

Relationship between Executive Functions and the Curriculum: A Systematic Review

Relación entre las Funciones Ejecutivas y el Currículo: Una revisión sistemática

<http://doi.org/10.17981/cultedusoc.15.1.2024.4984>

Received: June 5, 2023. Accepted: January 29, 2024. Published: March 18, 2024.

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For cite this article:

Cifuentes, P.-A. & Marín-Gutiérrez, A. (2024). Relationship between Executive Functions and the Curriculum: A Systematic Review. *Cultura, Educación y Sociedad*, 15(1), e03434984. DOI: <http://dx.doi.org/10.17981/cultedusoc.15.1.2024.4984>

Abstract

Introduction: This research focuses on the relationship between executive functioning and academic success of college students. At present, there is a lot of information about executive functioning in the school context, but little or no information in the university context. **Objective:** To explore the literature that shows relationships between executive functions and curriculum. **Methodology:** The qualitative methodology of literature review based on the PRISMA system was used. Search equations were used in the different engines and databases. The search was conducted with publications in Spanish. **Results:** Most of the articles presented information on these two variables, but only in the context of secondary education. We found no information on executive functioning and curriculum in future teachers. **Conclusions:** There is little evidence of the relationship between curriculum, academic success, and executive function, which implies a novel, interesting, and necessary workspace. It is important to address this phenomenon because psychological factors such as emotional control, which is one of the main executive functions, can be essential to help university students in their academic work.

Keywords: Executive functions; curriculum; systematic review; education; Neuropsychology; Neuroeducation

Resumen

Introducción: La presente investigación se centra en la relación entre el funcionamiento ejecutivo y el éxito académico de estudiantes universitarios. En la actualidad se encuentra bastante información sobre el funcionamiento ejecutivo en el contexto escolar, pero poca, o nula en el contexto universitario. **Objetivo:** Revisar la literatura y explorar la relación entre las funciones ejecutivas y el currículo. **Metodología:** Se utilizó la metodología cualitativa de revisión bibliográfica basada en el sistema PRISMA. Se crearon ecuaciones de búsqueda en los diferentes motores y bases de datos. La búsqueda se realizó con publicaciones en español. **Resultados:** La mayoría de los artículos presentó información de estas dos variables, pero solo en el contexto de la formación secundaria. No se encontró información sobre el funcionamiento ejecutivo y el currículo en futuros profesores. **Conclusiones:** Existe poca evidencia de la relación entre currículo, éxito académico y función ejecutiva, lo cual supone un espacio de trabajo novedoso, interesante y necesario. Es importante abordar este fenómeno porque factores psicológicos como el control emocional, que es una de las principales funciones ejecutivas, puede ser esencial para ayudar a los universitarios en su quehacer académico.

Palabras clave: Funciones ejecutivas; currículo; revisión sistemática; educación; Neuropsicología; Neuroeducación

INTRODUCTION

Should executive functions be considered when designing an academic curriculum? The purpose of this systematic review is to explore the potential relationship between curriculum and Executive Functions, paying special attention to the possible benefits for both, teachers, and students, in incorporating executive functions into curriculum design in the educational context.

According to [Gilbert and Burgess \(2008\)](#), Executive Functions (EF hereafter EF) are a set of skills involved in the generation, supervision, regulation, execution, and readjustment of appropriate behaviors to achieve complex objectives, especially those that require a novel and creative approach. EF is the cognitive component present in all cognitive domains ([Gilbert and Burgess, 2008](#)). It is the field of action that allows school-aged children to succeed and, of course, determines their social and professional future ([Heckman, 2006](#)). It is this thematic area of interest in the present work.

Research about brain development is not new, since there has always been a desire to investigate; yet, when it develops in the field of education by including the EF, it produces innovative studies that are of wide relevance to the education system. In this context, the teachers should be able to recognize when there is a problem, deficit, or cognitive decline, which can prevent the full development of some of the EF. ([Huizinga et al., 2018](#)) From a quick diagnosis, teachers should be able to refer the student to a professional or specialist who can assist with the case ([Best et al., 2011](#)). Therefore, EF is associated with possessing skills and abilities that make knowledge more accessible to people, in this case, students. That is why, it is required EF can be incorporated into the curriculum as a model of instruction that operates naturally and constructively for the benefit of students.

As EF must engage in targeted behaviors, mental flexibility, and the capacity to predict the implications of one's actions as a complicated kind of reasoning permits the settlement of disputes and the adaptation and incorporation of students into the educational environment ([Ardila and Ostrosky-Solís, 2008](#)). According to [Ardila and Ostrosky-Solís \(2008\)](#), it is recognized that, in contrast to actions using an instinctive reaction, the executive response requires a series of mental processes that govern and control other more complex abilities to accomplish goals.

It is evident that at the end of the nineteenth century and the beginning of the twentieth century, research on executive functions and the documentation that addresses their study, which give greater efficiency to the answers given by students in certain situations, as well as the ability to plan and modify behaviors following the demands of the environment in which the child operates, begins to take on significance. Thus, EF extends beyond the sensory reaction, as more structured and specialized cognition permits the realization of objectives and the execution of the processes required to reach them.

Executive functions

The concept of EF has been studied extensively in cognitive science and neuropsychology, and it has been found to be an important factor in many aspects of human life, including education, social interaction, and mental health ([Zelazo et al., 2017](#)). According to [Castillero \(2017\)](#), there are eleven EF, or sets of mental processes, including *reasoning*,

planning, goal setting, decision making, task initiation and completion, organization, inhibition, monitoring, verbal and non-verbal work memory, anticipation, and flexibility, These EF are described below:

- Reasoning requires the student to be able to think critically and to provide responses based on his/her degree of abstraction to the world, as well as to find connections between circumstances and conclusions.
- Planification capacity entails the creation of strategies and processes that enable the attainment of proposed goals or objectives.
- Goal setting is heavily tied to motivation, as this is the direction in which the learner will focus his or her conduct.
- Decision-making is a capacity that enables a student to pick amongst several alternatives or possibilities; task initiation and completion include concentrating on the performance of a task and being able to see it through to its end.
- Organization is a skill that includes the effective and usable arrangement of information.
- Inhibition is the capacity to resist certain urges that are known to interfere with doing what is right and achieving one's goals. This skill is significant because it enables the identification of potential problems or deficiencies on the side of the learner.
- Monitoring can also assist a teacher in detecting a student's potential failure since this relates to the student's capacity to concentrate on the tasks at hand.
- Verbal and nonverbal working memory refers to the capacity of a youngster to temporarily store knowledge that is going to be used later.
- Anticipation is considered a skill in which the student can anticipate the consequences of their actions and what may occur based on a specific situation; the memories that comprise a learning database are highly valued in this skill.
- Flexibility enables the student to modify his or her behavior or attitude as the circumstances surrounding a fact change or are altered.

In sum, EF entails a set of cognitive processes that are responsible for the cognitive control of behavior. Therefore, they are necessary for selecting and successfully monitoring behaviors that facilitate the attainment of chosen goals (Diamond, 2013). Additionally, the location of the EF inside the brain is also crucial to the educational field's pursuit of a deeper knowledge of the EF; nevertheless, there is no consensus on this point.

Neuroanatomical basis

As for the anatomical "location" of EF, it can be stated that the prefrontal cortex (prefrontal dorsolateral cortex and orbitofrontal) is the main region on which EF depends and develops, as indicated by most studies, both those conducted after lesions of specific brain regions and those conducted with neuroimaging (Gil, 2020). Although indeed, proper executive functioning does not depend just on the prefrontal cortex but also incorporates

other cortical and subcortical brain regions, the frontal regions would be responsible for coordinating or directing the other structures (Gil, 2020).

In conclusion, motivation, behavior, and emotions are human qualities that are of educational interest, since it is simple to create stimuli that promote the healthy development of EF, which enables the learning process, viewed from a more organic and biological perspective that strengthens over time. The EF has a broad duty in the development of literacy, arithmetic, and scientific abilities, as the acquisition of these types of knowledge involves attention, relationship, comparison, integration, and comprehension (Gil, 2020).

In contrast, when EF is dysfunctional in kids, it can be regarded as a defect in the acquisition of learning, which is not only an issue at the educational level but also causes the student to have difficulty integrating into society and is not always appreciated by the family. To discover answers to this issue, a multidisciplinary team is essential to assist this kid or teenager thoroughly. Nevertheless, according to Blanco (2019), the concept of diversity refers to the fact that all students have individual and specific educational needs to access the learning experiences necessary for their socialization, the satisfaction of which requires individualized pedagogical attention. In this conception, economic, social, cultural, family, and cognitive variables impact the teacher and need curriculum change as needed.

Curriculum and EF

EF are cognitive skills that allow university students to plan, organize, regulate their behavior, and solve problems effectively (Barceló et al., 2006; Gutiérrez-García & Landeros-Velázquez, 2018; Zavaleta et al., 2022). In general, it is important for university students to develop and maintain executive functions to succeed in their academic and personal lives.

In this context, a curriculum is described as a set of approaches and practices designed to help students realize their maximum potential. Historically, the curriculum has existed since ancient Rome, when it referred to the total of the honors that a citizen needed to enter a magistracy. Throughout the Middle Ages, the curriculum referred to the body of knowledge that should be taught at a university (Gimeno, 2010). To meet the demands of learning, it is obvious that the study of EF and their link to the curriculum is crucial. In this regard, the educator should oversee the process by which pupils acquire information. The interest in this mechanism leads to a proper manifestation of EF, and it is in this environment that the curriculum should be guided, where subjects that are intended to make a student suitable for a certain future skill should be included, as well as mental processes to enhance EF when necessary and to detect failures in its execution and seek solutions when necessary.

According to Tirapu et al. (2012), strategies for enhancing EF should be included in the school curriculum. Methods for working with Metacognition should be taught through explicit teaching and instructor modeling. The delivery of strategies must be structured and methodical. Continuous coaching and ongoing feedback are necessary. Methods must be positive and motivating for children. Motivation is essential.

Consequently, the educational reality has long demanded that teachers, rather than knowledge, focus on knowing how; therefore, it is not sufficient to make constant curricular adaptations to accommodate children with special educational needs if the teacher is unwilling to reveal how the student is processing the taught content.

Lastly, subject experts such as Gil (2020) suggest that EF, can be educated and refined in students, value this, represented by an education based on competencies, which involves not only two distinct curriculum designs but also a change in the evaluation methodology of the students themselves and the educational system itself.

The present systematic review of the findings focuses on the studies where there is a relationship between them, as the role of the school in the development of the EF is essential, and the teacher must abandon the notion of the student as a knowledge bank, in which he or she is only concerned with the why and not the how.

METHODOLOGY

Studio Design

The study was conducted according to the protocol of PRISMA-P (Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols). The details of the process of its elaboration and the rational explanation of each of the items proposed in the checklist can be read from the original publication of its authors, which is equally relevant when the researcher intends to publish (Page et al., 2021).

Sample of studies:

The literature search was conducted until June 2022. The articles were extracted from the databases of Scopus, Science Direct, Scielo, and Redalyc. The time by which the search was filtered corresponds to the most recent indexed publications (from 2009 to June 2022).

It is important to note that the methodological aspect taken into account for the conduct of the present review is those studies that exclusively address quantitative studies, to make the analysis corresponding to them, the selected databases are those already mentioned and only the results that appear in Spanish were taken into account, (except for Scopus, which involved writing the search in English to obtain results) the words that were used were Executive Functions and Curriculum, which at times gave positive results, but also the combination, Executive Functions, and Education was performed as a filter that was convenient to the area of study.

The criteria for the selection of studies, the exploration strategy, and methods for the collection and synthesis of information in the Scopus database are presented below. The search terms are the articles that were selected in Spanish, these were chosen with a basic criterion that included the words “executive functions” and “curriculum” in their abstract, summary, or keywords. Applying these search criteria, to ensure the results obtained, the search was conducted in English. The nominal word groups were “Executive Functions” and “Curriculum”, using the “AND” Boolean operator.

TABLE 1. *Search in Scopus.*

Scopus Strategic Search (Literary search conducted in June 2022)	
1.	(TITLE-ABS-KEY (executive functions)) AND (curriculum).
2.	AND (LIMIT-TO (DOCTYPE, "ar")).
3.	AND (LIMIT-TO (LANGUAGE, "Spanish"))
4.	AND (LIMIT-TO (SRCTYPE, "j"))

Note: The search yielded 1,365 documents after the search criteria were applied. Inclusion of search criteria (see Figure1). Source: Self-elaboration.

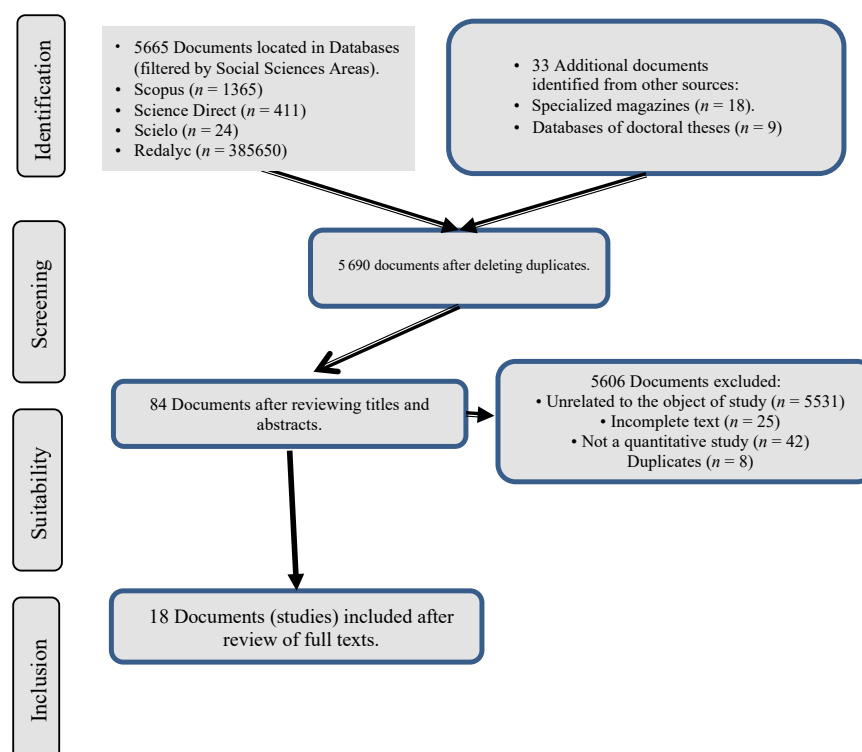
Studies that have been conducted with a student population, whether preschool, primary, secondary, or university, quantitative studies, available in Spanish, carried out in Ibero-American countries and which address the relationship between executive functions and the curriculum.

In addition to the above, the search by publication was leaked since articles related to the social sciences and psychology were selected. In some databases the search was directed through the Boolean operators OR and AND, or ADD, to omit, include, and add information to the requested category.

Exclusion of search criteria

Qualitative studies, that are in a language other than Spanish, that have not been carried out in Ibero-American countries, which do not directly involve executive functions in the curriculum, and any type of document that is not a scientific article were excluded.

Figure 1. PRISM matrix.



Source: Authors.

Data analysis

To assign weight to the results of the selected articles, each of them was evaluated. The aspects that were taken are the selection of participants, the methods used for the research, and the results obtained. So, it can be said that after analyzing each database, it is evident that the subject can be divided into some fields, perspectives, epistemological approaches, trends, or lines of research, such as a relationship between good performance or school performance when executive functions are incorporated into curriculum design in the field of pre-school, primary, secondary or university education, according to the studies analyzed.

The studies that were selected cover the same research perspective as regards the thematic area of education where it is demonstrated that they are part of the neural process of learning and can therefore guide the destiny of learning that is achieved consolidated inside and outside the classroom.

In summary, the global analysis of the information allows us to say that there have been advances in EF and curriculum, however, there are still developments to be studied, however, greater involvement of social and political actors is needed to ensure that education is in line with the reality in educational institutions, so the teaching community must be urged to intentionally transform pedagogical practices for the development of EF.

RESULTS AND DISCUSSION

The following tables summarize the findings of the 18 studies analyzed in the systematic review. These studies cover the participation of children, adolescents, and university adults, all of which demonstrate the importance of the inclusion of EF in the school curriculum.

From the data collected in this review at early ages, the curriculum that stimulates executive functions improves academic performance. In other words, it provides students with the ability to learn from mistakes, generate alternative strategies, and better information processing. It also observed that the curriculum, in addition to providing the basic, minimum, and common teachings, should provide the student with the tools to improve their ability to acquire learning.

There is no indicator to assess whether the development of executive functions depends on sex. The average age in the systematic review is 9 to 10 years. However, 2 of the studies show the importance of the curriculum in the development of executive functions, and together with the results of the remaining studies it is observed that the most significant changes are obtained at an early age. The rate of improvement in early ages (2-9 years) is estimated at 40% (Bernal-Ruiz et al., 2020). Also, the integration of the EF into the school curriculum following the revised studies has to be through the implementation of the same in the different educational projects and the previous training that the teacher must have as a guide of the process of teaching-learning, A comprehensive view of the curriculum can emerge that will benefit all educational actors, including children's parents, since as students' cognitive skills are improved or perfected, their quality of life can be positively influenced.

Under this same context, within the realm of higher education, one can somehow predict the future of the student by how they perform in their EF. So, this student population, as at other educational levels such as primary or secondary, may suffer from a certain degree of frustration that motivates them to drop out of school, due to inadequate management of these skills, making the student become misunderstood and at the same time a student who does not assimilate each of the subjects that make up the curriculum of the career he intends to study (Astin, 1994).

Finally, it is a question of taking the educational environment a step further that will lead to improvements in the academic context, the teacher must have among their responsibilities, not only the fact of transferring certain contents but also must incorporate into their practice how the student will process those contents, when attempting to make curricular adaptations. For example, it is always good to have the EF, as a transversal axis that guides the educator in his educational work, regardless of the level to which it belongs Díaz and Lim (2022).

During the process of a systematic review of the literature related to executive functions and the curriculum in the various databases consulted, it is evident that there is a wide variety in this regard since research has been formulated and developed to show that there must be a necessary link between EF and the curriculum to achieve better performance in the school performance of primary and high school students respectively.

However, there are some shortcomings regarding the realization of this fact as a tangible reality, in all the studies analyzed, the EF, in the educational environment, are regarded as mere projects that are not yet fully implemented, without denying that the intentions are very good, but unfortunately, they are not enough.

In this particular scenario, it is intended to achieve an approximation to the coverage of the gaps that exist in the Colombian field in this matter, banking education, reason for the criticism of Paulo Freire has shown that they do not work, the student cannot be a mere receiver of contents and victim of the indifference on the part of the teacher of how he is going to process what is being imparted to him, it is here that it turns out an area of interest in favor of the children (Angulo and León, 2005).

Based on the above, with the analyzed information it can be affirmed that although in the field of educational psychology, a wide investigation has been generated, especially in Spain, which is very beneficial to ensure that the purpose of including EF in the Spanish curriculum is fulfilled, as is already being done, in the countries of Latin America and especially in Colombia, there is a huge gap about publications on the positive effects of linking EFs to the curriculum.

The existing literature in Latin American countries is very scarce, so it requires the incentive of more teachers to focus their attention on an educational fact so relevant and vital to understanding the core process of learning in our children, it also helps because it provides the teacher with tools and techniques when dealing with or managing situations where children may have special educational need.

Hence, it is necessary, especially in Colombia, to open a field for research in this area that, in turn, lead to the generation of literature that is most efficient and timely to facilitate decision-making in the face of problems that may arise from the teacher's ignorance in the way in which the student processes the contents that are taught and that are shown in their school performance.

On the other hand, the review of databases based on one or the other study does not indicate, except for one or two papers that address the area of study that is proposed, which is a tremendous gap in knowledge and therefore in the implementation of activities that are effective and efficient in the teaching-learning process.

TABLE 2. *Results in Scopus.*

Authors	Participants	Age	Man	Woman	Results
Fernández-Hernández et al. (2022)	70	9	36	34	A better physical education class had a greater effect on executive functions than on the physical one, and the improvement was compared with students without a specialized physical education class
Romero-López et al. (2021)	110	5	46	54	The children who followed the specialized program improved their executive functions
Gutiérrez-Ruiz et al. (2020)	104	18	72	32	Executive functions in the university population only help 19% of academic performances
Papazian et al. (2009)	25	3	13.00	12	Training in executive functions improves ADHD, and this improves the performance of children

Note. Documents extracted from Scopus and the main variables used for this analysis. Source: Self-elaboration.

TABLE 3. *Results of Science Direct.*

Study	Methodological Approach	Sample	Main finding
Romero et al. (2017)	Quantitative.	100 children. 5-6 years old.	The Intervention program has a significant impact on all the executive function variables analyzed.
Villaseñor et al. (2018)	Quantitative.	40 children.	The cognitive performance of children in the street context is generally below their peers in school.
Ygual et al. (2010)	Quantitative	26 children with TDAH.	Executive functions, in addition to verbal IQ, have a predictive weight on the variables of the history analyzed. Implications for improving social and academic problems experienced by children with ADHD.
Bausela-Herreras & Luque-Cuenca (2017)	Quantitative.	1077 parents. 902 teachers.	Creation of an instrument to be applied by educational and clinical psychologists in children and adolescents with various neurodevelopmental disorders.
Cristiano et al. (2019)	Quantitative.	106 college students.	Cognitive processes are independent of the type of laterality; however, EF determines student achievements

Note. Documents extracted from Science Direct and the main variables used for this analysis. Source: Self-elaboration.

TABLE 4. *Scielo Database.*

Study	Approach	Sample	Main finding
Tamayo et al. (2018)	Quantitative. Descriptive. Transversal.	280 high school students.	More than half of the students in the sample had mild or severe alterations in the EF index, which was associated with the academic skills evaluated.
Fonseca et al. (2016)	Quantitative. Descriptive. Correlational.	139 Students 6-12 Age	The results show improvements in performance in neuropsychological tests with increases in the medians as age increases. learning processes.
García-Escalera et al. (2020)	Quantitative. Descriptive.	2 groups of students. Ages 10-12.	Executive functioning suggests the need to influence the set of variables studied to promote among students increasing levels of control over the learning process.
Álvarez et al. (2015)	Quantitative.	82 students.	EF presents a differentiated pattern whereby cognitive flexibility is more associated with students, while attention processing is focused on students.

Note. Documents extracted from Scielo and the main variables used for this analysis. Source: Self-elaboration.

TABLE 5. *Results of Redalyc.*

Study	Approach	Sample	Main finding
Montoya-Arenas et al. (2021)	Quantitative.	42 college students.	Executive deficits are evident in most EF dimensions of students with low academic performance.
Presentación et al. (2016)	Quantitative.	209 preschool students.	Early executive functioning has a role in maintaining mathematical difficulties from the early stages of schooling, highlighting the importance of inhibition and the verbal component of MT.
Rello et al. (2018)	Quantitative.	148 students. Age 10-12.	In terms of neuropsychological tasks, statistically, significant correlations were observed between the two working memory tests and all comprehension indicators
Chino & Zegarra-Valdivia (2019)	Quantitative.	150 college students.	Multidisciplinary and critical reading understanding is made possible by the ability to build judgments, evaluate, and make decisions that are only possible with EF intervention

Note. Documents extracted from Redalyc and the main variables used for this analysis. Source: Self-elaboration.

CONCLUSIONS

In Latin America, as such, there is not much information about it, but as shown in the tables, it is Spain that has generated more literature and concern in merging in the good sense the EF and the school curriculum, it is good to have these studies in the respective

databases that are offered as it allows documentation and support to be able to formulate possible solutions. It is regrettable that in these latitudes there is no extensive development of this type of study, but there are other teachers who, even if they do in other countries, can inquire into its progress and its relevance in the current context.

The limitations, for its part in terms of the revised literature, lie in the fact that in this continent it is very scarce as already pointed out, which suggests that not all teachers are aware that probably the failures that are occurring in the educational system in terms of school performance, is being affected by the nonobservance of the EF.

Finally, it is recommended that, because of the present review, the definitive incorporation of the EF in the curriculum design should be originated as a public policy and teachers should be trained in its implications. It can also be observed that executive functions in academic performance or, in other words, “take advantage of curriculum knowledge”, do not have a greater impact on higher education studies, and lack of studies in this area of education can lead to the formulation of the following question:

Is good academic performance in higher education possible without executive functions? So, it can be concluded that, if that is the case, the curriculum in higher education is inefficient.

FUNDING

Paola is a Fellowship recipient from the Universidad Libre de Colombia. Thus the Universidad Libre de Colombia has funded the project from which this research comes from.

CONFLICT OF INTEREST

The authors report no conflict of interest.

AUTHORS CONTRIBUTION

Paola Andrea Cifuentes: Conceptualization; Data curation; Formal Analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Validation; Visualization; Writing – original draft; Writing – review & editing.

Alejandro Marín-Gutiérrez: Conceptualization; Formal Analysis; Data curation; Methodology; Software Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

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