.33 **	0.15 *	0.26 **	ns	ns	ns
A&C1	0.21 *	ns	0.32 **	0.24 **	0.33 **	ns	ns	ns
A&C2	0.21 *	ns	0.15 *	ns	ns	ns	ns	ns
Balance (B)	0.24 **	ns	ns	0.34 **	0.47 **	ns	ns	ns
B1	0.18 *	ns	ns	0.28 **	0.34 **	ns	ns	ns
B2	0.17 *	ns	ns	0.34 **	0.39 **	0.29 **	ns	ns
B3	0.22 *	ns	0.20 *	0.23 **	0.36 **	ns	0.20 *	ns
R-FACES								
Net Hits	0.27 *	ns	0.34 **	0.31 **	0.40 **	0.27 *	1 **	0.70 **
ICI	ns	ns	ns	0.22 **	0.22 **	0.19 *	0.70 **	1 **

ns: $p > 0.05$; * $p < 0.05$; ** $p < 0.01$. ICI = Impulsivity Control Index.

From an applied point of view and to better inform clinicians and school staff, Appendix A shows individuals' absolute and relative frequencies according to their range of performance in EFs. Additionally, several G3 children with typical motor development showed difficulties in some EFs. Specifically, 32.1% of G3 children presented a deficient performance in the colour path. Furthermore, 11.3% of this group performed poorly in rings and semantic fluency. In phonological fluency, 26.4% gave a low performance.

According to teachers' initial impressions, 38.5% of children had difficulties following and maintaining verbal instructions (frequently = 19.8%; sometimes = 18.8%); 43.8% had impulsiveness (frequently = 20.8%, sometimes = 22.9%); 53.1% had attention problems (often = 26.0%, sometimes = 27.1%); and 46.9% had difficulties organising and solving complex problems (frequently = 22.9%, sometimes = 24%).

After conducting the comprehensive evaluation, the occupational therapist related each child's results and observations to the children's performance on tasks in the classroom. Teachers were asked to what extent this information matched their daily observations. The teachers showed a high degree of agreement (4.0 ± 0.8). However, they expressed that they had not observed some motor skills, except for two teachers, one specialised in physical education and the other in special education. They unanimously showed high satisfaction with the information provided by the occupational therapist (4.6 ± 0.5) and considered that it allowed them to understand their students better (4.8 ± 0.4). They thought it seemed very important or essential to carry out these evaluations at school (4.6 ± 0.5). They emphasised needing more advice to help their students in the classroom and additional training in these areas of development. They also indicated that the information had been useful even for children with good academic performance.

4. Discussion

This study aimed to compare motor and executive skills performance in second-grade children and analyse its relationship with some sociodemographic variables. The findings offer a comprehensive perspective on executive and motor functions and consider the complex interplay between these two domains. Therefore, it supports school-based occupational therapists who advocate for a broader focus on children's participation in school and incorporating regular assessment in collaboration with teachers.

First, we found significant differences between the sociodemographic variables between both schools, although they are in the same school district. This data can allow us to see a broader spectrum of the study population and analyse the effects of sociodemographic factors on motor and EF performance [5,6,13]. According to the latest data published, the population of foreign origin in the city of Zaragoza is currently 16% [33], and 40% of all families in Aragon have incomes of less than 2000 € [34]. In our sample, 80% of both parents are of foreign origin in school 1 (public state-funded) compared to 12% in school 2 (private state-funded). In the same way, school 1 has 79% of households with an income of less than 2000 € compared to 23% in school 2 (38% in the entire sample). These data can help us increase the effect of the relationship between these sociodemographic variables and those of executive and motor functions while maintaining the sample's representativeness.

Second, both motor development and EF measures obtained worse results than expected throughout our sample. These results could be partially explained by the consequences that the COVID-19 pandemic has had on children's development. Several studies have pointed out the pandemic's impact on children's development. Okely et al. (2021) surveyed 948 parents of children between 3 and 5 years of age from 14 countries, including Spain. These researchers concluded that children from countries with high restrictions during COVID-19 considerably decreased their physical activity time and increased their sedentary time in front of a screen [35]. Navarro-Soria et al. (2023) surveyed 953 parents with residence in Spain of children and adolescents aged 6 to 18 years. They assessed anxiety, sleep habits, and executive functioning in three periods: April 2020 (T1; $n = 953$), October 2020 (T2; $n = 134$), and October 2021 (T3; $n = 53$). These authors conclude that anxiety levels in children and adolescents have remained high after the pandemic, negatively affecting executive functioning [36]. However, most parents who responded at all three time points had a university education, and, as Okely points out, the more disadvantaged populations could have been more affected during this period [35].

Factors such as a drastic decrease in play activities, especially outdoors, minus social interactions, or lack of schooling for an extended time have negatively impacted motor development and EFs [35–37]. Even when Spanish schools opened, they did so with severe restrictive measures [36]; for example, play activities in the playground were limited, or children's play areas remained closed [35]. Hence, these children had fewer environmental opportunities in a critical period when EFs and motor development show a more significant mutual influence [12]. The development period between 5 and 6 years old is vital for improving working memory since it is fundamental to all cognitive-motor functioning [6]. Furthermore, our results align with a recent study that indicates the concern of parents and preschool teachers regarding the increase in children with delays in language acquisition, difficulties with concentration and self-regulation, and a noticeable change in play patterns [38].

Furthermore, 44.8% of our sample obtained a percentile <16% on the MABC-2. These results differ from data from a study conducted in northwest Spain in 2017, which found that approximately 12% of schoolchildren are at risk of motor difficulties [2]. On the other hand, in Houwen's study sample, there was 32%, which was noted as a limitation [13]. Besides, several authors also highlight a strong connection between poor motor performance and the level of education and socioeconomic status of the families [2,13,26], partially explaining our results. School 1 has a high percentage of children with special educational needs and families with low socioeducative and economic status compared to other schools in the same Autonomous Community, as informed by the principal. However, in 2015, the authors reviewed how the increase in sedentary and inadequate food intake over 50 years negatively impacted people's health. These authors warned of a significant decline in motor performance even in preschool children [39]. Therefore, researchers, educators, and clinicians should consider lifestyle changes to decrease adverse development effects.

We found that children who obtained worse scores on the MABC-2 presented more difficulties on the ENFEN tests. Rosenberg et al. evaluated 44 children under 6 years old, 22 with mild developmental disabilities. They found that EFs contribute more to children's participation and independence in daily activities than motor skills. Expressly, they point out that the interaction between inhibitory control and motor skills significantly impacts participation. They also highlight that children with motor challenges have fewer opportunities to develop EFs due partly to a lack of autonomy and a need for support [16]. On the other hand, Rosenblum points out that children with dysgraphia have less control of EFs and, therefore, must invest more emotional and cognitive resources in handwriting, which can negatively impact other class tasks [15]. Consequently, children with sensorimotor deficits could benefit from EF interventions at school as these impact participation and daily activities [5].

Our results show that sociodemographic variables (except for gender) correlate more with EFs than motor skills. Furthermore, the variable level of education of the parents was connected with a more significant number of motor and executive variables. This result aligns with prior research that found parental educational status influences the EFs [11,13] and motor development in children [2,26]. Interestingly, Houwen et al. [13] used maternal educational level to determine children's socioeconomic status; we believe these indicators should be differentiated in research since many migrant people may be working in sectors that do not correspond to their educational level. Regardless, our results support intervention in schools with low socioeconomic families who may have difficulty accessing specialised therapy services, as other authors have already pointed out [2,26].

On the other hand, no sociodemographic variable was correlated with the ENFEN verbal tests, and in the semantic fluency test, no significant differences were observed between G1 (significant motor difficulty) and G3 (no movement difficulty). A plausible explanation can be found in the study by Navarro-Soria et al. (2020) that used the ENFEN in a sample of 197 children between 6 and 12 years old, 134 diagnosed with attention-deficit hyperactivity disorder (ADHD). They point out that semantic fluency provided a poor diagnosis and phonological fluency a mediocre diagnosis with an area under the curve (AUC) of 0.52 and 0.71, respectively [28]. Furthermore, the score of the entire sample in phonological fluency was below average, which seems to agree with the concerns regarding the language development of teachers and families [38].

Colour path and rings variables obtained moderate correlations with all motor functions and sociodemographic variables except gender. These tasks specifically engage working memory, planning and sequencing, mental flexibility, inhibitory control, and problem-solving strategies [27,28]. On the other hand, the grey path presented weak correlations with some motor tasks and did not correlate with Impulsivity Control Index. We agree with Navarro-Soria that the grey path is easier for children and requires fewer cognitive resources, given that interference is not present as in the colour path or rings [28]. Furthermore, concerning the Impulsivity Control Index results, several authors have pointed out that inhibitory control is a variable that impacts participation and learning [16,21], which should be considered when addressing evaluations in the school setting.

In our study, the Impulsivity Control Index did not correlate with any motor variable. In the study carried out on 153 children between 3 and 5 years old by Houwen et al. (2017), no significant differences between motor performance and the Inhibition Subscale of the Behaviour Rating Inventory of Executive Function–Preschool version were found. Our results indicate a lack of relationship between motor functions and inhibition [13]. However, the Impulsivity Control Index did correlate with colour path, rings, and interference tasks that required inhibitory control and working memory (Basic level) but involved higher-level EFs [7]. Therefore, evaluating EFs requires different tests to understand children's performance better.

The fact that grey and coloured paths correlate with the catching tasks (A&C1) could be related to the fact that catching a ball and following a path requires the visual and motor systems to interact before the motor action. The recent study by Recker et al. included eye movement measurements of 62 adult participants via an eye-tracker while they performed the computerised version of the Trail Making Test. This study shows that eye movement measurements (e.g., fixations and saccades, among other variables) are sensitive to EFs in the Trail-Making Test [40]. This fact highlights the need to collaborate with optometrists who evaluate visual functions due to their implications for motor and executive performance. The interdisciplinary evaluation can help to have a whole view of children's challenges.

We found that tests of the colour path and rings correlate with all MABC-2 balance tests. This finding aligns with the results of a current study in Hungary. Tószegi et al. (2023) evaluated 95 children between 5 and 7 years old, with 55 at risk of learning difficulties. They used some subtests of the Sensory Integration and Praxis Test (SIPT) and different aspects of EFs, such as response inhibition, cognitive flexibility, and verbal working memory. Their results indicate that some skills, such as balance, bilateral coordination, working memory and response inhibition, predict risk for learning difficulties [21]. Accordingly, we agree with these authors that the model, which combines the evaluation of sensorimotor and executive functions, is the most convenient for detecting performance challenges in children.

Teachers pointed out that many children had difficulties with attention, impulsivity, following instructions, or problem-solving in class, so we are focusing on their real concerns. Furthermore, many children with typical motor performance in our sample presented problems in some EFs. Previous research indicates that teachers and occupational therapists have limited knowledge about EFs [14,19,24,25], and school-based occupational therapists focus more on sensorimotor functions [14,18]. Therefore, we agree with Tanis and Erb that identifying this problem is the first step for school staff to learn more about it [14].

The occupational therapist provided simple and accessible explanations, aligning with other researchers' recommendations [24,25]. Teachers agreed that the information provided by the occupational therapist had made it easier for them to understand the challenges of classroom participation, even for children with good academic results. For example, one child had poor results on the ring test even though he was achieving good grades. After the therapist made remarks, the teacher understood the family's comments: "We spend a lot of time repeating the same math exercises and problems daily to help him." Therefore, evaluating EFs in children, especially those with normal motor development, is essential [6,27]. In this way, identifying subtle difficulties in EFs can facilitate the implementation of appropriate intervention programmes in the school context [27] for all children. Partnerships with stakeholders such as teachers are necessary to compare real-life performance.

Finally, the teachers showed satisfaction with the information provided but also demanded greater collaboration with the occupational therapist to help the children within the classroom and more training in both areas of development. This aligns with recent studies indicating that teachers demand more training regarding EFs and related topics [24,25]. School-based occupational therapists may train teachers and adopt collaborative practices (share knowledge) to address children's engagement challenges and align with the best practices [18,41].

Our results show the interplay between sociodemographic factors, motor skills, and executive functions in school-aged children. Our findings emphasise the critical role of family characteristics and support the growing body of literature advocating that school-based occupational therapists should conduct regular assessments to detect challenges in EFs in addition to sensory processing and motor skills [10,14–16,19,21,22,41] to support children's academic and social development. Children from disadvantaged households are more likely to experience difficulties in both areas of development, so it is necessary to take action to ensure equal opportunities and minimise social inequalities. In collaboration with teachers and other school staff, school-based occupational therapists must identify challenges in motor-executive functioning to detect early and design effective interventions.

Limitations and Future Directions

This study is subject to certain limitations. The sample size allowed for exhaustive evaluations; however, separating the children according to their motor performance reduced the group sizes considerably, limiting the generalisation of the results. In addition, we used non-probability sampling for convenience, so the generalisation of results is limited to populations with similar characteristics. One of the schools in our study may not represent the general population due to the high number of children with special educational needs and migrant families. The principal informed us that they serve children of 95 different nationalities, so the results might lack population validity because each school's demographic characteristics may differ. An essential limitation of this study is that no observations were made in the natural environment. However, the results and observations of the occupational therapist were contrasted with the perception of the teachers, which provides ecological validity to the conclusions drawn. However, the occupational therapist who bestowed the information to teachers had extensive experience in paediatric and school settings, so some caution is recommended. Accordingly, less experienced therapists might have difficulty transferring standardised test results to children's real-life performance. For this reason, future research could compare natural environment performance observations from experienced and inexperienced professionals and contrast them with performance on standardised tests and teachers' perspectives and concerns. The data in this study are cross-sectional. Therefore, future studies should use a longitudinal design and larger sample size to provide more evidence on the interaction between motor performance, EFs, and confounding variables across development and consider individual differences. Future research should address intervention in school, collaboration between different members of the educational team and its impact on children's outcomes. Furthermore, monitoring development in the general population throughout the lifespan is necessary.

5. Conclusions

Planning, organising, initiating, and monitoring goal-directed behaviours are essential for completing many school and daily tasks. Therefore, school-based occupational therapists should include an assessment of EFs along with motor skills. School-based occupational therapists should collaborate with teachers to identify children at risk of academic or occupational performance issues. In this way, they can develop effective interventions to promote their success and participation in school. A joint vision of motor skills and EFs could facilitate the development of holistic, valid programmes in school settings, especially in schools with more disadvantaged populations.

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Appendix A

Table A1. Absolute and relative frequencies of individuals who pass the executive function tests by groups.

	G1n = 26 (%)			G2n = 17 (%)			G3n = 53 (%)		
	Very Low	Low	Average	Very Low	Low	Average	Very Low	Low	Average
ENFEN									
Phonological fluency	8 (30.8)	10 (38.5)	8 (30.8)	4 (23.5)	4 (23.5)	9 (53.0)	2 (3.8)	14 (26.4)	37 (69.8)
Semantic fluency	6 (23.1)	2 (7.7)	18 (69.2)	0 (0.0)	4 (23.5)	13 (76.5)	6 (11.3)	6 (11.3)	41 (77.4)
Grey path	5 (19.2)	3 (11.5)	18 (69.2)	2 (11.8)	2 (11.8)	13 (76.5)	4 (7.5)	3 (5.7)	46 (86.8)
Colour path	21 (80.8)	1 (3.8)	4 (15.4)	9 (52.9)	2 (11.8)	6 (35.3)	17 (32.1)	5 (9.4)	31 (58.5)
Rings	14 (53.9)	5 (19.2)	7 (26.9)	6 (35.3)	3 (17.6)	8 (47.1)	6 (11.3)	6 (11.3)	41 (77.4)
Interference	5 (19.2)	5 (19.2)	16 (61.5)	2 (11.8)	5 (29.4)	10 (58.8)	10 (18.9)	4 (7.5)	39 (73.6)
R-FACES									
Net Hits	2 (7.7)	4 (15.4)	20 (76.9)	0 (0.0)	4 (23.5)	13 (76.5)	4 (7.5)	0 (0.0)	49 (92.5)
ICI	3 (11.6)	3 (11.6)	20 (76.9)	5 (29.4)	1 (5.9)	11 (64.7)	5 (9.4)	4 (7.5)	44 (83.0)

ICI = Impulsivity Control Index. G1 = significant motor difficulty; G2 = "at risk"; G3 = no movement difficulty.

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