



Motor literacy and executive functions in upper elementary school students from the province of Talca

Alfabetización motriz y funciones ejecutivas en escolares del segundo ciclo básico de la provincia de Talca

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Abstract

Introduction: Motor literacy and executive functions are key components of students' integral development, linking physical and cognitive dimensions. Evidence in Chilean school contexts remains limited.

Objective: To analyze the levels of motor literacy and executive functions and to compare differences according to sex in upper elementary school students from the province of Talca.

Methodology: A cross-sectional observational, descriptive, and comparative study was conducted with 103 students (67 boys and 36 girls; mean age = 12.8 ± 0.76 years). Motor literacy was assessed using the SEMOK questionnaire, and executive functions with the EFECO. Descriptive statistics and Student's t-test for independent samples were applied, complemented by Cohen's d effect size (p < 0.05).

Results: Students showed moderate levels of motor literacy (M = 9.31 ± 4.74) and executive functions (M = 71.15 ± 39.11). Higher scores were observed in object control, initiative, and working memory. Significant differences were found only in body control (p = 0.006; d = 0.57), with girls outperforming boys.

Discussion: The findings indicate intermediate development in both variables, with minimal sex differences. The advantage observed in body control among girls may be associated with sociocultural and pedagogical factors influencing motor development.

Conclusions: Students presented moderate levels of motor literacy and executive functions, highlighting the need to strengthen Physical Education strategies that integrate motor and cognitive development.

Keywords

SEMOK; cognition; Physical Education; EFECO; Chile.

Resumen

Introducción: La alfabetización motriz y las funciones ejecutivas son componentes esenciales del desarrollo integral, integrando dimensiones físicas y cognitivas. Existe escasa evidencia en el contexto escolar chileno.

Objetivo: Analizar los niveles de alfabetización motriz y funciones ejecutivas, y comparar diferencias según sexo en escolares de segundo ciclo básico de la provincia de Talca.

Metodología: Estudio observacional, descriptivo y comparativo de corte transversal con 103 estudiantes (67 hombres y 36 mujeres; edad media = 12,8 ± 0,76 años). Se utilizó el cuestionario SEMOK para alfabetización motriz y el EFECO para funciones ejecutivas. Se aplicaron estadísticos descriptivos y prueba t de Student, junto con tamaño del efecto (d de Cohen), con p < 0,05. **Resultados:** Se observaron niveles moderados de alfabetización motriz (M = 9,31 ± 4,74) y funciones ejecutivas (M = 71,15 ± 39,11). Las mayores puntuaciones se dieron en control de objetos, iniciativa y memoria de trabajo. Solo hubo diferencias significativas en control corporal (p = 0,006; d = 0,57), a favor de las mujeres.

Discusión: Los resultados muestran un desarrollo intermedio de ambas variables, con escasas diferencias por sexo, lo que coincide con literatura previa en contextos escolares.

Conclusiones: Se requiere fortalecer estrategias pedagógicas que integren el desarrollo motor y cognitivo para favorecer el desarrollo integral del estudiantado.

Palabras clave

SEMOK; cognición; Educación Física; EFECO; Chile.

Introduction

Currently, the comprehensive development of students has become a central focus in education. Within this context, physical education plays an important role in contributing to the emotional, social, and cognitive growth of students (Macias Giler, 2025). The regular and appropriate implementation of physical education in educational institutions is therefore essential for the development and well-being of schoolchildren (Bernate et al., 2020).

In Chile, the levels of physical activity (PA) among children and young people (CYP) remain alarmingly low: only 26.4% meet the minimum recommendations proposed by the World Health Organization (WHO), i.e. at least 60 minutes of moderate or vigorous PA per day. The remaining 73.6% do not meet these recommendations, which negatively affects their physical and cognitive development (Ministerio del deporte de Chile, 2024).

In this context, motor literacy emerges as a fundamental tool, since its proper development allows for increased regular physical activity, encourages adherence to healthy habits, and promotes overall well-being (Arroyo et al., 2024). According to Whitehead (2019), motor literacy is the basis for people to feel competent, motivated, and confident in their movement abilities, which enhances learning and active participation throughout life, promoting overall well-being and motivation towards physical activity (Pinilla et al., 2024).

Internationally, a positive correlation has been demonstrated between physical activity, motor literacy (ML), and executive functions (EF). The literature indicates that adequately developed motor knowledge and skills are associated with better performance in so-called executive functions, such as working memory, emotional control and planning, which are essential for learning and everyday life (Razali et al., 2025; Andrades-Suárez et al., 2022; Martin-Martinez et al., 2015).

The WHO (2023) highlights that regular physical activity contributes significantly to brain development, strengthening memory, attention and executive functions, understood as the mental processes responsible for planning, organising and self-regulating behaviour.

In the national context, although there is no specific policy on motor literacy, the Physical Education Curriculum Guidelines (Ministerio de Educación, 2015) recognise the importance of developing integrated motor and cognitive skills. However, there are still gaps in their practical implementation, especially with regard to their impact on students' executive functioning.

Chile also presents worrying figures in terms of sedentary lifestyles and childhood obesity. According to Fierro (2025), only 18.5% of children and adolescents are active, i.e. they engage in physical activity three or more days a week, reflecting a structural deficit in the promotion of healthy lifestyles. The results of the National Survey on Physical Activity and Sport (Ministerio del deporte de Chile, 2024) show a trend towards sedentary lifestyles that affects not only physical health but also cognitive and socio-emotional development.

It is essential not to confuse motor literacy with physical education in general, as the latter constitutes the educational context in which motor literacy is developed, the purpose of which is to promote essential principles that guide teaching towards meaningful learning of movement (Castillo et al., 2024).

Considering this reality, there is a need to explore the relationship between ML and EF in schoolchildren in the province of Talca, specifically in schools in Talca and San Clemente. This approach will provide an understanding of how motor skills can be linked to cognitive development in diverse educational contexts.

Consequently, studying this relationship can offer a more comprehensive understanding of the student, considering not only their physical abilities but also their higher mental processes, providing useful evidence for the design of inclusive and contextualised pedagogical strategies that improve the teaching-learning process (Andrades et al., 2022). Previous studies have reported potential sex-related differences in motor competence and its specific dimensions; however, the evidence remains inconsistent, particularly during late childhood and early adolescence. Therefore, exploring these differences without assuming a priori direction is relevant to better understand motor and cognitive development in school contexts. Therefore, the objective of this study was to analyze the levels of motor literacy and executive



functions and to compare their differences according to sex in upper elementary school students from the province of Talca.

Method

Design

This study is an observational, descriptive, and comparative cross-sectional design (Guzmán-Muñoz et al., 2025), whose purpose was to analyze ML and EF levels and compare their differences according to sex in seventh and eighth-grade students in the second school cycle.

The research was conducted in three educational establishments, two public and one private, located in the municipalities of Talca and San Clemente, in the province of Talca, in the Maule region (Chile). Data collection took place between September 29 and October 29, 2025. The study was authorized by the academic administrations of the participating centers and was carried out in accordance with institutional ethical and confidentiality standards.

Participants

The sample consisted of 103 students in the second cycle of basic education. Of these, 36 were female (35%) and 67 were male (65%), with an average age of $M = 12.8$ years ($SD = 0.76$).

The sampling method was non-probabilistic convenience sampling, considering establishments where trainee teachers were doing their professional placements. Seventh- and eighth-grade students who participated voluntarily and had the authorization of their parents or guardians were included.

Instruments

Motor literacy (ML): ML was assessed using the SEMOK (Selbstwahrnehmung Motorischer Kompetenzen) perceived motor competence questionnaire, developed by Herrmann and Seelig (2017) and validated in Spanish by Cárcamo-Oyarzun et al. (2020).

The instrument consists of eight items that assess everyday motor actions, with Likert-type responses ranging from 1 to 5 points (1 = strongly disagree; 5 = strongly agree). It assesses two dimensions: object control (1, 2, 3, 4) and body control (5, 6, 7, 8). In the present study, the questionnaire showed adequate internal reliability ($\alpha = 0.894$).

It was administered in digital format during class time under the supervision of the research team and the teachers responsible.

Executive functions (EF): EF were assessed using the EFECO questionnaire (Scale for assessing executive functions in self-report), developed by García-Gómez (2015) in Spain. The instrument consists of 67 items grouped into eight domains: monitoring (items 2, 6, 11, 12, 25, 29, 31, 35, and 43); inhibition (3, 14, 15, 18, 21, 33, 34, 37, 42, and 46); cognitive flexibility (4, 23, 27, 32, 49, and 59); emotional control (7, 19, 48, 50, 55, 63, and 67); planning (22, 28, 39, 44, 58, 61, and 62); organization of materials (1, 9, 10, 26, 30, 45, 51, and 60); initiative (8, 17, 20, 36, 40, 47, 53, 56, 64, and 65); and working memory (5, 13, 16, 24, 38, 41, 52, 54, 57, and 66).

Each item is rated on a scale of 0 to 3 points (0 = never; 1 = sometimes; 2 = often; 3 = very often). In the present study, the instrument showed excellent internal reliability ($\alpha = 0.926$).

Like the SEMOK questionnaire, the EFECO was administered digitally, in a single session, with the researcher and the professor responsible for the course present.

Procedure

Before applying the instruments, a formal letter was sent to the technical-pedagogical units of the participating establishments, requesting institutional authorization. After approval, the evaluation sessions were coordinated in conjunction with the physical education teachers at each school.

The applications were carried out in the classroom or computer lab of each center, in digital format and guided, using electronic forms. First, the SEMOK questionnaire was applied, and then the EFECO questionnaire. Each session lasted approximately 30 to 40 minutes.



Statistical analysis

Data analysis was performed using IBM SPSS Statistics software version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean, standard deviation, frequencies, and percentages) were calculated to characterize the sample and describe the scores obtained in the SEMOK and EFECO questionnaires.

The normality of the data was verified using the Shapiro–Wilk test. Subsequently, Student's t-test for independent samples was applied to compare the means between men and women in the different dimensions of motor literacy and executive functions. In addition, the effect size (Cohen's *d*) was calculated for each comparison in order to estimate the practical magnitude of the differences observed, interpreted according to the cut-off points proposed by López-Martín and Ardura (2023): $d < 0.20$: small effect, $d = 0.50$: medium effect, $d \geq 0.80$: large effect.

A significance level of $p < 0.05$ was considered for all tests. The results are presented in tables and graphs, highlighting both statistically significant differences and relevant effect sizes.

A post hoc statistical power analysis was conducted using G*Power software (version 3.1) to assess the adequacy of the sample size. Considering an independent samples t-test, an observed effect size of $d = 0.57$, an alpha level of 0.05, and the total sample size ($n = 103$; $n_1 = 67$, $n_2 = 36$), the achieved statistical power ($1-\beta$) was 0.83. This indicates that the study had sufficient power to detect medium-sized effects.

Ethical considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments for research involving human subjects (World Medical Association [WMA], 2024) and current regulations for research involving human subjects. Parents or guardians signed an informed consent form, and students gave their assent before participating. Participation was voluntary, anonymous, and risk-free, with the right to withdraw at any time guaranteed. All information collected was kept strictly confidential and used solely for academic and scientific purposes.

Results

The sample consisted of 103 students with an average age of 12.8 years ($SD = 0.76$). Of the total, 35% were female ($n = 36$) and 65% were male ($n = 67$), forming a homogeneous group in terms of age and school stage. Participants obtained an average total score of 9.31 ($SD = 4.74$) on the SEMOK questionnaire. By dimension, body control had a mean of 4.03 ($SD = 3.53$), while object control reached 5.27 ($SD = 2.75$), showing a slight advantage in the latter dimension. Overall, the group was at a moderate level of motor literacy.

With regard to EF, participants obtained an average total score of 71.15 ($SD = 39.11$). The values obtained indicate an overall average performance, with Initiative and Working memory standing out as the best-developed functions, and Emotional control and Planning as the lowest (Table 1).

Table 1. Average and standard deviation of SEMOK and EFECO

	Average	SD
Age	12,8	0,76
Motor literacy		
Body control	4,03	3,53
Object Control	5,27	2,75
SEMOK	9,31	4,74
Executive functions		
Monitoring	7,47	4,31
Inhibition	8,66	5,63
Cognitive flexibility	8,7	4,38
Emotional control	7,09	4,92
Planning	7,39	5,27
Organization of materials	8,23	5,85
Initiative	10,2	6,93
Working memory	10,3	6,47
EFECO	71,15	39,11

Note: SEMOK= (Selbstwahrnehmung Motorischer Kompetenzen); EFECO= Scale for assessing executive functions in self-report; SD= standard deviation



Table 2 shows the results of the Student's t-test and effect sizes (Cohen's *d*) for comparisons between men and women. Statistically significant differences were observed only in the body control dimension ($t = -2.79$; $p = 0.006$; $d = 0.57$), indicating a medium-sized effect in favor of women ($M = 4.94 \pm 2.59$) compared to men ($M = 3.55 \pm 2.32$). No significant differences were found in the other SEMOK dimensions and in all EFECO dimensions ($p > 0.05$), and the effect sizes were small ($d < 0.20$), indicating no meaningful differences in overall performance between sexes.

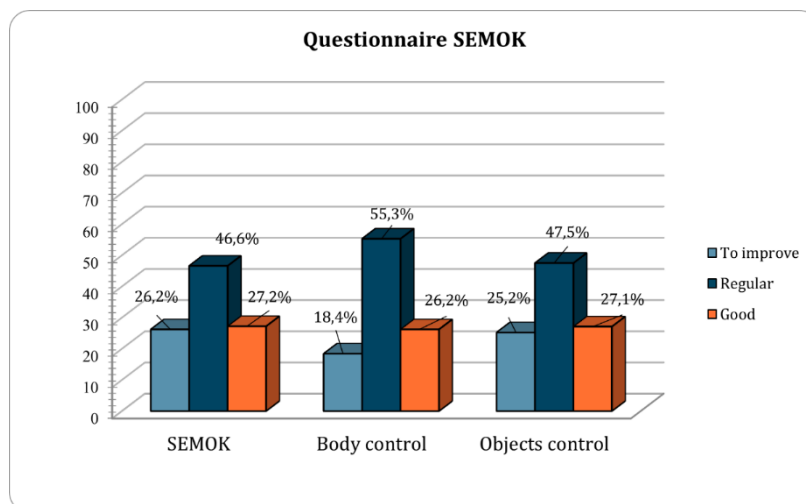
Table 2. Comparison of SEMOK and EFECO results between men and women (n=103)

	Men (n=67)		Women (n=36)		Δ (M-W)	$t_{(DF,101)}$	p	d	(CI95%)	
	Average \pm SD		Average \pm SD						LL	UL
Age (years)	12,79	0,75	12,92	0,81	-0,13	-0,790	0,431	0,17	-0,57	0,24
Motor literacy										
Body control	3,55	2,32	4,94	2,59	-1,39	-2,791	0,006	0,57	0,16	0,99
Object control	5,28	2,90	5,25	2,51	0,03	0,059	0,953	0,01	-0,39	0,42
SEMOK	8,84	4,78	10,19	4,62	-1,36	-1,393	0,167	0,29	0,12	0,69
Executive functions										
Monitoring	8,03	4,55	6,44	3,75	1,59	1,788	0,077	0,37	-0,04	0,78
Inhibition	8,87	5,58	7,92	5,77	0,95	0,814	0,418	0,17	-0,24	0,57
Cognitive flexibility	9,06	4,56	8,06	4,08	1,00	1,105	0,272	0,23	-0,18	0,63
Emotional control	6,58	4,68	7,86	5,39	-1,28	-1,253	0,213	0,26	0,15	0,67
Planning	7,33	5,19	7,53	5,51	-0,20	-0,182	0,856	0,04	-0,44	0,37
Organization of materials	8,19	5,42	8,31	6,68	-0,11	-0,092	0,927	0,02	-0,43	0,38
Initiative	10,57	7,01	9,72	6,86	0,84	0,588	0,558	0,12	-0,28	0,53
Working memory	10,42	6,09	10,19	7,30	0,22	0,165	0,869	0,04	-0,37	0,44
EFECO	72,31	37,82	69,00	41,88	3,31	0,408	0,684	0,08	-0,32	0,49

Note: SEMOK= (Selbstwahrnehmung Motorischer Kompetenzen); EFECO= Scale for assessing executive functions in self-report; SD= Standard deviation; Δ (M-W)= Delta value between men and women; t = Difference of averages; DF= Degrees of freedom; p = Probability value; d = Effect Size (Cohen's *d*); CI= Confidence interval; LL= Lower Limit; UL= Upper Limit

Figure 1 shows the distribution of motor literacy levels, with most students falling into the intermediate category, while a smaller proportion achieve higher levels of performance. This pattern suggests that while there is a positive trend toward appropriate motor development, there are still important areas for improvement.

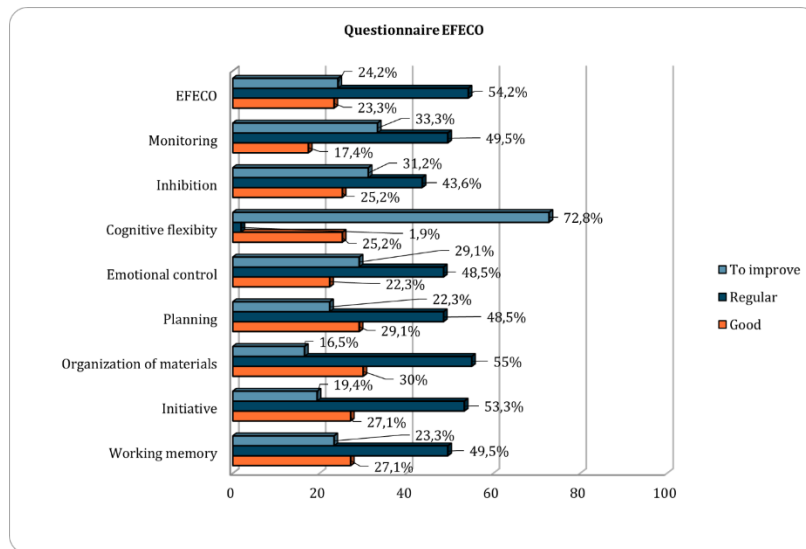
Figure 1. Results of the SEMOK questionnaire according to motor performance levels in the dimensions evaluated.



Note: SEMOK: Selbstwahrnehmung Motorischer Kompetenzen (2017).

Figure 2 shows the distribution of executive function levels, with normal performance being the most common. It is important to note that cognitive flexibility stands out as the dimension with the highest proportion of low performance, highlighting a potential cause for concern regarding students' cognitive development.

Figure 2. Results of the EFECO questionnaire according to performance levels (needs improvement, fair, and good) in the different dimensions of executive functions



Note: EFECO: Scale for assessing executive functions in self-report (2015)

Overall, the results indicate that students have intermediate levels of motor literacy and executive functions, with no significant differences by sex, except in body control, where women performed better with a medium effect ($d = 0.57$). This indicates no meaningful differences in overall performance between sexes, albeit with individual variability and specific areas that could be strengthened through systematic school physical activity.

Discussion

The aim of this study was to analyze motor literacy and executive function levels in students in the second cycle of basic education in the province of Talca, as well as to compare the results according to sex. The findings showed that both ML and EF presented predominantly average levels, indicating intermediate development in both dimensions. In the SEMOK questionnaire, the total average was 9.31 points, with slightly higher results in object control ($M = 5.27$) than in body control ($M = 4.03$). This indicates that students feel more competent in tasks involving object manipulation, such as throwing or catching, than in those requiring postural awareness and control. These results are consistent with the theoretical framework, which emphasizes that body control requires greater precision and systematic practice to consolidate (Keegan et al., 2019; Whitehead, 2019).

Regarding EF, measured using the EFECO questionnaire, the overall average was 71.15 points, with the highest scores in the dimensions of initiative and working memory, and the lowest in emotional control and planning. This pattern is consistent with previous evidence describing a gradual and uneven development of executive functions in childhood and preadolescence, where self-regulation and planning processes tend to consolidate later (Diamond, 2013; Zelazo, 2020).

With regard to comparisons by sex, statistically significant differences were observed only in the dimension of body control, in which women obtained better results ($p = 0.006$; $d = 0.57$). This finding suggests that female students have greater body mastery and postural control, possibly linked to sociocultural and methodological factors that favor their participation in expressive or coordinative activities. In contrast, no significant differences were found in the other SEMOK dimensions and in all EFECO dimensions, which is consistent with studies reporting similar performance between both sex in general motor and cognitive tasks when practice opportunities are equivalent (Martínez et al., 2024; Reloba et al., 2016).

A key finding of the study was the low score obtained in the cognitive flexibility dimension, where a high percentage of students fell into the “needs improvement” category (72.8%). This finding is concerning, given that cognitive function is essential; it plays a crucial role in adapting to different situations, responding to challenges, and resolving them. This observation points to a critical issue in the current Chilean curriculum, as from a pedagogical perspective, it is evident that teaching methodologies favor a structured and repetitive learning framework that lacks educational instruction in fostering cognitive processes associated with creative and divergent thinking. This is a call to incorporate new methodologies that address students’ needs, employing more didactic and effective methods, so that the executive function in question can be stimulated and reinforced more efficiently.

Overall, the results indicate that students show balanced development between motor skills and cognition, as there are still areas that need strengthening. The predominance of average levels and high standard deviations suggest great heterogeneity in motor and cognitive experiences, which could be related to factors such as decreased physical activity at school, increased sedentary time, and a lack of active methodologies in the classroom. From this perspective, there is a reinforced need for physical education classes to integrate strategies that simultaneously stimulate motor skills and cognitive processes, promoting more meaningful and inclusive learning. These findings reinforce the need to integrate motor and cognitive development within physical education, promoting teaching strategies that go beyond physical performance and incorporate executive function stimulation.

Among the main limitations of the study is the use of self-reported instruments (SEMOK and EFECO), which, although validated, depend on the subjective perception of the participants. In addition, the non-probabilistic convenience sampling limits the generalizability of the findings to the broader student population. Likewise, the cross-sectional design prevents the establishment of causal relationships between variables. Despite these limitations, the use of standardized instruments and the inclusion of students from different types of educational establishments strengthen the internal consistency of the findings.

Future research could delve deeper into the relationship between motor literacy and executive functions using longitudinal or experimental designs, incorporating objective measurements of motor and cognitive performance and considering contextual variables such as the educational environment, socio-economic status, or intrinsic motivation toward physical activity. From an educational perspective, these findings highlight the need to design integrated pedagogical approaches that simultaneously stimulate motor competence and executive functioning, particularly in school contexts characterized by low physical activity levels and high sedentary behavior.

Conclusions

The study characterized the levels of motor literacy and executive functions in students in the second cycle of basic education in the province of Talca, revealing an intermediate development profile in both dimensions. The results showed that most students fall into the regular or needs improvement categories, suggesting the need to strengthen both motor and cognitive skills within the school context. In particular, women showed greater mastery of body control, while men did not show significant advantages in any of the dimensions analyzed.

These findings highlight the importance of promoting diverse, active, and cognitively challenging motor experiences in physical education classes that contribute to the comprehensive development of students. Although no substantive differences were identified in most executive functions, the results reflect a pedagogical opportunity to integrate programs that combine movement, problem solving, and emotional self-regulation in order to simultaneously promote motor literacy and executive thinking.

In summary, ML and EF represent complementary dimensions of child development, the strengthening of which must be addressed in a coordinated manner, taking into account the educational context, opportunities for practice, and student motivation.

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