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Review Article

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The Relationship between Executive Functions and Students' Academic Performance: A Systematic Review and Meta-Analysis

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Abstract

Executive functions in young and middle-aged adults are closely associated with success in occupational domains and mental health; however, their impact on students' academic performance has not been fully clarified. The present study aimed to examine the relationship between executive functions and academic performance among students. This research employed a meta-analytic and systematic review method, covering studies published between 2010 and 2024, from which 19 articles were selected (n=50, 166). The study was preregistered in the PROSPERO database under the registration number "CRD42024616147", and quality assessment using the PEDro scale indicated that all studies had high methodological quality. The main inclusion criteria were peer-reviewed English or Persian articles that reported clear statistical data on the relationship between executive functions and academic performance in university students aged 18-25, using validated self-report tools or at least one objective measure of executive functions. The analysis with a random-effects model demonstrated a significant overall effect size (Z Fisher's=0.192), showing that executive functions are significant predictors of academic performance. Among the components, task monitoring (effect size=0.466) had the strongest predictive power, followed by working memory (0.360), initiation (0.346), and organization (0.341). The findings of this meta-analysis demonstrated that executive functions play a key role in predicting academic performance. As university students should independently manage and organize their academic tasks, strong executive functions become essential. These results highlight the need to strengthen executive skills to support academic success in higher education.

Keywords: Academic success, Executive functions, Mental Health, Self report, Students, Universities

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Introduction

In recent decades, university enrollment has increased significantly; however, despite the growth in student numbers, low academic performance, dropout rates, and reduced graduation rates remain among the major concerns (1), which have been addressed in numerous studies (2-5). For this reason, studying the university population in recent years has been a highly important goal in public and institutional policy programs (1). Many studies in this area have been limited to analyzing demographic and social variables, such as gender and socioeconomic status (6). However, some researchers suggest that differences in academic performance may be partly attributable to individual differences in various self-regulation mechanisms, such as Executive Functions (EFs) (7-9).

EFs can significantly influence human success and adaptation across various domains (10). EFs are recognized as higher-order cognitive processes that regulate lower-level processes to guide goal-directed behavior (1). They are among the essential skills for mental and physical health, occupational success, and social and cognitive development (11), largely determining an individual's success in different contexts, particularly academic performance in educational settings (12,13). Various studies have found that several aspects of EFs—including initiation, planning and organization, inhibition, self-monitoring, working memory, task monitoring, and organization of materials—are associated with academic procrastination, a phenomenon that often negatively affects academic performance (14-17). Wingo *et al* (18) examined this relationship more directly in a study of 77 undergraduate women. Those who reported greater difficulties in metacognition and verbal set-shifting—as aspects of EFs—faced more academic challenges.

Studies have also shown that even first-year students who are mentally healthy but possess low EF skills face serious challenges. For most freshmen, the environmental transition from secondary to higher education is accompanied by a mix of excitement, high expectations, distress, and anxiety (19,20). Moreover, the fact that first-year students are typically in late adolescence further complicates the situation (21). This stage, referring to individuals aged 18 to 23, is characterized by major changes in physical development (22), psychosocial functioning, personal growth, neuropsychological performance, emotions, social cognitions, and behavior (19). Scholars have labeled this developmental period as emerging adulthood (23).

Research has highlighted the importance of EFs in university students; students with weaknesses in EF skills often experience stress and higher levels of distraction due to difficulties in self-regulation and engaging in independent, goal-directed behaviors that affect their learning. They may also be unaware of how to seek help (24). Therefore, an individual's academic success or failure in higher education largely depends on the extent to which they possess executive functions (14,25).

Most research in the field of EFs has focused on a limited age range (*e.g.*, 2-5 years) (26), preschool children (27), and school-aged students (28). Therefore, despite the extensive literature on EFs in children, there is no actual developmental report of EFs during adolescence and adulthood, and the influence of executive functions on students' academic achievement has been somewhat neglected. A review of the studies indicated that not only has limited research been conducted on the impact of EFs on academic performance in university students (29-32), but also it is mistakenly assumed that EF-related problems stem from low intelligence and persistence, or that only students with Attention-Deficit/Hyperactivity Disorder (ADHD) and Learning Disabilities (LD) lack the executive function skills necessary for solving problems and achieving goals (11). However, evidence shows that deficits in EFs can significantly affect students' academic performance, including planning and behavior monitoring, studying, exam participation, and writing term papers (15,19,20). Nevertheless, comprehensive and consistent results in this area have not yet been reached. For example, a study conducted in Colombia by Ramos-Galarza *et al* (33) reported no association between executive functions and students' academic performance. In contrast, other studies, such as the one carried out in the Netherlands by Baars *et al* (34), demonstrated that students suffering from EF-related difficulties (*e.g.*, self-monitoring, planning, and self-control) were more likely to experience academic decline (34). These inconsistencies underscore the

necessity of systematically compiling and analyzing the findings of existing research.

Meta-analysis, as a quantitative approach for synthesizing findings across multiple studies, provides a comprehensive and precise understanding of the relationship between executive functions and academic performance. By computing effect sizes and examining moderating factors, meta-analysis resolves inconsistencies in prior research and offers deeper insights into the dynamics of this relationship. Accordingly, the present study was designed as a meta-analytic investigation aimed at systematically reviewing and integrating empirical evidence in this domain. The central research question is: What is the relationship between specific components of executive functions (*i.e.*, working memory, inhibitory control, cognitive flexibility, planning, attention, organization, organization of materials, and self-monitoring) and students' academic performance? Accordingly, this study aimed to synthesize the overall association between executive functions and academic performance, identify the most influential executive function components, and examine whether age and age appropriateness of the tool used moderates this relationship. Grounded in both theoretical frameworks and empirical findings, the primary hypothesis of this study posits that executive function components are significantly associated with students' academic performance. Moreover, recent evidence suggests that executive functions may be stronger predictors of academic success than Intelligence Quotient (IQ) (35), underscoring the importance of examining this relationship systematically.

Materials and Methods

Inclusion and exclusion criteria

Inclusion criteria were as follows: 1) provision of clear statistical data and correlations: articles should report explicit statistical data on the relationship between executive functions (or any of their components) and academic performance; 2) publication: the article should have been published in a peer-reviewed journal in English or Persian; 3) age group: studies should focus on university students aged 18 to 25 years; 4) outcome: assessment should have been conducted using validated self-report instruments with strong psychometric properties, or at least one objective measure of executive functions (working memory, inhibitory control, cognitive flexibility, planning, reasoning, sustained attention, problem-solving, *etc*.); 5) reverse approach: articles that investigated the relationship between executive functions and poor academic performance; 6) longitudinal studies: studies that began at the high school level and predicted future academic performance, or that commenced at middle school and continued into university (up to 25 years of age).

Exclusion criteria were as follows: 1) language: articles published in languages other than English or Persian; 2) exclusive focus on learning disabilities: articles in which the entire sample consisted of individuals with learning disabilities. The exclusion criteria in this study are based on the guidelines proposed by Chalmers *et al* (36), who emphasized that individual studies should be designed in a way that allows for their integration and analysis in meta-analytic research; furthermore, they should share a degree of similarity and comparability (36).

Composite framework for measuring academic performance

Objective and subjective indicators: In this meta-analysis, academic performance was conceptualized as a multidimensional construct assessed through both objective and subjective indicators. Objective measures included overall GPA (self-reported or university-recorded), number of completed courses or credits (ECTS or equivalent systems), scores on examinations or term microscores, performance in comprehensive or specialized exams (*e.g.*, comprehensive exams or NPTE), and reading comprehension and digital literacy as components of academic success. Subjective-perceptual indicators encompassed academic adjustment and self-regulated learning. Thus, academic performance was analyzed as a composite of these objective and subjective measures.

Search strategy

Inclusion and screening criteria: This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (37) and was pre-registered in the PROSPERO database under registration number

CRD42024616147. An electronic literature search was performed between July and September 2024 across the databases Scopus, PsycINFO, MEDLINE, Web of Science, PubMed Central, Magiran, Google Scholar, NoorMags, SID, and IranMedex, in both English and Persian. The search strategy employed Boolean operators (AND, OR) and truncation () to ensure a comprehensive retrieval of relevant literature. The first search category targeted executive function constructs, including terms such as executive function, working memory, inhibitory control, cognitive flexibility, planning, reasoning, sustained attention, and problem-solving. The second category focused on academic outcomes, encompassing keywords such as academic performance, academic success, academic achievement, and student achievement. These two sets of terms were then combined using the Boolean operator AND to form the final search string: (executive function OR working memory OR inhibitory control OR cognitive flexibility OR planning OR reasoning OR sustained attention OR problem-solving) AND (academic performance OR academic success OR academic achievement OR student achievement) *.

A publication date filter was applied to include studies published between 2010 and 2024. This time frame was selected to ensure the inclusion of contemporary and methodologically robust research reflecting current theoretical perspectives and empirical approaches in the field. Over the past decade, the conceptualization and measurement of executive functions have evolved significantly, and educational assessment systems and academic performance indicators have become more refined due to advances in technology, curriculum design, and psychological research methods. Limiting the search to studies published after 2010 ensured that only research consistent with modern definitions, assessment tools, and analytic standards was included. This approach enhanced the relevance, validity, and comparability of the studies selected for the meta-analysis and ensured that the findings are aligned with current scientific and educational contexts.

A gray literature search, including conference proceedings, doctoral dissertations, and symposia, was also conducted but did not yield additional relevant data. Reference lists of identified studies were screened to locate further relevant research. Two independent reviewers (NF & AM) performed study selection according to inclusion criteria, resolving discrepancies through discussion. The final analysis included 19 articles (17 in English and 2 in Persian), with no additional data requested from authors beyond what was published (Figure 1).

Coding procedure

This study followed the guidelines outlined in the Cochrane Handbook for Systematic Reviews by Higgins and Green (38). These guidelines provide a set of clear objectives, defined search terms, and pre-specified eligibility criteria for included studies. In some articles, EFs were reported as a general factor, while others addressed their constituent components, including working memory, cognitive flexibility, etc. All the studies were coded individually, resulting in a total of 95 effect sizes. Correlations were used as the primary metric, and the corresponding standard errors and confidence intervals were calculated.

Quality assessment

To evaluate the methodological quality, including the risk of bias, of the included empirical studies, the PEDro scale (Physiotherapy Evidence Database) was employed (39). This scale consists of 11 dichotomous criteria (yes/no), with criteria 2 to 9 assessing randomization/internal validity and criteria 10 and 11 evaluating the presence of reproducible statistical results. In this study, the methodological quality of the 19 selected articles was independently assessed by two reviewers (AM & FS); disagreements were resolved by a third reviewer (MA). The mean PEDro score was 8.6, indicating high methodological quality among the selected studies. EZAnalyze software (an add-in for Microsoft Excel, 2019) was used for classification, data coding, and generating descriptive statistics.

Effect size

The statistical approach in this study employed the analysis of continuous variables. Therefore, correlation coefficients were used as the effect size to establish the relationship between executive functions and academic performance. Based on the sample correlation coefficients, these were transformed

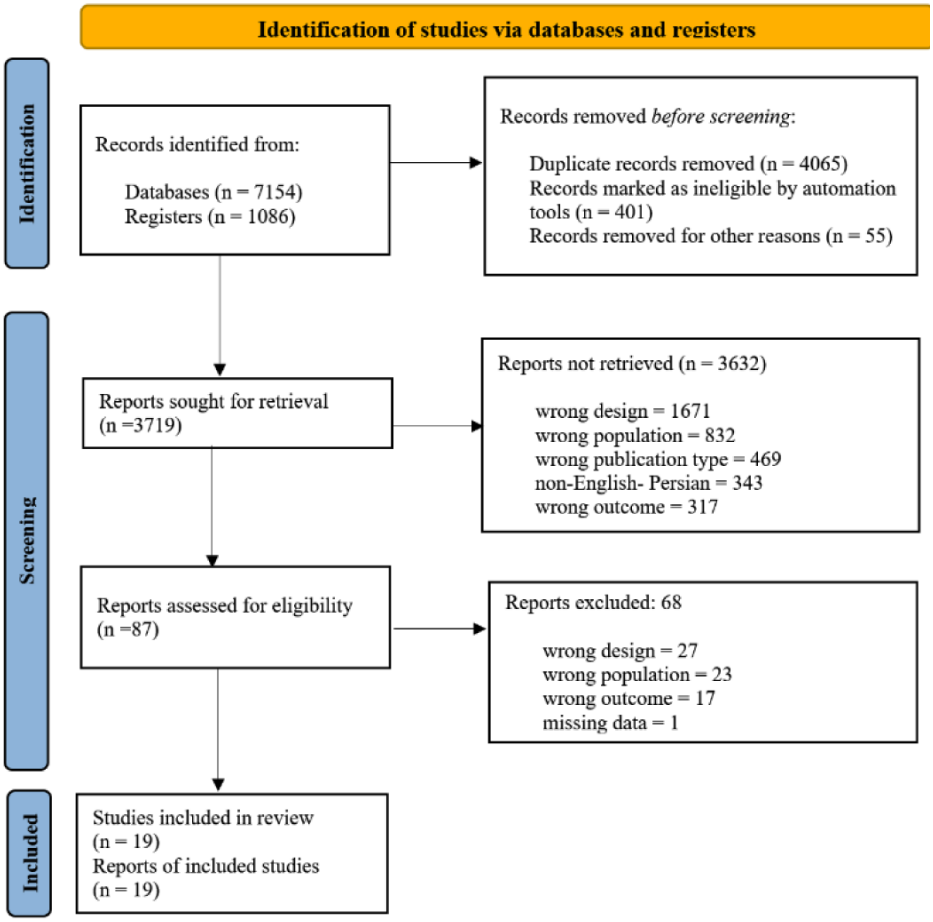


Figure 1. Flowchart of the inclusion protocol.

into Fisher's Z values to ensure that the variance of the effect size was dependent on the sample size. Correlation coefficients below 0.10 were considered small, around 0.30 medium, and above 0.50 large (40). For conducting the meta-analysis and meta-regression, Comprehensive Meta-Analysis software [CMA, Version 3.0;(41)] was used.

Results

Characteristics of the included studies

The mean age of the participants was 21.26±1.8 years (two of the reviewed articles reported only the age range of the participants; therefore, they were not included in the calculation of the mean and variance). Only studies that provided clear correlation statistics were selected to allow data integration. The studies presented in table 1 demonstrate a diverse range of research on executive functions across different countries, participant demographics, and assessment tools. The mean PEDro score was 8.6±0.81 (range 7 to 10), indicating high methodological quality among the reviewed studies.

All the studies focused on university students. Sample sizes ranged from small groups, for example, 13 participants in the study by Roitsch *et al* (10), to large-scale studies, such as Baars *et al* (34) with 1,760 participants. North America and the United States conducted several studies (42,43), while Canada also had notable contributions (44,45). European representation, particularly from the Netherlands, was significant (34,46), whereas South America (*e.g.*, Argentina, Ecuador, Chile) and Asia (*e.g.*, Iran, Pakistan) had relatively fewer studies. The methods used to measure academic performance were primarily consistent with the standardized academic achievement tests of each respective country (Table 1).

In the reviewed articles, various instruments were used to assess executive functions, most of which indicate better performance with higher scores. However, three instruments employed in the selected studies interpret higher scores as reflecting greater

Table 1. Characteristic of studies included in the meta-analysis

First author	Country	Mean age or reng	Quality scorea	Scale (s) "Executive functions specified"	Scale (s) "academic performance"	Distribution of the participants
Mercuri (45)	Canada	20.84	9	BRIEF-A "emotional control, inhibitory control, planning, organization, initiate, self-monitor, shift, task monitor & working memory"	Students' GPA's along with demographic information and number of hours spent studying were gathered using self-report	107 participants from five different first-year courses
del-Valle *et al* (1)	Argentina	22.63	9	1- Five digits test 2- Fingers task 3- Reading span task "inhibitory control, shift & working memory"	Academic records to assess AP, data were collected regarding participants' (a) year of enrollment, (b) number of courses taken and passed, (c) number of courses taken but failed, (d) number of courses taken but abandoned, (e) number of final exams passed, (f) number of final exams failed, and (g) GPA (including failures). The proposals of Luque and Sequi (2002) and Devincenzi *et al* (2018) were used and adapted to create a comprehensive university AP index	287 psychology students enrolled in the third curricular year of the Bachelor's degree in Psychology at the National University of Mar del Plata, Argentina
Javier Tabullo *et al* (47)	USA	20.34	9	Battery the cognitive self-regulation test battery "flexibility, working memory & inhibitory control"	Digital literacy test: digital literacy was assessed through the WebLEC test (Salmerón *et al*, 2018)	85 university students (66% F, 44% M)
Manuhuwa *et al* (46)	Netherlands	19.8	10	BRIEF "Emotional control, Flexibility, Inhibitory Control, Initiate, Organization, Planning, Self-monitor, Shift, Task monitor & Working memory"	Study success was measured by retrieving the number of credits earned after the first school year (including two semesters) from the university's database	315 first-year psychology students of a University of Applied Sciences in the Netherlands
Shaban-zadeh *et al* (48)	Iran	18-25	8	ADEXI "Inhibitory Control, Organization, Planning Executive Function total"	To evaluate students' academic performance, the microscores of the second semester of the 2019-20 academic year were used	397 high school students (202 F, 195 M) from Mahdishahr, Iran, in the academic year 2019–2020, selected through systematic random sampling
Pinochet-Quiroz *et al* (49)	Chile	19.82	8	EFECO Scale self-report version (Ramos-Galarza & *et al* (2020) "Emotional control, Flexibility, Inhibitory Control, Initiate, Organization, Planning, Self-monitor, Working memory & Executive Function total"	Self- Regulated Learning Management Scale (Ramos-Galarza *et al*, 2019) made up of 19 items distributed in 4 subscales in its self-reported format, that allow to know self-management of learning, academic performance perception, conscious motivation strategies for learning, and deep learning strategies	379 college students from pedagogy programs (64.1% M, 35.9% F), selected through non-probabilistic convenience sampling

Contd. table 1.

Taylor & Zaghi (50)	USA	19.82	9	BDEFS "Executive Function total"	Students' GPA's along with demographic information and number of hours spent studying were gathered using self-report	220 undergraduate engineering students at a public university in the United States, recruited via flyers and emails
Khawar *et al* (51)	Pakistan	22.8	8	ADEXI "Inhibitory Control, Working memory & Executive Function total"	In order to measure the academic intent to entrepreneurship, five items were developed by the authors of present study after consulting experts in the field	539 university students enrolled in various undergraduate and postgraduate programs
Roitsch *et al* (10)	USA	26	9	CEFI-Adult "attention, emotional control, flexibility, inhibitory control, organization, planning, self-monitor, working memory & executive function total"	At the end of the academic year, program GPA, performance on a written comprehensive exam, and performance on the NPTE were collected. Additional data retrieved from student records included admissions metrics of UGPA and Verbal, Quantitative and Analytic GRE scores. The written comprehensive exam for this program involves 200 multiple choice questions designed to mimic the PT licensing exam. It is a timed test with a limit of 4 *hr*	13 third-year PT graduate students
Sanjabi *et al* (52)	Iran	20-25	7	Clinical trial "Executive Function total"	-	40 probation students from Razi University of Kermanshah, Iran, selected through simple random sampling
Ramos-Galarza *et al* (53)	Ecuador	21.49	8	EFECO Scale self-report version "emotional control, organization & working memory"	To assess academic performance, the mean of the overall grades obtained by the university student in the last academic period was considered	175 university students
Sheehan & Iarocci (54)	Canadian	19.3	8	BRIEF "Emotional control, flexibility, inhibitory control, initiate, organization, planning, self-monitor, shift, task monitor & working memory"	Academic adjustment was measured by the Student Adaptation to College Questionnaire (SACQ; Baker & Siryk, 1989)	Participants included 135 university students, of which 93 (68.9%) were females and 42 (31.1%) were males. Participants ranged in age from 17 to 25 years, with a mean of 19.3 years. Most students were in their first year (51.9%) and were pursuing an arts and social sciences degree (61.5%) or a science degree (16.3%)

Contd. table 1.

Georgiou & Das (55)	Canada	21.82	10	1-Colour-word Stroop and number Stroop 2-Listening Spa 3- Color-word Stroop and number planned connections and color/ shape shifting "Inhibitory Control, Shift & Working memory"	Reading comprehension was assessed with Form G of the Nelson–Denny Reading Test (Brown, Fishco, & Hanna,1993)	90 Ninety university students (65 F, 25 M)
Alizadeh *et al* (56)	Iran	19.5	8	1- Wisconsin card sorting 2- Word color Stroop 3- Letter-digit spacing test "inhibitory control, shift & working memory"	Students' GPA's along with demographic information and number of hours spent studying were gathered using self-report	34 female students from the University of Kurdistan, Iran, in the second semester of the academic year 2018–2019
Georgiou & Das (44)	Canada	21.82	8	D–NCAS "planning & working memory"	Reading comprehension was assessed with Form G of the Nelson–Denny Reading Test (Brown, Fishco, & Hanna,1993)	178 undergraduate students (120 F, 58 M) from the University of Alberta, Canada
Fine (43)	USA	22.3	9	CEFI "attention, emotional control, flexibility, inhibitory control, initiate, organization, planning, self-monitor & working memory"	Students' GPA's along with demographic information and number of hours spent studying were gathered using self-report	123 undergraduate students (82 F, 41 M) from the University of Utah, USA
Baars *et al* (34)	Netherlands	18.9	10	AEFI "attention, planning, self-monitor & executive function total"	First-year study success, defined as study progress, was measured by the total number of credits according to the European Credit Transfer and Accumulation System (ECTS EU, 2015) that were achieved on first exam attempts in the first year after study enrolment	1760 first-year students at a University of Applied Sciences
Wingo *et al* (18)	California	19.1	9	KEFS (Delis *et al*, 2001) and the BRIEF-A (Roth et al, 2005) "Executive functioning. EF was assessed via an objective assessment and a subjective assessment: the D-KEFS (Delis *et al*, 2001) and the BRIEF-A (Roth *et al*, 2005), respectively"	Academic adjustment was measured by the Student Adaptation to College Questionnaire (SACQ; Baker & Siryk, 1989)	A sample of 77 females was recruited from a midsize urban university introductory psychology class

Contd. table 1.

Rabin *et al* (16)	California	21.7	8	BRIEF-A "emotional control, inhibitory control, planning, organization, initiate, self-monitor, shift, task monitor & working memory"	To measure academic procrastination, the Lay GP scale, which is a 20-question scale, was used	Data were collected from February 2007 through February 2009. Participants (n=212) were drawn from various undergraduate psychology courses at a four-year public college that is part of a large, urban university system

executive function difficulties (*i.e.*, Barkley Deficits in Executive Function Scale, EFECO Scale, and the Behavioral Rating Inventory of Executive Function–Adult Version [BRIEF-A]). Therefore, in the studies using these three instruments, the statistical results (Pearson correlations) were multiplied by negative one to align the interpretation with other instruments, where higher scores indicate better performance.

Effect size and significance

The findings from the meta-analysis indicated that the obtained data demonstrated good consistency. The effect size of executive functions was r=0.193, with a 95% confidence interval ranging from 0.053 to 0.333, based on a sample of k=19 studies and a population of n=50,166. Accordingly, the weighted average effect size was significant at $p<0.05$ (Figure 2).

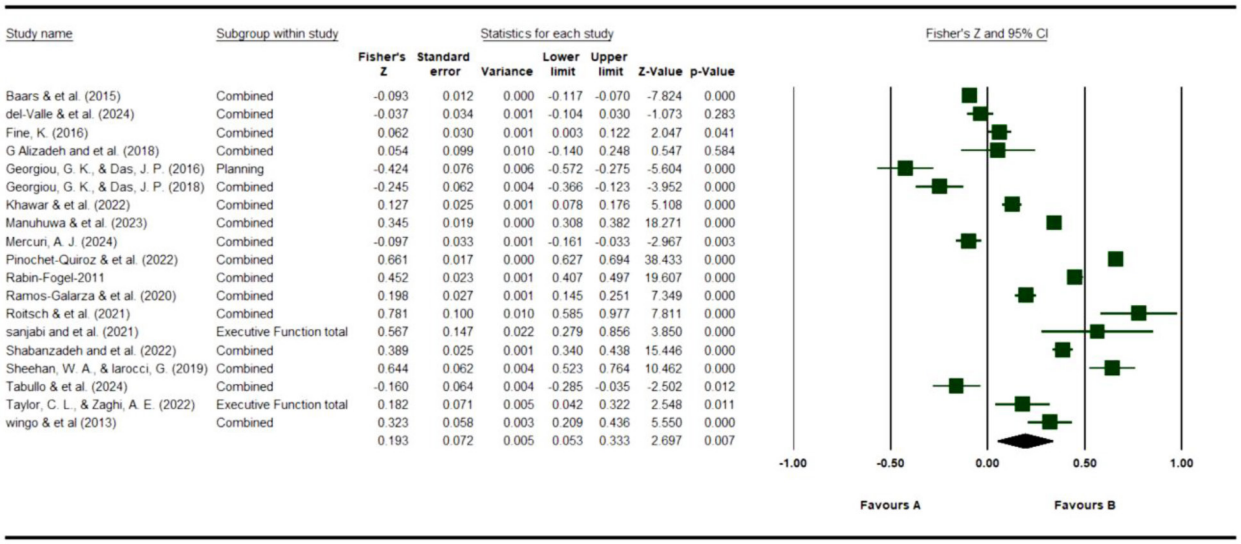
Heterogeneity analysis

To examine sampling variability, the parameters considered included Cochran's Q test (for testing the null hypothesis of homogeneity across studies) and the I^2 index (proportion of variability). According to Higgins and Green (38), an I^2 value of 25% indicates low heterogeneity, 50% indicates moderate heterogeneity, and values above 75% indicate high heterogeneity. Accordingly, various meta-analyses were conducted, and results from Model 1 (fixed effects) and Model 2 (random effects) were analyzed. Based on the Cochran's Q test (Q=2097.62, df=80, p=0.001), which indicated heterogeneity in effect sizes across studies, the random-effects model was selected for the meta-analysis. In the random-effects model, sampling variability is lower and is considered true variability in the variance and effect size rather than sampling error.

The I^2 index in this study was extremely high (I^2=96.18%), indicating substantial heterogeneity among studies. Although part of this heterogeneity may arise from sampling errors or true variability in effect size, explaining it solely through statistical factors is insufficient. Qualitative factors also appear to play a significant role in generating this high level of heterogeneity. For example, differences in methods used to measure executive function (such as laboratory-based objective tasks versus self-report questionnaires), variations in operationalizing academic success (*e.g.*, GPA *vs.* standardized tests), and diversity in cultural contexts and educational systems may contribute significantly to this variability. Therefore, in this study, it was decided to include all studies in the initial analysis.

Publication bias analysis

The funnel plot (Figure 3) facilitates the assessment of the presence or absence of bias regardless of sample size. This plot indicates that the obtained Z-values from the studies included in this meta-analysis are



Study name	Subgroup within study	Fisher's Z	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Baars & et al. (2015)	Combined	-0.093	0.012	0.000	-0.117	-0.070	-7.824	0.000
del-Valle & et al. (2024)	Combined	-0.037	0.034	0.001	-0.104	0.030	-1.073	0.283
Fine, K. (2016)	Combined	0.062	0.030	0.001	0.003	0.122	2.047	0.041
G Alizadeh and et al. (2018)	Combined	0.054	0.099	0.010	-0.140	0.248	0.547	0.584
Georgiou, G. K., & Das, J. P. (2016)	Planning	-0.424	0.076	0.006	-0.572	-0.275	-5.604	0.000
Georgiou, G. K., & Das, J. P. (2018)	Combined	-0.245	0.062	0.004	-0.366	-0.123	-3.952	0.000
Khawar & et al. (2022)	Combined	0.127	0.025	0.001	0.078	0.176	5.108	0.000
Manuhuwa & et al. (2023)	Combined	0.345	0.019	0.000	0.308	0.382	18.271	0.000
Mercuri, A. J. (2024)	Combined	-0.097	0.033	0.001	-0.161	-0.033	-2.967	0.003
Pinochet-Quiroz & et al. (2022)	Combined	0.661	0.017	0.000	0.627	0.694	38.433	0.000
Rabin-Fogel-2011	Combined	0.452	0.023	0.001	0.407	0.497	19.607	0.000
Ramos-Galarza & et al. (2020)	Combined	0.198	0.027	0.001	0.145	0.251	7.349	0.000
Roitsch & et al. (2021)	Combined	0.781	0.100	0.010	0.585	0.977	7.811	0.000
sanjabi and et al. (2021)	Executive Function total	0.567	0.147	0.022	0.279	0.856	3.850	0.000
Shabanzadeh and et al. (2022)	Combined	0.389	0.025	0.001	0.340	0.438	15.446	0.000
Sheehan, W. A., & Iarocci, G. (2019)	Combined	0.644	0.062	0.004	0.523	0.764	10.462	0.000
Tabullo & et al. (2024)	Combined	-0.160	0.064	0.004	-0.285	-0.035	-2.502	0.012
Taylor, C. L., & Zaghi, A. E. (2022)	Executive Function total	0.182	0.071	0.005	0.042	0.322	2.548	0.011
wingo & et al (2013)	Combined	0.323	0.058	0.003	0.209	0.436	5.550	0.000
		0.193	0.072	0.005	0.053	0.333	2.697	0.007

Figure 2. Forest plot effect size (Fisher'S Z). Executive functions—academic performance.

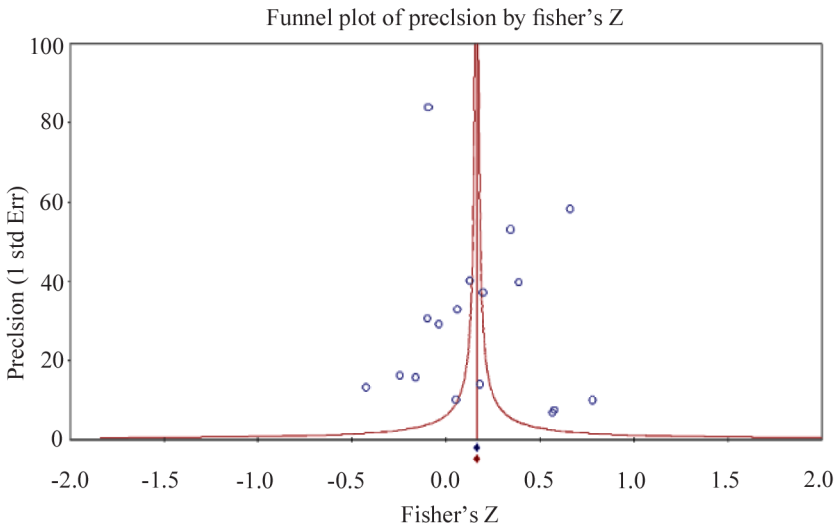


Figure 3. Funnel plot. executive functions—academic performance.

relatively small, ranging between 0 and 1. Egger's test at a 95% confidence interval was (−9.74, 9.76), with t=0.002, df=15. The one-tailed and two-tailed p-values were both greater than 0.05. The rank correlation test by Begg and Mazumdar was also examined (Kendall's tau b=−0.007), and in both one-tailed and two-tailed analyses, the p-value exceeded 0.05. Additionally, missing studies were evaluated using Duval and Tweedie's Trim and Fill method. The analysis indicated that in the random-effects model, the point estimate and 95% confidence interval for the combined studies were 0.162 (0.011, 0.31). Using the Trim and Fill method, these values remained unchanged. Therefore, the findings emphasize the absence of publication bias.

Outliers and sample size variations

A sensitivity analysis was conducted to examine whether any particular study had a substantial impact on the effect size. The analysis revealed that none of the studies contained outlier data, and when studies with outlier values were identified, there were no significant differences in effect size. Furthermore, when studies with larger sample sizes were excluded, virtually no difference in the results was observed. Therefore, it was decided not to exclude any study

from the meta-analysis, as none accounted for more than 50% of the statistical weight, and the differences in effect size were not significant.

Moderator variable

To examine the moderating roles of the participants' age and the age-appropriateness of the measurement instruments, a meta-regression based on a random-effects model was conducted. These two variables were selected as moderators since age represents one of the most fundamental indicators of individual differences in cognitive and psychological development, and even within early adulthood it may influence executive functioning and related academic outcomes. Additionally, the age-appropriateness of the instruments carries substantial psychometric importance; using tools normed for children or adolescents in adult samples can introduce measurement error, attenuate correlations, or reduce the stability of variables across studies (as was the case in several studies included in this meta-analysis; Table 2). Therefore, from both a psychometric perspective and a heterogeneity-analysis standpoint, age-appropriateness constitutes a plausible source of between-study variance, providing sufficient theoretical and empirical rationale for testing its moderating role. Consequently, the simultaneous examination of these two factors through meta-regression was methodologically necessary to determine whether they could account for any portion of the observed between-study variance.

Table 2. Validated age range in executive function assessment studies

Instrument name	Age range (years)
Das-naglieri cognitive assessment system (D-N CAS)	5–17
Digit span backward (WISC-III, 1992)	6–16
Comprehensive executive function inventory (CEFI)	5–18
Planned connections (D-N CAS)	5–17
Amsterdam executive function inventory (AEFI)	15–18
EFECO scale	13–18
Cognitive self-regulation test battery (Richards *et al*, 2018) (58)	9–13
Kulij brain executive function questionnaire	Up to 17

The meta-regression analyses revealed that neither of the two moderator variables—participants' age nor the age-appropriateness of the instruments used to assess executive functions—significantly predicted variability in the association between executive functions and academic performance. The coefficient for age-appropriateness of the measurement tools was 0.1380 (SE=0.0850), which did not reach statistical significance (p=0.1038), and its 95% confidence interval ranged from –0.0283 to 0.3050. Similarly, the coefficient for participants' age was 0.0158 (SE=0.0239), with a non-significant p-value (p=0.5081) and a 95% confidence interval extending from –0.0311 to 0.0627. A simultaneous test of all the coefficients indicated that the overall meta-regression model was not statistically significant, Q(2)=4.26, p=0.1189.

Model fit indices also indicated substantial between-study heterogeneity (Tau^2=0.1031; Tau=0.3210; I^2=96.30%; Q (72)=1943.40, p<0.001). Comparison with the intercept-only model showed that including the moderator variables did not reduce the amount of between-study variance (Tau^2=0.0988 in the null model), and the proportion of explained variance was effectively zero (R^2 analog=0.00). These results suggest that neither age differences within the 18–25-year-old university population nor the use of instruments originally designed for younger age groups significantly alter the strength of the relationship between executive functions and academic achievement.

Additionally, the distribution of effect sizes across executive function components showed that most effects fell within the small range (0.10 to 0.29). In contrast, flexibility, initiation, organization, task monitoring, and working memory demonstrated medium effect sizes (0.30 to 0.49). Attention yielded the smallest effect size. Taken together, these findings indicate that certain executive function components—particularly working memory, organization, and cognitive flexibility—play a comparatively stronger role in predicting academic performance. Tables 3 and 4 present the detailed regression coefficients, heterogeneity statistics, and effect size ranges (Table

Table 3. Meta-regression with moderating variables: age and age appropriateness of the scale used

Covariate	Coefficient	Standard Error	95% Lower	95% Upper	Z-value	2-sided p-value
Intercept	-0.2180	0.4990	-1.1961	0.7601	-0.44	0.6622
Scale: Age-inappropriate	0.1380	0.0850	-0.0283	0.3050	1.63	0.1038
Age	0.0158	0.0239	-0.0311	0.0627	0.66	0.5081
Statistics for model 1 Test of the model: Simultaneous test that all coefficients (excluding intercept) are zero Q=4.26, df=2, p=0.1189 Goodness of fit: Test that unexplained variance is zero Tau²=0.1031, Tau=0.3210, I²=96.30%, Q=1943.40, df=72, p=0.0000						
Comparison of model 1 with the Null Model Total between-study variance (intercept only) Tau²=0.0988, Tau=0.3143, I²=96.27%, Q=1986.44, df=74, p=0.0000 Proportion of total between-study variance explained by Model 1 R² analog=0.00 (computed value is -0.04)						

Table 4. Effect size of each executive function

	Group	Number studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	p-value
Medium	Task monitor	3	0.466	0.040	0.002	0.387	0.544	11.638	0.000
	Working memory	12	0.360	0.021	0.000	0.319	0.400	17.383	0.000
	Initiate	7	0.346	0.028	0.001	0.292	0.400	12.496	0.000
	Organization	8	0.341	0.024	0.001	0.293	0.388	14.043	0.000
	Flexibility	5	0.307	0.036	0.001	0.236	0.378	8.474	0.000
Small	Emotional control	7	0.220	0.028	0.001	0.166	0.274	7.939	0.000
	Inhibitory control	13	0.185	0.020	0.000	0.146	0.223	9.449	0.000
	Shift	7	0.133	0.030	0.001	0.074	0.192	4.436	0.000
	Planning	10	0.121	0.017	0.000	0.089	0.154	7.296	0.000
	Self-monitor	8	0.114	0.018	0.000	0.079	0.150	6.332	0.000
	Attention	5	0.049	0.022	0.000	0.091	0.006	2.221	0.026
Executive function total		10	0.175	0.016	0.000	0.143	0.207	10.625	0.000
Overall		95	0.192	0.006	0.000	0.179	0.204	29.849	0.000

3).

As shown in table 4, most of the effect sizes fall within the small range (0.10 to 0.29). However, flexibility, initiation, organization, task monitoring, and working memory exhibited medium effect sizes (between 0.30 and 0.49). It is noteworthy that attention demonstrated the lowest effect size. These findings indicate that certain components of executive functions—such as working memory, organization, and flexibility—have a greater impact on academic performance.

Effect sizes of executive function components

Meta-analytic findings: The findings of the present study, based on the results of the meta-analysis, demonstrated that all dimensions of executive functioning were statistically significant (all $p<0.05$). Among these, the largest effect sizes at a moderate level were observed for task monitoring (Task

monitor; 0.466), working memory (Working memory; 0.360), initiation (Initiate; 0.346), organization (Organization; 0.341), and cognitive flexibility (Flexibility; 0.307). In contrast, some components exhibited smaller effect sizes, particularly emotional control (Emotional control; 0.220), inhibitory control (Inhibitory control; 0.185), shifting attention (Shift; 0.133), planning (Planning; 0.121), self-monitoring (Self-monitor; 0.114), and attention (Attention; 0.049). Furthermore, the overall mean executive functioning score (Executive Function total) was 0.175, indicating a small to moderate effect. Finally, the overall effect size across all studies (Overall) was reported as 0.192, which was statistically significant based on $Z=29.849$ and $p<0.001$ (Table 4).

Discussion

The academic context has become increasingly open and diverse, which requires new educational competencies as well as autonomous management of learning by students to regulate their learning processes. These include program design, anticipating solutions and outcomes, and controlling thoughts, emotions, and behaviors. Such skills are directly associated with higher-level cognitive processes, including attention, working memory, inhibitory control, cognitive flexibility, planning, and problem solving, which are recognized as executive functions (16,18,52,57-59).

The aim of this study was to examine the relationship between executive functions and academic performance among students aged 18 to 25 over the past 15 years. This meta-analysis revealed that executive functions serve as strong predictors of academic achievement in students (Fisher's $Z=0.193$). However, the significance of the influence of EF components on academic performance was not uniform. The findings demonstrated that task monitor, working memory, flexibility, initiate, and organization had the greatest impact on students' academic performance, while emotional control, inhibitory control, planning, attention, and self-monitor exerted comparatively weaker effects. In the following, the impact of the executive function components (in order of importance) on academic performance is discussed.

Task self-monitoring

Task self-monitoring, defined as the mental ability to appropriately oversee one's own performance (53), had the greatest impact on academic performance. Studies emphasized that students with superior academic achievement possess the ability to self-monitor their learning and adequately plan for their study goals (60,61). The importance of this executive function component aligns with the central policy of academic education, as the university context is designed such that teachers should not constantly remind students of what they need to do; rather, it is the students themselves who should independently take on this responsibility.

Working memory

Working memory, recognized as an individual's capacity to actively maintain information in mind for task performance or response generation (62), was found to be the second most influential component affecting academic performance. This finding is consistent with the studies of Gropper and Tannock (63), Gareau *et al* (64), and Hong *et al* (65). Several experts have confirmed that during text comprehension and academic activities, working memory provides a cognitive workspace for retaining current information and integrating it with prior knowledge. However, other studies, such as those by Figueroa *et al* (66) and Hung (67), reported no relationship between working memory and performance in higher education. The contradictory results in the literature may be attributed to various factors, such as the interaction between different variables considered in each study, the characteristics of the analyzed population (*e.g.*, occupation, academic year), or the inclusion of mediating or moderating factors.

Initiation

Initiation is defined as an individual's ability to begin an activity without the need for external motivation to do so (68). The findings indicated that initiation was the third most important component influencing academic performance. Students who struggle with initiation typically have the desire to succeed but face difficulties in starting an activity and may require multiple cues or stimuli to get started (69). Therefore, adequate initiation can enhance students' academic

performance.

Organization of materials

Organization of materials, defined as the ability to maintain order and ensure the availability of necessary elements for the successful completion of a task (33), was found to exert a significant influence on students' academic performance. This component provides the foundation for academic self-efficacy and students' cognitive-emotional growth. Organization of materials plays a vital role in shaping the learning process, reducing academic stress, improving time management, and increasing motivation (69). Students who have effectively developed this skill demonstrate better performance in achieving academic success.

Cognitive flexibility

Cognitive flexibility, defined as the ability to generate alternative responses to achieve a goal (70), was shown to have a considerable effect on academic performance. Based on the findings, this ability helps individuals, when facing academic challenges, to move away from repetitive and ineffective solutions and to identify more effective alternatives for problem solving. Students with higher levels of cognitive flexibility are better able to adapt to new conditions, change learning strategies, and persist in their academic progress when confronted with difficult situations such as exam failures or complex study materials. This result is consistent with the findings of Lee *et al* (71), who demonstrated that cognitive flexibility can be a determining factor in improving academic performance.

Emotional control

Emotional control is defined as the mental ability to modulate emotional reactions in accordance with the context in which an individual is acting (72). Individuals with higher emotional control are better able to demonstrate adaptive responses in social contexts. The findings showed that this component influences academic performance. In fact, emotion regulation and the emotions experienced by an individual may interact with academic success through their effects on other executive function components (73-76).

Inhibition

Inhibition is defined as the individual's ability to consciously regulate automatic responses and control interferences (77). This component was identified in the present study as one of the executive function (EF) components affecting Academic Performance (AP), consistent with the findings of other authors (78,79). Inhibitory capacity enables students to resist distracting stimuli while studying or paying attention in class (80). Moreover, by reducing or overcoming responses, behaviors, and emotions that are inconsistent with task goals, inhibition facilitates better adaptation to the academic environment (81,82). Inhibition also helps readers avoid activating irrelevant information—whether from environmental stimuli or from long-term memory systems—that would otherwise interfere with constructing coherent text representations and helps prevent Working Memory (WM) overload (83).

Shifting

One of the findings of the present study showed that shifting had an effect on students' academic performance. The theoretical literature indicated that students with greater shifting capacity perform better in regulating their responses within academic contexts (84,85). Shifting allows students to adjust their learning processes by alternating between different study methods or strategies depending on the demands of the subject, teacher, or exam, and to disengage cognitively or emotionally from previous tasks (86). Shifting also plays an important role by supporting the transition between mental sets, the formation of new concepts, the integration of new and sometimes unexpected inputs into the unfolding text representation, sufficient forward inferences (through selecting and alternating between relevant information), switching between reading strategies, and engaging in metacognitive processes such as metacognitive monitoring (83).

Planning

Planning is defined as the individual's capacity to set goals and develop sequential steps to achieve them through the application of appropriate strategies and practical schemes (87). The findings suggested that this component affects students' academic

performance. Students who struggle with planning and organization may fail to start academic tasks on time or act inefficiently, as they do not have the necessary tools or resources available when beginning their work (69). Such individuals may also engage in activities in a disorganized and fragmented manner or feel helpless when faced with a large volume of information.

Self-monitoring

Self-monitoring is defined as the extent of an individual's ability to track their own behaviors and their impact on others (16). The findings revealed that this component influences academic performance. In an educational context, this skill involves students' ability to accurately recognize the strategies used in problem-solving, evaluate their effectiveness, and make informed judgments about task difficulty (72). Therefore, the effective use of task-monitoring abilities by students in the academic environment leads to improved academic performance.

Attention

The findings represented that the attention component influences students' academic performance. Norwalk *et al* (88) also found that inattention symptoms among students, based on the ADHD self-report scale, negatively predicted academic success and adaptation to educational demands. Students who scored higher on inattention symptoms also reported poorer study habits and skills, such as failing to complete assigned readings or watching television while studying (88).

Inconsistent studies

The review conducted in the field of the impact of executive functions on academic performance demonstrated that some studies have shown that executive function components do not significantly influence academic performance. One possible explanation may lie in the models used to assess these mental abilities. Even when classical laboratory tasks are applied, they tend to lack ecological validity because they do not evaluate executive functions in everyday life. Assessing these functions in daily contexts would be more logical when explaining a student's academic performance (89). Another reason for these inconsistent findings could be that objective and subjective measures of executive functions have been described as discrepant constructs. Objective EF measures, such as the D-KEFS test, and subjective EF measures, such as the BRIEF-A questionnaire, have been shown to exhibit low correlations with one another (90). In contrast, relatively moderate correlations have been reported between BRIEF and other self-report EF tools (*e.g.*, the Frontal Systems Behavior Scale [FrSBe] and the Dysexecutive Questionnaire [DEX]; (69).

Conclusion

Executive functions consist of cognitive processes and self-directed actions that are vital for academic success, including time management, organization, motivation, self-control, and emotional regulation; the successful management of thoughts, emotions, and behavior and prioritizing among conflicting demands. These functions exert a positive influence on students' academic performance and ultimately lead to deeper learning and greater academic achievement. Accordingly, weaknesses in executive functions have been associated with reduced academic success as well as deficiencies in study habits and skills among adults. Even seemingly minor study habits and skills, such as completing assigned readings or minimizing distractions while studying, require multiple abilities that depend on executive functions (*e.g.*, organizational skills and the capacity to sustain attention).

Therefore, it is evident that executive functions play a fundamental role in academic success. Specifically, greater difficulties in executive functioning are linked to lower academic performance and fewer course credits earned after one academic year. A student equipped with more advanced executive function strategies can reflect on rules, select among them, or integrate them, when necessary, thereby enhancing their capacity for learning and achieving success.

Potential implications

Universities place the responsibility for daily academic life planning on the students themselves; that is, they should decide when and how to study new material. This stands in sharp contrast to high school, where students are typically guided by specified assignments, structured note packets, and teacher

instructions to prepare for each class. For some students, this transition can be challenging and even intimidating, particularly if they have moved away from their families and no longer have parents nearby to assist with daily tasks and personal aspects of life. Students may struggle due to a lack of organizational and planning skills and may, for the first time, learn how to utilize the full set of their executive function abilities. Moreover, facing a new educational environment can be highly overwhelming, especially if their metacognitive skills have not been adequately developed.

The importance of planning and organization in academic success becomes more evident when considering the multifaceted nature of academic responsibilities at the university level. College courses generally involve a higher level of complexity and require students to manage multiple assignments, deadlines, and projects simultaneously. Those who lack effective planning and organizational skills may find it difficult to coordinate these demands, a difficulty that can result in missed deadlines, increased stress, and ultimately negative effects on academic performance.

The findings of these studies broadly reveal important implications for understanding the strong association between students' deficits in executive functions and their academic performance. Working memory emerges as a central focus of attention; findings indicate that this component not only plays a pivotal role in academic performance and achievement but is also a critical factor in the deficits observed among university students. Furthermore, other skills encompassed within executive functions—such as planning/organization and organizing academic resources—have also demonstrated their significance in influencing students' academic success. Therefore, fostering and strengthening these skills is crucial for achieving success in the complex and demanding path of higher education.

Limitations and future directions

For future research, several important directions are suggested:

1. Future studies should employ longitudinal designs and repeated measurements of both EF and academic performance across different stages of university (from the first year to graduation) to examine the reciprocal relationships between the two. This approach could clarify how engagement in demanding academic tasks strengthens executive functions and, conversely, how executive functions influence academic performance.
2. Psychological and behavioral factors such as self-esteem, emotional intelligence, sleep quality, and motivational strategies may function as mediating or moderating variables in predictive models. Examining these roles in future research could contribute to the development of more comprehensive and realistic models of academic achievement.
3. It is recommended that future studies develop and validate specific tools for assessing the executive functions of university students. Combining objective laboratory tasks with validated self-report questionnaires (with higher ecological validity) could provide a more complete picture of EF.

Ethical approval

This study was conducted in accordance with the ethical standards approved by the Research Ethics Committee of Allameh Tabataba'i University, under the ethical approval code IR.ATU.REC.1404.130

Consent for publication

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Conflict of Interest

The authors declare that they have no competing interests.

References

1. del-Valle MV, Canet-Juric L, Zamora EV, Andrés ML, Urquijo S. Executive functions and their relation to academic performance in university students. Psicol Educ 2024;30(1):47-55.

2. Balkis M. Academic amotivation and intention to school dropout: The mediation role of academic achievement and absenteeism. Asia Pac J Educ 2018;38(2):257-70.

3. Fernández-Hileman MDR, Corengia Á, Durand J. Deserción y retención universitaria: una discusión bibliográfica. Pensando Psicol 2014;10(17):85-96.

4. Gallegos JA, Campos NA, Canales KA, González EN. [Factores determinantes en la deserción universitaria. Caso Facultad de Ciencias Económicas y Administrativas de la Universidad Católica de la Santísima Concepción (Chile).] Form Univ 2018;11(3):11-8. Spanish.

5. Munizaga Mellado FR. Retención y abandono estudiantil en la educación superior universitaria en América Latina. 2018.

6. Mora SES. [Factores asociados a la calidad del rendimiento académico de estudiantes en la educación superior.] Rev Cienc Salud Educ Med 2021;3(3):36-43. Spanish.

7. Baumeister RF, Monroe AE. Recent research on free will: Conceptualizations, beliefs, and processes. Adv Exp Soc Psychol 2014;50:1-52.

8. Duckworth AL, Carlson SM. Self-regulation and autonomy: Social and developmental dimensions of human conduct. Cambridge University Press; 201. Chapter 10, Self-regulation and school success; p. 208-30.

9. Hofmann W, Schmeichel BJ, Baddeley AD. Executive functions and self-regulation. Trends Cogn Sci 2012;16(3):174-80.

10. Roitsch J, Walker ML, Raymer AM. Executive functions and student success during physical therapist education an exploratory study. J Allied Health 2021;50(4):107E-14E.

11. Meltzer L. Executive function in education: From theory to practice. 2nd ed. Guilford Publications; 2018. 396 p.

12. Roebers CM. Executive function and metacognition: Towards a unifying framework of cognitive self-regulation. Dev Rev 2017;45:31-51.

13. Viana-Sáenz L, Sastre-Riba S, Urraca-Martínez ML. Executive function and metacognition: Relations and measure on high intellectual ability and typical schoolchildren. Sustainability 2021;13(23):13083.

14. Knouse LE, Feldman G, Blevins EJ. Executive functioning difficulties as predictors of academic performance: Examining the role of grade goals. Learn Individ Differ 2014;36:19-26.

15. Pérez MV, Valenzuela Castellanos M, Díaz A, González-Pienda JA, Núñez JC. [Dificultades de aprendizaje en estudiantes universitarios de primer año. Atenea (Concepción).] 2013(508):135-50. Spanish.

16. Rabin LA, Fogel J, Nutter-Upham KE. Academic procrastination in college students: The role of self-reported executive function. J Clin Exp Neuropsychol 2011;33(3):344-57.

17. Mokhtari S, Mokhtari A, Bakizadeh F, Moradi A, Shalbafan M. Cognitive rehabilitation for improving cognitive functions and reducing the severity of depressive symptoms in adult patients with major depressive disorder: a systematic review and meta-analysis of randomized controlled clinical trials. BMC Psychiatry 2023;23(1):77.

18. Wingo J, Kalkut E, Tuminello E, Asconape J, Han SD. Executive functions, depressive symptoms, and college adjustment in women. Appl Neuropsychol Adult 2013;20(2):136-44.

19. Casey B, Duhoux S, Cohen MM. Adolescence: What do transmission, transition, and translation have to do with it? Neuron 2010;67(5):749-60.

20. Grieve A, Webne-Behrman L, Couillou R, Sieben-Schneider J. Self-Report assessment of executive functioning in college students with disabilities. J Postsecond Educ Disabil 2014;27(1):19-32.

21. Veroude K, Jolles J, Croiset G, Krabbendam L. Changes in neural mechanisms of cognitive control during the transition from late adolescence to young adulthood. Dev Cogn Neurosci 2013;5:63-70.

22. Dahl RE. Adolescent brain development: A period of vulnerabilities and opportunities. Keynote address. Ann N Y Acad Sci 2004;1021(1):1-22.

23. Arnett JJ. Emerging adulthood: What is it, and what is it good for? Child Dev Perspect 2007;1(2):68-73.

24. Rivera CJ, Wood CL, James M, Williams S. Improving study outcomes for college students with executive functioning challenges. Career Dev Transit Except Individ 2019;42(3):139-47.

25. Casey BJ, Getz S, Galvan A. The adolescent brain. Dev Rev 2008;28(1):62-77.

26. Isquith P, Gioia G, PAR S. Behavior rating inventory of executive function. Interpretative report Lutz: Psychological Assessment Resources, Lutz, FL. 2008.

27. Garon N, Bryson SE, Smith IM. Executive function in preschoolers: A review using an integrative framework. P Psychol Bull 2008;134(1):31.

28. Traverso L, Viterbori P, Usai MC. Improving executive function in childhood: evaluation of a training intervention for 5-year-old children. Front Psychol 2015;6:525.

29. Cumming MM, Oblath R, Qiu Y, Frazier SL, Zelazo PD, Flores H, *et al*. Executive function, perceived stress, and academic performance among middle schoolers with and without behavior problems. Remedial Spec Educ 2024;45(2):85-100.

30. Fuhs MW, Nesbitt KT, Farran DC, Dong N. Longitudinal associations between executive functioning and academic skills across content areas. Dev Psychol 2014;50(6):1698.

31. Lemberger-Truelove ME, Ceballos PL, Molina CE, Carbonneau KJ. Growth in middle school students' curiosity, executive functioning, and academic achievement: Results from a theory-informed SEL and MBI school counseling intervention. Prof Sch Couns 2021;24(1_part_3):2156759X211007654.

32. Rhodes SM, Booth JN, Palmer LE, Blythe RA, Delibegovic M, Wheate NJ. Executive functions predict conceptual learning of science. Br J Dev Psychol 2016;34(2):261-75.

33. Ramos-Galarza C, Cruz-Cárdenas J, Bolaños-Pasquel M, Acosta-Rodas P. Factorial structure of the EOCL-1 scale to assess executive functions. Front Psychol 2021;12:585145.

34. Baars MA, Nije Bijvank M, Tonnaer GH, Jolles J. Self-report measures of executive functioning are a determinant of academic performance in first-year students at a university of applied sciences. Front Psychol 2015;6:1131.

35. Ren FF, Alderman BL, Wang WG, Chen FT, Zhou WS, Zong WJ, *et al*. Effects of exercise training on executive functioning in adults with depression: A systematic review and meta-analysis of randomized controlled trials. Sports Med 2023;53(9):1765-88.

36. Chalmers I, Hedges LV, Cooper H. A brief history of research synthesis. Eval Health Prof 2002;25(1):12-37.

37. Hutton B, Salanti G, Caldwell DM, Chaimani A, Schmid CH, Cameron C, *et al*. The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: Checklist and explanations. Ann Intern Med 2015;162(11):777-84.

38. Higgins J, Green Se. Cochrane handbook for systematic reviews of interventions. 1st ed. Mississauga, Ont: Wiley-Blackwell; 2008.

39. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. Phys Ther 2003;83(8):713-21.

40. Cohen J. Statistical power analysis for the behavioral sciences. routledge; 2013 May 13.

41. Borenstein M, Hedges LV, Higgins JP, Rothstein HR. Introduction to meta-analysis. 2nd ed. John Wiley & Sons; 2021. 544 p.

42. Cushman GK, West KB, Davis M, LaMotte J, Eaton CK, Gutierrez-Colina AM, *et al.* The role of executive functioning, healthcare management, and self-efficacy in college students' health-related quality of life. J Am Coll Health 2022;70(8):2356-64.

43. Fine K. Executive functioning and grade point average in college students. Department of Psychology, University of Utah; 2016.

44. Georgiou GK, Das JP. What component of executive functions contributes to normal and impaired reading comprehension in young adults? Res Dev Disabil 2016;49:118-28.

45. Mercuri AJ. Inside the student mind: an exploration of self-reported executive functioning skills in university students. University of British Columbia; 2024.

46. Manuhuwa DM, Snel-de Boer M, Jaarsma D, Fleer J, De Graaf JW. The combined value of executive functions and self-regulated learning to predict differences in study success among higher education students. Front Psychol 2023;14:1229518.

47. Javier Tabullo Á, Saux G, Grasso L. Associations between digital literacy and executive functions in college undergraduates. Psykhe 2024;33(2).

48. Shabanzadeh A, Nasri S, Damavandi MI. The role of executive functions on students' academic achievement. J Posit Sch Psychol 2022:10109-21.

49. Pinochet-Quiroz P, Lepe-Martínez N, Gálvez-Gamboa F, Ramos-Galarza C, del-Valle-Tapia M, Acosta-Rodas P. Relationship between cold executive functions and self-regulated learning management in college students. Estud Sobre Educ 2022;43:93-113.

50. Taylor CL, Zaghi AE. Leveraging divergent thinking to enhance the academic performance of engineering students with executive functioning difficulties. Think Skills Creat 2022;45:101109.

51. Khawar R, Amin R, Zulfqar A, Hussain S, Hussain B, Muqaddas F. Dark personality traits and entrepreneurial intentions among Pakistani university students: The role of executive functions and academic intent to entrepreneurship. Front Psychol 2022;13:989775.

52. Sanjabi A, Karami J, Eivazi S. Effectiveness of cognitive rehabilitation of executive functions on improvement of academic performance of probative students of Razi University. Neuropsychology 2021;7(24):9-22.

53. Ramos-Galarza C, Acosta-Rodas P, Bolaños-Pasquel M, Lepe-Martínez N. The role of executive functions in academic performance and behaviour of university students. J Appl Res High Educ 2020;12(3):444-55.

54. Sheehan WA, Iarocci G. Executive functioning predicts academic but not social adjustment to university. J Atten Disord 2019;23(14):1792-800.

55. Georgiou GK, Das J. Direct and indirect effects of executive function on reading comprehension in young adults. J Res Read 2018;41(2):243-58.

56. Alizadeh G, Kordnoghabi R, Rashid K, Gholizadeh Z. The impact ofupper-alpha neurofeedbacktraining on executive functioning ofKurdistan University female studentswith academic burn-out syndrome and depression symptoms. J Clin Psychol 2017;9(3):55-66.

57. Caffarena Barcenilla C, Rojas-Barahona C. [La autorregulación en la primera infancia: avances desde la investigación.] Revista Ecuatoriana de Neurología 2019;28(2):37-49. Spanish.

58. Richard's MM, Vernucci S, Stelzer F, Introzzi I, Guàrdia-Olmos J. Exploratory data analysis of executive functions in children: A new assessment battery. Current Psychology 2020 Oct;39(5):1610-7.

59. Posner MI, Rothbart MK. Developing mechanisms of self-regulation. Dev Psychopathol 2000;12(3):427-41.

60. Damasio A. El error de Descartes Santiago. Chile: Editorial Andrés Bello; 1994.

61. Pérez Villalobos MV, Valenzuela Castellanos MF, Díaz Mujica A, González-Pienda JA, Núñez Pérez JC.

[Disposición y enfoques de aprendizaje en estudiantes universitarios de primer año.] Univ Psychol 2011;10(2):441-9. Spanish.

62. Baddeley A. Working memory: Theories, models, and controversies. Annu Rev Psychol 2012;63(1):1-29.

63. Gropper RJ, Tannock R. A pilot study of working memory and academic achievement in college students with ADHD. J Atten Disord 2009;12(6):574-81.

64. Gareau A, Chamandy M, Kljajic K, Gaudreau P. The detrimental effect of academic procrastination on subsequent grades: The mediating role of coping over and above past achievement and working memory capacity. Anxiety Stress Coping 2019;32(2):141-54.

65. Hong J-R, Hwang J-H, Kim E-J. Difference of working memory according to academic achievement with college students: Functional magnetic resonance imaging. J Korean Soc Radiol 2012;6(3):173-82.

66. Figueroa C, Acuña R, Quiroz L, Navarrete M, Roa D, Rodríguez F. [Factores asociados al rendimiento académico de estudiantes de la carrera de Fonoaudiología, en el año 2015.] Rev Educ Cienc Salud 2018;15(1):12-5. Spanish.

67. Hung SJ, editor Executive function and academic performance among Taiwanese students in higher education: A correlational study. Proceed Int Conf Educ 2020.

68. Ramos Galarza CA, Pérez Salas CP. [Relación entre el modelo híbrido de las funciones ejecutivas y el trastorno por déficit de atención con hiperactividad. Psicología desde el Caribe.] 2015;32(2):299-314. Spanish.

69. Roth RM, Isquith PK, Gioia GA. Behavior rating inventory of executive function®--adult version. Arch Clin Neuropsychol 2005.

70. Simola J, Zhigalov A, Morales-Muñoz I, Palva JM, Palva S. Critical dynamics of endogenous fluctuations predict cognitive flexibility in the Go/NoGo task. Sci Rep 2017;7(1):2909.

71. Lee K, Ng SF, Pe ML, Ang SY, Hasshim MNAM, Bull R. The cognitive underpinnings of emerging mathematical skills: Executive functioning, patterns, numeracy, and arithmetic. Br J Educ Psychol 2012;82(1):82-99.

72. Roth RM, Lance CE, Isquith PK, Fischer AS, Giancola PR. Confirmatory factor analysis of the behavior rating inventory of executive function-adult version in healthy adults and application to attention-deficit/hyperactivity disorder. Arch Clin Neuropsychol 2013;28(5):425-34.

73. Daniels LM, Stupnisky RH, Pekrun R, Haynes TL, Perry RP, Newall NE. A longitudinal analysis of achievement goals: From affective antecedents to emotional effects and achievement outcomes. J Educ Psychol 2009;101(4):948.

74. Garg R, Levin E, Tremblay L. Emotional intelligence: Impact on post-secondary academic achievement. Soc Psychol Educ 2016;19:627-42.

75. Mega C, Ronconi L, De Beni R. What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement. J Educ Psychol 2014;106(1):121.

76. Villavicencio FT, Bernardo AB. Positive academic emotions moderate the relationship between self-regulation and academic achievement. Br J Educ Psychol 2013;83(2):329-40.

77. Barkley RA, Barkley RA. Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment. New York: Guilford press; 1998. 898 p.

78. Álvarez MÁ, Morales C, Hernández DR, Cruz L, Cervigni M. [Predictores cognitivos de rendimiento académico en estudiantes de diseño industrial.] Arquit Urban 2015;36(1):86-91. Spanish.

79. Berbén ABG, Moreno LMG, Bernardo GÁ, López MR. [Funcionamiento ejecutivo, estrategias de aprendizaje y rendimiento en universitarios.] Temas actuales de investigación 2017:45. Spanish.

80. Duckworth AL, Taxer JL, Eskreis-Winkler L, Galla BM, Gross JJ. Self-control and academic achievement. Annu Rev Psychol 2019;70(1):373-99.

81. Friedman NP, Miyake A. The relations among inhibition and interference control functions: a latent-variable

analysis. J Exp Psychol Gen 2004;133(1):101.

82. Tangney JP, Boone AL, Baumeister RF. High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. Self-regulation and self-control. Routledge; 2018. p. 173-212.

83. Butterfuss R, Kendeou P. The role of executive functions in reading comprehension. Educ Psychol Rev 2018;30:801-26.

84. Dajani DR, Uddin LQ. Demystifying cognitive flexibility: Implications for clinical and developmental neuroscience. Trends Neurosci 2015;38(9):571-8.

85. Genet JJ, Malooly AM, Siemer M. Flexibility is not always adaptive: Affective flexibility and inflexibility predict rumination use in everyday life. Cogn Emot 2013;27(4):685-95.

86. Follmer DJ, Sperling RA. The mediating role of metacognition in the relationship between executive function and self-regulated learning. Br J Educ Psychol 2016;86(4):559-75.

87. Tirapu-Ustarroz J, Luna-Lario P. [Neuropsicología de las funciones ejecutivas.] Manual de neuropsicología 2008;2:219-59. Spanish.

88. Norwalk K, Norvilitis JM, MacLean MG. ADHD symptomatology and its relationship to factors associated with college adjustment. J Atten Disord 2009;13(3):251-8.

89. Pérez-Salas CP, Ramos C, Oliva K, Ortega A. Bifactor modeling of the behavior rating inventory of executive function (BRIEF) in a Chilean sample. Percept Mot Skills 2016;122(3):757-76.

90. McAuley T, Chen S, Goos L, Schachar R, Crosbie J. Is the behavior rating inventory of executive function more strongly associated with measures of impairment or executive function? J Int Neuropsychol Soc 2010;16(3):495-505.