

Executive functioning in adults with attention deficit hyperactivity disorder: A systematic review

Carlos Francisco Rincón¹, Lady Bernal Morales¹, Sheylla Tello Sandoval¹

Abstract

Introduction: Executive function deficits are associated with attention deficit hyperactivity disorder (ADHD) in both children and adults. The inattentive subtype is primary related to “cold” executive functions, while the hyperactive subtype is related to “warm” executive functions.

Objective: To systematically review studies on executive functioning in adults with attention deficit hyperactivity disorder published during the last decade.

Methodology: A documentary research was conducted, encompassing 33 articles retrieved from PubMed, Web of Science and EBSCO platforms. The analysis considered years and countries of publication, attention deficit hyperactivity disorder diagnostic criteria, participants, comorbidities, subtypes, medication use, assessment tools, and processes of executive functions evaluated.

Results: It was evidenced that there is a high percentage of adults with attention deficit hyperactivity disorder who present a deficit or lower performance in executive function tests. However, the results varied depending on specific characteristics of the study and/or participants, which confirms the heterogeneity of the disorder. In addition, the main instruments for measuring executive functions and diagnostic criteria for adult attention deficit hyperactivity disorder were identified.

Discussion: These results support the established links between attention deficit hyperactivity disorder, impaired executive functions, and major life activities found in the adult attention deficit hyperactivity disorder literature. However, some of the limitations were the poorly controlled variables such as comorbidities, attention deficit hyperactivity disorder subtypes that were not assessed, and usage of instruments that measure executive functions that can lead to reduced credibility of the results presented here.

Conclusions: According to the results presented, there is a high percentage of adults with attention deficit hyperactivity disorder who present a deficit or lower performance in executive function tests, compared to both neurotypical adults and those with other psychiatric disorders. Further research is recommended to continue studies on the topic and to include other variables.

Keywords: ADHD, Adults, Executive functions, Prefrontal Cortex Neuropsychology, Mental disorder.

Funcionamiento ejecutivo en adultos con trastorno por déficit de atención con hiperactividad: una revisión sistemática

Resumen

Introducción: Los déficits de la función ejecutiva están asociados al trastorno por déficit de atención/hiperactividad (TDAH) tanto en niños como en adultos. El subtipo inatento se relaciona con función ejecutiva fría y el subtipo hiperactivo con función ejecutiva cálida.

Objetivo: Revisar sistemáticamente los estudios sobre funcionamiento ejecutivo en adultos con trastorno por déficit de atención/hiperactividad publicados durante la última década.

Metodología: Se realizó una investigación documental que abarcó 33 artículos recuperados de las plataformas PubMed, Web of Science y EBSCO. El análisis tuvo en cuenta años y países de publicación, criterios diagnósticos de trastorno por déficit de atención/hiperactividad, participantes, comorbilidades, subtipos, medicación, instrumentos utilizados y procesos de función ejecutiva evaluados.

Resultados: Se evidenció que existe un alto porcentaje de adultos con trastorno por déficit de atención/hiperactividad que presentan un déficit o menor rendimiento en las pruebas de funciones ejecutivas. Sin embargo, los resultados variaron dependiendo de las características específicas del estudio y/o de los participantes, confirmando la heterogeneidad del trastorno. Además, se identificaron los principales instrumentos para medir las funciones ejecutivas y los criterios diagnósticos más utilizados en adultos.

Discusión: Estos resultados apoyan los vínculos establecidos entre el trastorno por déficit de atención/hiperactividad, el deterioro de la función ejecutiva y las principales actividades vitales encontrados en la literatura sobre el trastorno por déficit de atención/hiperactividad en adultos. Sin embargo, algunas limitaciones fueron variables mal controladas como comorbilidades, subtipos de trastorno por déficit de atención/hiperactividad que no fueron evaluados y el uso de instrumentos que miden la función ejecutiva que pueden llevar a una menor credibilidad de los resultados presentados.

Conclusiones: Según los resultados obtenidos, existe un alto porcentaje de adultos con trastorno por déficit de atención/hiperactividad que presentan un déficit o menor rendimiento en las pruebas de función ejecutiva, en comparación tanto con adultos neurotípicos como con aquellos con otros trastornos psiquiátricos. Se sugieren recomendaciones para continuar los estudios sobre el tema e incluir otras variables.

Palabras clave: TDAH, adultos, funciones ejecutivas, córtex prefrontal, neuropsicología, desorden mental

¹ Facultad de Ciencias de la Salud,
Universidad Pedagógica y Tecnológica
de Colombia, Tunja, Colombia

✉ Correspondence / Correspondencia

Carlos Francisco Rincón Lozada,
calle 24 #5-63, Facultad de Ciencias de la
Salud, Universidad Pedagógica y Tecnológica
de Colombia, Tunja, Colombia.

E-mail: carlosfrancisco.rincon@uptc.edu.co

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Introduction

Attention deficit hyperactivity disorder (ADHD) is characterized by symptoms of inattention, hyperactivity, and impulsivity. It is considered a public health problem due to its high prevalence and impact on the different spheres of the people suffering from it (1–2). The approximate prevalence worldwide is 5% in children and 2.5% in adults (3).

A literature review about the prevalence of ADHD in children and adolescents revealed that European countries such as Spain report a prevalence of 11.52% among children aged 6 to 11 years (4–5), while England shows a rate of 8% in 10-year-olds (6). Norway records a prevalence of 5.2% in children aged 7 to 9 years (7). In Asia, ADHD prevalence is higher in Japan, with a prevalence of 31% in children aged 3–6 years (8), while in China the prevalence is 4.6% among those aged 5–15 years (9). In Africa, the Republic of Congo has a prevalence of 6% in children aged 7–9 years (10) and in Nigeria the prevalence is 6.6% in those aged 6–8 years (11).

Latin America presents the greatest variability and the highest prevalence figures, with ranges between 5 and 20% (12). According to the Latin American League for the Study of ADHD (13), there are 36 million people in Latin America affected with ADHD, with less than a quarter receiving multimodal treatment. In Panama, the prevalence is 7.4% among those aged 6–11, years (4–14). Brazil reports a rate of 13% in population aged 6–12 years (15), while Mexico shows a prevalence of 14.6% (16). In the case of Colombia, the ADHD prevalence reaches up to 20%, being the highest in Latin America (17).

Table 1 presents the compiled ADHD prevalence data from various studies.

Regarding the prevalence of ADHD in adults, a multi-country study covering Europe, Latin America, the Middle East, and the United States aimed to assess the prevalence of mental disorders. The study showed an overall prevalence for ADHD in adults of 3.4%, with the highest rates in France, with 7.3%, and the United States and Holland with 5%; unlike the aforementioned study, Colombia had the lowest prevalence of 1.9%, just as Mexico (18). Although the prevalence of ADHD in adults is low compared to that of children and adolescents, it still represents one of the most frequent psychiatric disorders, on top of schizophrenia (1%) and bipolar disorder (1.5%) (19).

Table 1. Prevalence of ADHD in different countries

Countries	Prevalence	Population
Spain (4-5)	11.52%	6 to 11 years
England (6)	8%	10 years
Norway (7)	5.2%	7 to 9 years
Japan (8)	31%	3 to 6 years
China (9)	4.6%	5 to 15 years
Republic of Congo (10)	6%	7 to 9 years
Nigeria (11)	6.6%	6 to 8 years
Panama (4-14)	7.4%	6 to 11 years
Brazil (15)	13%	6 to 12 years
Mexico (16)	14.6%	Children
Colombia (17)	Up to 16%	Children
France (19)	7.3%	Adults
United States & Holland (19)	5%	Adults
Colombia & Mexico (19)	1.9%	Adults

Source: The authors.

Between 50% and 60% of children who present the disorder in childhood will continue to present it in adulthood (20.) This leads to the conclusion that the diagnosis of ADHD is often underdiagnosed in adulthood, and therefore the prevalence rates found are lower than those reported in children and adolescents. This occurs because the diagnostic criteria are pointed at children and are not as sensitive nor flexible enough to assess changes during their development (21).

Studies on the possible causes of ADHD suggest it is due to a combination of several factors. In terms of genetics, studies with family members have shown that there is between 5 to 10 times more risk of presenting the disorder when there are first-degree relatives with ADHD (22–23). Studies with twins estimated a heritability percentage between 70% and 80% (24).

Environmental factors such as prenatal exposure to alcohol, smoking, and illicit drugs have been associated with an increased risk of ADHD (25–26). In addition, perinatal factors such as health complications after birth, fetal distress (hypoxia, forceps delivery), eclampsia, prolonged labor, and low birth weight are part of the background of children with this disorder (27). However, only a small part of the etiology of ADHD can be explained by environmen-

tal, perinatal, and psychosocial factors (28). Still, these factors might have an influence, especially in the evolution of the disorder (22–27).

The clinical description of these symptoms in children can be found in medical texts for over 200 years, and even since 1798 some historical references point to the previous observation of behaviors that could be compatible with the disorder (29). Approximately 50 years ago the first publications on ADHD in adults were made, and even more recently, research began to explore the relationship between ADHD and executive functions.

Because the characteristic symptoms of the disorder may be reduced or modified in adulthood, studies show that hyperactive behavior in adults may be directed towards sports activities or occupations that require great activity (30), it also may be reflected in excessive speech, noises in inappropriate situations and/or as a subjective feeling of restlessness or internal uneasiness (31). Symptoms of inattention include low concentration at work, a tendency to forget, not following instructions, not completing tasks, losing objects, neglecting daily activities, or getting upset when performing tasks of sustained mental effort (20). Impulsivity in adults manifests itself as poor frustration tolerance, easy loss of control or impatience (32), difficulty waiting one's turn, interrupting, or intruding in other people's conversations, and getting involved in potentially dangerous activities (20).

There have been several studies that point out the differences between adults with ADHD and the general population. Adults with ADHD are twice as likely to be involved in traffic accidents, and these tend to be more serious (33); they are also more likely to be arrested (39% vs. 20%); they have up to 20% more problems with drug abuse or dependence compared to adults without ADHD (34); they present greater difficulties in maintaining couple and interpersonal relationships (35), have a lower annual income, more dependence on public aid and an increased risk of poverty (36). The risk behaviors previously presented are due to the deficit in executive functions presented by people with ADHD (37).

In addition, 67% of subjects with ADHD have at least one psychiatric comorbidity (38). Because comorbidities are diverse and recurrent in adults, it is common that they mask the primary picture, leading the clinicians to focus more on treating the comorbidities than the ADHD. This would explain how of 4.4%

of adults who may have ADHD, only 1.4% are diagnosed (39). Among the most frequent comorbidities in adults with ADHD are drug dependence (19%), affective disorders such as major depression (28%), antisocial personality disorder (23%), and anxiety disorders (10 or 15%) (21). Between 32–53% of adults diagnosed with ADHD have a comorbid alcohol use disorder (40).

On the other hand, executive functions (EF) are defined as high-order skills involved in the generation, regulation, effective execution, and readjustment of goal-directed behaviors (41). These EFs are divided into "cool" and "hot" EFs, the former depends on the dorsolateral prefrontal areas and group cognitive processes, whereas hot EFs are associated with the ventromedial prefrontal area and involve emotional and motivational processes (42). Difficulties in working memory, initiative, planning, order, and monitoring (cool EFs) are a priority in the inattentive subtype, and difficulties in inhibition, change, and emotional control (hot EFs) would be characteristic of the hyperactive/impulsive subtype (37).

Although there is a clear association between ADHD and deficits in EF in childhood, studies in adults present variable data on this relationship. A systematic review found subtle compromises in measures of EF, low speed of processing complex information, attention deficits, and auditory-verbal learning deficits (43). This low relationship found in different studies can be attributed to different causes: the low sensitivity of tests to assess EF, the existence of different subtypes of ADHD, and even the possibility that there are patients with ADHD without difficulties in EF (44). Other authors argue that EF deficits in ADHD have been associated with the presence of comorbidity and not with the disorder itself (45).

Considering the impact on the quality of life of people with ADHD, it is important to increase the knowledge of executive dysfunctions in adults with ADHD to establish neuropsychological profiles and to enable the development of more effective interventions. Based on the above considerations, the aim of the research was to systematically review studies on executive functioning in adults with ADHD published over the last decade. The objective was to analyze the relationship between these variables and provide an integrative view to the area of neuropsychology.

Methodology

This study is framed within document analysis, specifically as a systematic review, which is an observational and retrospective research that synthesizes the results of multiple primary research on a specific topic (46).

Unit of Analysis

Scientific research articles published from January 2010 to October 2020 that evaluate executive functioning in adults diagnosed with ADHD were considered. This time period was chosen because an increase in the number of annual publications on the topic since 2010 was observed. The unit of analysis consists of 33 articles that meet the inclusion criteria established in the procedure. This sample was extracted from 887 documents retrieved from PubMed, Web of Science and EBSCO platforms. Platforms such as Springer, Taylor & Francis, Science Direct and Nature were initially included, but discarded later on because they had less than 3 articles that met the inclusion criteria, or these were already included in any of the 3 selected platforms.

Procedure

Phase I Planning: The research topic was selected and delimited. Subsequently, through a preliminary search for information, the inclusion and exclusion criteria were defined to select the relevant documents for the study, these were:

- Scientific articles published between 2010 and 2020 in full text. There were no restrictions by country or language, all were included.
- To assess executive functions in adults aged 18 to 60 years diagnosed with ADHD.
- To make use of validated tests for the assessment of executive functioning.
- To have at least 50 people in the study for the results to be meaningful.

Phase II Data collection: The search was carried out from October 12 to 25, 2020, using the PubMed, Web of Science and EBSCO platforms, including all their associated databases. The keywords that were chosen after trying different combinations were: "ADHD", "adults", and "executive functions", without

a applying a Boolean search. This search combination was selected as it gave the greatest number of articles that could meet the inclusion criteria. Articles that did not meet the inclusion criteria and studies with inconclusive results were excluded.

Phase III Organization, analysis, and interpretation:

For the selection of the studies, all the abstracts of the articles were read and those that did not meet the inclusion criteria were excluded (Figure 1). Then, a detailed reading of the methodology, results, discussion, and conclusions was made to choose those studies that would be included. In the end, the sample consisted of 33 articles, 22 were extracted from PubMed, 9 from Web of Science, and 4 from EBSCO. For the organization of the information, an Excel database was created with the descriptive and relevant data of each article. Finally, an analysis of the selected studies was carried out, considering the years and countries of publication, diagnostic criteria for ADHD in adults, participants, comorbidities, subtypes, medication, instruments used, dimensions of executive functions assessed, and results.

Phase IV Presentation of results: Preparation of the document presenting the results found after the review and analysis of the studies.

Results

Based on the matrix developed, the categories mentioned in the methodology were analyzed. Table 2 presents the general characteristics of each study. Table 3 contains the main measures and sources considered by the studies to diagnose adults with ADHD, which should be collected in at least 4 articles. Table 4 shows the significant differences in the EFs of ADHD patients. Finally, Table 5 provides a detailed description of the most commonly used instruments to assess executive functions. Instruments used in at least 3 articles for this purpose were considered.

To present the EF findings of the articles, the information was organized, taking into consideration the results of the ADHD group with one of comparison, normal control, control group with other psychiatric disorders, ADHD with medication use, and ADHD with different characteristics. The last column showcases the only two studies that evaluated only one ADHD group, these results show whether they

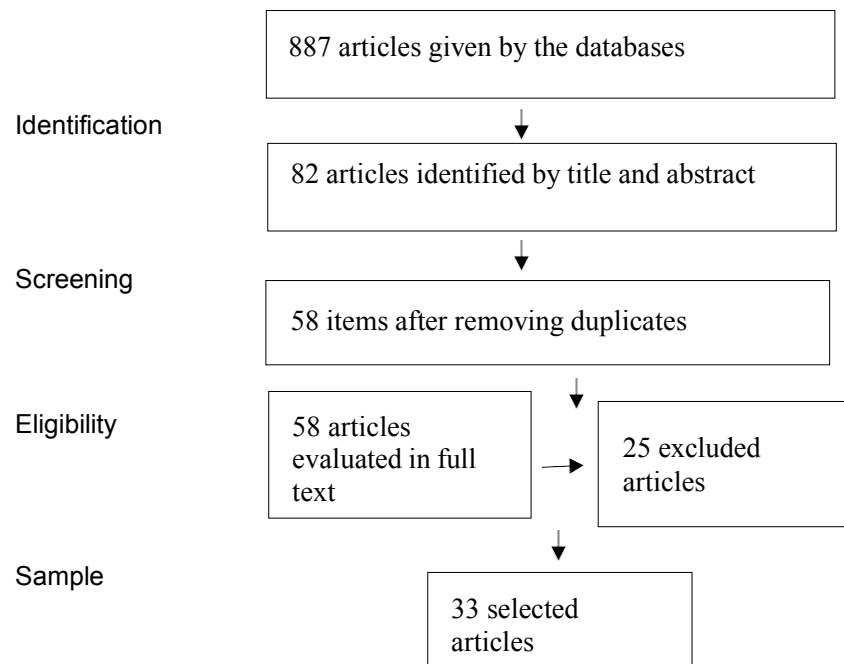


Figure 1. Prism flowchart for article selection

Source: The authors.

found alterations in EF regarding what was expected by each test used.

The EF processes that were considered for the analysis of the results were chosen because of their frequency of evaluation in at least 3 articles. The main measures and sources that the studies took into account for the diagnosis of adults with ADHD are presented, with only those reported in at least four articles included. Finally, the main instruments for the assessment of executive function processes were identified, with only those used in at least three studies for evaluating the same process considered in the analysis.

As shown in Table 2, the year in which the most articles meeting the inclusion criteria of the review were published was 2013 with 21.2%; followed by the years 2014 (15.2%), 2011 and 2017 (12.1% each). In terms of countries, USA is the pioneer in publications with 42.4% of the sample, followed by Brazil with 12.1%, Germany with 9.1%, Norway and Israel with 6.1% each.

In relation to the participant groups, less than 50% of the studies included different groups of patients

varying according to the presence/absence of ADHD or characteristics such as medical history, medication, IQ, comorbidities, etc.

Almost half of the sample (48.5%) was aged between 18 and 60 years, 21.2% between 18 and 40 years, and 30.3% of the sample only specified the mean age.

Regarding ADHD subtypes, the majority of the articles (66.7%) did not specify which ADHD subtype the participants presented. In the articles that did report this data, a sample with ADHD of mostly combined type (21.2%) was evident.

The 42.4% of the articles reported that the ADHD group presented comorbidities, the most frequent being: mood disorders, substance abuse, and anxiety disorders.

Finally, 39.4% of the items reported that the ADHD group was not taking medication at the time of assessment, as those who were taking medication had withdrawal or stomach pumping between 24 and 48 hours prior to neuropsychological testing. A total of 21.2% had at least one group taking medication,

Table 2. Characteristics of the sample of articles and participants

Feature	Categories	Frequency (%)
Year of publication	2013 21%	
	2014 15.2%	
	2011 12.1%	
	2017 12.1%	
Country of publication	United States	42.4%
	Brazil 12.1%	
	Germany	9.1%
	Norway	6.1%
	Israel 6.1%	
Groups of participants	ADHD group / normal control group	33%
	ADHD groups with other characteristics such as (IQ, emotional dysregulation, other)	27.3%
	ADHD group / ADHD medicated group	21.2%
	ADHD group / psychiatric patients without ADHD group	12.1%
	ADHD adult group only	6.1%
Age Range	18 to 60 years old	48.5%
	18 to 40 years old	21.2%
	Not specified average age	30.3%
ADHD Subtype	No subtype specified	66.7%
	Combined ADHD subtype	21.2%
	Inattentive ADHD subtype	9.1%
	ADHD with comorbidities	42.2%
	ADHD without comorbidities	12.1%
ADHD group with medication	No use of medications during the evaluation	39.4%
	At least one of the groups had medication	21.2%
	Some participants were taking medication	15.2%
	It does not specify medication use	24.2%

Source: The authors.

and it was one of their variables. 15.2% mentioned that some participants were taking medication at the time of assessment but did not account for it in the results, and 24.2% did not specify whether participants were taking medication at the time of the assessment.

Table 3 presents the most frequently used sources in the sample of articles to diagnose ADHD in adults. The DSM IV was the most commonly used diagnostic manual, despite the DSM V being published in 2013. The majority of articles used at least

3 sources: interview, a participant self-applied instrument, and criteria from a diagnostic manual. The most frequently used instrument to assess ADHD symptomatology was the Adult ADHD Self-Report Scale (ASRS), used in 39% of the articles. Additionally, 21% of the items used the Structured Clinical Interview for DSM-IV (SCID) (SCIDV-R) and 18% used the Schedule of Affective Disorders and Schizophrenia for School-Aged Children, current and lifetime version (K-SADS) to confirm the presence of ADHD and/or disorders.

Table 3. Main sources and measures for the diagnosis of ADHD

Diagnostic Criteria	Description	Number of articles	Frequency
DSM IV	Diagnostic and Statistical Manual of Mental Disorders, IV edition (1994).	22	67%
The Adult ADHD Self-Report Scale (ASRS)	WHO scale that assesses the current frequency of the 18 DSM IV symptoms. The scale is used to detect possible cases in which a more detailed clinical interview would be efficient.	13	39%
Interview by psychologist/psychiatrist	Interview by a professional psychologist or psychiatrist.	11	33%
Interview by another	Interview by a trained person or general practitioner.	10	30%
Previous diagnosis	Articles that reported obtaining the sample from a hospital, clinic, psychiatric entity, longitudinal study or only mentioned that there was already a diagnosis.	8	24%
Third party interview/questionnaire	Interview with family members or another person close to the patient.	8	24%
Structured Clinical Interview for DSM-IV (SCID) (SCIDV-R)	This is a semi-structured interview designed to establish the most important diagnoses of Axis I of the DSM-IV (1994).	7	21%
DSM IV TR	Diagnostic and Statistical Manual of Mental Disorders, IV edition (1998).	6	18%
Affective Disorders and Schizophrenia Program for School-Aged Children, Current and Lifelong (K-SADS) version	Semi-structured interview that assesses psychopathology categorically according to DSM-IV diagnostic criteria. It allows establishing the age of onset and/or remission of symptoms in the present and throughout life.	6	18%
WAIS-III	Clinical instrument for individual application to assess intelligence.	5	15%
Conners Adult ADHD Rating Scales (CAARS)	It assesses the 18 symptoms that make up the DSM IV diagnostic criteria. There is one model for the patient and another for an external informant.	4	12%
Wender Utah Rating Scale (WURS-K)	To aid in the retrospective diagnosis of ADHD in childhood, this is a self-administered questionnaire.	4	12%
DSM V	Diagnostic and Statistical Manual of Mental Disorders, IV edition (2013).	4	12%
ADHD Rating Scale, Self-Report Version (ADHD RS-SRV)	18-item questionnaire that assesses attention deficit, hyperactivity and impulsivity that make up attention deficit hyperactivity disorder (ADHD).	4	12%

Source: The authors.

Table 4 shows that the most evaluated process in the sample of articles was that of inhibition, assessed in 79% (N=26) of the articles included in this review. Followed by working memory, evaluated by 67%(N=22) of the articles, and then planning, which was included in 45%(N=15) of the articles.

The processes in which significant differences were found in all groups were: set switching (90%), sustained attention, organization of materials, and task supervision (83%), general EF and self-monitoring (80%), hot EF and problem-solving (75%), working

memory (73%), cognitive flexibility (67%), inhibition (62%), and planning and selective attention (60%). In the fluency process, half reported significant differences (50%). Specific results comparing the groups will be explained in the discussion.

Table 5 compiles the most commonly used instruments for the assessment of the processes considered in the review. The most frequent were the Wisconsin Card Sorting Test (WCST), Conners Continuous Performance Test (CPT and CPT II), Stroop Color Word Test (SCWT), Trail Making Test (TMT),

Table 4. Number and percentage of studies reporting significant differences in EF processes among the groups assessed

Executive function processes	ADHD/ Normal Control	ADHD/ Psychiatric	ADHD/ Medicated ADHD	ADHD/ ADHD other	ADHD single group	%Total Significant	Total N
Inhibition	8 – 67%	3 – 100%	1 – 33%	3 – 43%	1 – 100%	62%	26
Working memory	6 – 75 %	2 – 100%	2 – 50%	4 – 67%	2 – 100%	73%	22
Planning	3 – 60%	1 – 50%	3 – 60%	-	2 – 100%	60%	15
Attention - vigilance	1 – 50%	1 – 100%	1 – 33%	2 – 33%	1 – 100%	46%	13
Hot EF	4 – 100%	2 – 100%	1 – 33%	2 – 33%	1 – 100%	75%	10
General FE	2 – 67%	2 - 100%	2 – 67%	2 –100%	-	80%	10
Set change	5 – 100%	2 – 100%	1 – 50%	-	1 – 100%	90%	6
Sustained attention	3 – 100%	1 – 100%	-	1 – 50%	-	83%	6
Organization of materials	2 – 100%	1 – 100%	1 – 50%	-	1 – 100%	83%	6
Task Monitoring	2 – 100%	1 – 100%	1 – 50%	-	1 – 100%	83%	6
Selective attention	1 – 100%	1 – 100%	-	1 – 50%	-	60%	5
Processing speed	-	-	-	1 – 50%	-	20%	5
Self-monitoring	2 – 100%	1 – 100%	1 – 100%	-	-	80%	5
Fluency	1 – 33%	1 – 100%	-	-	-	50%	4
Reaction time	1 – 33%	-	-	-	-	25%	4
Troubleshooting	-	-	1 – 100%	1 –100%	1 – 100%	75%	4
Cognitive flexibility	1 – 50%	-	-	1 –100%	-	67%	3

Note: Total N= The total number of articles that included each domain, even if they did not report significant differences.

Source: The authors.

WAIS-IV Digit Retention subtest, Go – no Go and Behavior Rating Inventory of Executive Function (BRIEF), each of these instruments were used in at least 5 articles.

Discussion

This study aimed to systematically review research on executive functioning in adults with ADHD published in the last decade. The sample consisted of 33 articles extracted from PubMed, Web of Science and EBSCO platforms. The information from these articles was organized by main characteristics of the study and the sample, findings in the EF processes that were most evaluated, instruments most used for such processes, and main sources and measures for the diagnosis of adults with ADHD.

The country with the highest academic production was the United States, with 14 articles. Western countries have the highest rates of ADHD, which in

turn may imply greater interest in studying the problem, as well as greater support and funding; this has been reflected in a greater number of exponents on the subject, explanatory theories, instruments for diagnosis and evaluation of EF, most of which are from this country.

In Latin America, the country with the highest number of publications was Brazil (4). Argentina and Mexico contributed 1 article each. In the other Latin American countries, no studies were found that could be included in the sample, as they were studies on children or adolescents, or review articles. The above reflects a disparity, despite Latin America having about 36 million people affected with ADHD (12) and Colombia reporting a prevalence rate of up to 20% –being the highest in the region (17)– research on the topic is not a priority.

Regarding the sources and measures used to diagnose ADHD in adults, the literature emphasizes clinical and psychosocial assessment, neurodevelop-

Table 5. Most used instruments for the assessment of EF processes

Process	Instruments
Inhibition	D-KEFS Color Word subtest, Stroop Color Word (SCWT), Stop Task, Go - No Go, The Attention Network Test (ANT)
Working memory	WAIS-IV: Digit Retention, Arithmetic/Digit and Symbol Retention, Wisconsin Card Sorting Test (WCST), Trail Making Test (TMT), Rey-Osterrieth Complex Figure (ROCF)
Planning	Continuous Performance Test (CPT), Behavior Rating Inventory of Executive Function (BRIEF)
Attention - vigilance	WAIS-IV: Digit Retention, Continuous Performance Test (CPT), Trail Making Test (TMT), Rey-Osterrieth Complex Figure, WAIS-IV: Digit Retention
General FE	Behavior Rating Inventory of Executive Function (BRIEF), Wisconsin Card Sorting Test (WCST)
Hot FE	Conners Adult ADHD Rating Scale (CAARS), Barkley Deficits in Executive Functioning Scale (BDEFS), Deficits in Executive Functioning Interview (DEFI), Behavior Rating Inventory of Executive Function (BRIEF)
Set change	Change from D-KEFS Color Word Task and Verbal Fluency Task, Trail Making Test (TMT), Cambridge Neuropsychological Test Automated Battery (CANTAB), WAIS-IV: Digits and Symbols
Sustained attention	Stroop Color Word (SCWT), Continuous Performance Test (CPT), Trail Making Test (TMT), Rey-Osterrieth Complex Figure (ROCF)
Selective attention	Stroop Color Word (SCWT), Continuous Performance Test (CPT)
Processing speed	Trail Making Test (TMT), WAIS-IV: digits and symbols
Self-monitoring, organization of materials and task supervision	Behavior Rating Inventory of Executive Function (BRIEF-E)
Fluency	D-KEFS Fluency Task
Reaction time	Go - No Go
Cognitive flexibility	Stroop Color Word (SCWT), Trail Making Test (TMT)
Troubleshooting	Behavior Rating Inventory of Executive Function (BRIEF), Barkley Deficit in Executive Functioning Scale (BDEFS)

Source: The authors.

mental history, cognitive and behavioral assessment, as well as reports from close individuals (47). The selected studies used these sources to a greater or lesser extent, the most frequent being the clinical interview, diagnostic manual criteria, and the use of a self-applied instrument by the participant. Therefore, it is necessary to include more sources for the diagnosis of adults with ADHD, such as the evaluation of a third party and the collection of a complete medical history.

The most widely used diagnostic manual continues to be the DSM IV, despite criticisms for the diagnosis of ADHD in adults. One of its limitations is that it provides equal weight to each symptom when making diagnostic decisions, even though it is well known that not all criteria are equal to their ability to predict ADHD (47). The DSM V was published in 2013 and adds clarifications about the importance of each

symptom, it also raises the age of manifestation of some symptoms from 7 to 12 years and points out the relevance of ADHD diagnosis in adults (3). This is why it is interesting that articles published after 2013 continue to use earlier versions of the DSM without clarifying the reason for their preference.

A total of 7,149 people were included in the evaluation of the EFs, 5,096 of whom were adults with ADHD. Almost all the processes assessed in the item sample are part of the cool EFs. The data included in the hot EFs were obtained from the emotional control component of the BRIEF, as none of the studies included in the sample assessed these EF processes with additional or different instruments; therefore, the high percentage of significance reported here (79%) should be taken with caution.

When comparing the performance of an ADHD group with a control group with no medical or psychiatric

history, it was determined that there are significant differences in most of the EF processes, especially in inhibition, working memory, and planning and attention–vigilance. These differences coincide with the results of Barkley (48) and Cheung et al. (49), who mention that patients with ADHD present a deficient capacity of inhibitory control that generates alterations in the global executive functioning, this causes little motor and emotional regulation before a stimulus, failing to inhibit the execution of an immediate response, hindering planning, attention, problem–solving and other processes of executive functioning.

The EF processes in which no significant differences were found when comparing the performance of these two groups were processing speed, fluency, and reaction time. Since only 30% of people with ADHD show total neuropsychological deficits in tests measuring EF (50), the importance of not taking the neuropsychological test as the main tool for diagnosis and giving greater importance to developing individualized intervention procedures is emphasized (51).

Studies comparing adults with ADHD to those with other psychiatric disorders, but without ADHD, have reported significant differences across all the processes assessed, which suggests inner executive failures in ADHD patients. Most people in the control groups were diagnosed with mood disorders and anxiety disorders, EF deficits have been reported previously in patients with depression (52), bipolar disorder (52), generalized anxiety disorder (53), and obsessive–compulsive disorder (54). Few studies compare the EF deficits of an ADHD group with a group of people with other disorders, because the sensitivity and specificity of the instruments is lower than when comparing an ADHD group with a normal control group (55). The results presented here are in line with what Holst and Thorell (55) posit, the EF deficits of adults with ADHD are not only significant with a normal control group, but also with people who have different disorders. This statement requires more studies and information, as most of the results of the 4 articles included in this category were significant only in a small range.

Moreover, the studies that evaluated executive functioning with the use of a medication reported significant differences in the processes of planning, self–monitoring, and problem–solving, and found no significant differences in the processes of

inhibition, working memory, attention, and hot EF. Regarding this group of articles, it should be noted that the medications used and the selection criteria in their participants varied. Most studies do not specify ADHD subtypes, comorbidities or the pharmacological treatment for these comorbidities, these diverse characteristics within the same experimental groups make the samples heterogeneous and the results may vary (56).

The variation in results may also be influenced by the difference in mechanism of action of each medication, the most used medications were methylphenidate and atomoxetine. Atomoxetine is associated with an improvement in sustained attention, inhibitory capacity, spatial planning and problem–solving (57). In contrast, while methylphenidate improves cognition in adults with ADHD, including improvements in attentional set shifting, spatial planning and problem–solving, it does not always normalize their performance levels. Therefore, combining pharmacological treatment with psychosocial intervention strategies and cognitive–behavioral therapy is essential to effectively improve the executive skills of adults with ADHD (58–59).

Regarding studies that related other variables in two ADHD groups, two of these were related to ADHD and IQ. The results of Milioni Chaim et al. (60), indicate that adults with ADHD and high IQ performed better on multiple executive functioning tests compared to those participants with ADHD and average IQ. This suggests that a higher IQ in adults with ADHD provides a wider range of strategies to compensate for deficits in EF. These findings may help explain why highly intelligent patients are often underdiagnosed when they are still children, as high IQ may mask their initial ADHD disorder (60).

Antschel et al. (61) compared a group with ADHD and high IQ to a control group with high IQ but no ADHD. They found that the ADHD group, despite having high IQ, performed worse than the high IQ group without ADHD. These results follow other studies suggesting the existence of a disparity between executive functioning and IQ, with the presence of executive deficits interfering with an individual's practical performance despite high IQ (60). Although this review only had two articles relating IQ level and ADHD, it shows the lack of existing consensus on the relationship between IQ and EF. It has been demonstrated the relative independence of IQ and executive functioning (62); nonetheless, there is also

evidence that suggests a high correlation between these variables (63).

A study compared an ADHD group without functional impairment with an ADHD group with functional impairment, significant differences were not found in any of the EF processes (64). Functional impairment is understood as meeting the diagnostic criteria on the existence of clear evidence that symptoms interfere with or reduce the quality of social, academic, or occupational functioning. By finding no significant differences between the functionally impaired and non-functionally impaired groups, it was concluded that although adults with ADHD receive behavioral treatments (diary, task list, etc.) aimed at improving EF, this does not guarantee improvement in other aspects of the disorder such as impulsivity, which can more easily overload the social environment and ultimately lead to greater occupational and social disability than other features of ADHD symptoms (64).

Torrvalva et al. (65) compared an ADHD group with high neuropsychological performance (ADHDhi), an ADHD group with low neuropsychological performance (ADHDlo), and a control group. They concluded that the adults in the ADHDlo group differed significantly from the participants in the ADHDhi group and the participants in the control group, while the ADHDhi group and the control group showed similar performance. In this regard, the authors mention that it is common to find adult patients who meet DSM-IV criteria for ADHD but function normally on neuropsychological tests. Similarly, they point out that the results demonstrate how some executive deficits can hinder the proper functioning of some people with ADHD, while others manage to compensate for these deficits as they grow so that their performance in EF tests is similar to that of a normal group (65).

In the study by Surman et al. (66) the performance of an ADHD group and an ADHD group with deficient emotional self-regulation (DESR) was evaluated. It was found that the groups had no significant differences in test performance. Therefore, the study does not support the hypothesis that neuropsychological deficits are etiologically related to DESR in ADHD participants. That is, EF processes do not contribute to DESR, and any relationships found may be due to chance and require confirmation. These results are contrary to previous studies in which neuropsychological deficits were found to

be associated with DESR in adults with ADHD (67). This disparity in findings may have implications for understanding the etiology of DESR among ADHD patients.

Kamradt et al. (68) made a comparison between an ADHD group with moderate sluggish cognitive tempo (SCT) and an ADHD group with severe SCT. SCT is understood as a condition in which the main symptoms are slowing of mental processes, tendency to daydream, hypo activity, frequent forgetfulness, and lethargy (69). In this study, the moderate SCT group showed greater deficits in working memory than the severe SCT group. These results could be attributed to the fact that moderate SCT symptoms are particularly associated with difficulties on specific neurocognitive tasks (70). Even given the understudied nature of this association, it is speculated that individuals with moderate SCT, may represent a subgroup of ADHD adults with neurocognitive impairment. Only one study has examined SCT in relation to neuropsychological performance in adults (71), and it found that neither SCT nor ADHD symptoms predicted neurocognitive performance in adults.

Gisbert et al. (72) compared ADHD groups with high and low emotional lability, finding low results in the former. Emotional lability is characterized by irritability, short temper, sudden and unpredictable shifts towards negative emotions (73), contributing to functional impairment in youth and adults with ADHD (74). This can increase the severity of ADHD symptomatology as well as comorbid disorders (75). Furthermore, ADHD and emotional lability could be associated with processes related to amygdala dysregulation (72), however, current research does not present sufficient evidence for this.

When comparing an ADHD group using cannabis with a non-using ADHD group, no significant differences were found in the processes, the differences were between those with ADHD –users or non-users– and those in the normal control group (76). The study did not show that cannabis use directly influenced the performance of participants with ADHD, but it found that clearly a diagnosis of ADHD had a much greater impact on EF than cannabis use, perhaps because ADHD is associated with developmental delays, particularly in the prefrontal cortex (77).

Finally, the two single-group studies of ADHD found below-expected performance on several EF processes, except self-monitoring (78–79). These studies

related EF to quality of life and found correlations with small, medium, and large effects in all aspects despite the samples having different characteristics, one consisting of college students aged 18–36 and the other of adults aged up to 58. These findings support the established links between ADHD, impaired EF, and major life activities found in the adult ADHD literature (80).

Although in most of the processes the homogeneity among the studies was acceptable, it should be noted that the sample selected according to the inclusion and exclusion criteria is small, and most of the articles did not specify relevant data such as comorbidities and their treatment, ADHD subtypes of their sample, and used only self-reported instruments or different instruments to assess different processes of EF. These poorly controlled variables may reduce the reliability of the results presented. These issues are discussed in more detail below.

Regarding comorbidities, although part of the deficits presented are due to ADHD, there is an impact on neuropsychological characteristics that occurs due to associated comorbidities that intensify specific deficits (81). The comorbidities reported to a greater extent by the studies were mood disorders and anxiety disorders. The emotional instability and impulsivity in these disorders could generate a greater number of errors in the resolution of the tests (82). The low report of comorbidities and the null association of these with the results of EF, shows that few studies have addressed the possibility that specific neuropsychological deficits in ADHD can be attributed to comorbid disorders (83).

About the instruments for the evaluation of EF processes, some problems were evidenced that may make it difficult to understand the results and clarify the relationship between ADHD and EF. For example, different tests are used to measure the same neuropsychological function, different versions of the same test are used, or a single test is used to measure all executive functioning. Regarding the latter, assessing EFs with only a self-report is very common, and the sole use of this type of instruments generates lower reliability, as it may cause an over- or under-estimation of symptoms by the patients themselves (56). As a result, the clinical utility and accuracy of such tasks for identifying EF-related impairments are limited (84).

In reference to the subtypes of ADHD, it is known that the most diagnosed subtype worldwide is inat-

tentive, followed by combined and then hyperactive, which was also reflected in the samples of the articles. However, the subtypes were not reported in 66.7% of the articles and most of the studies that mentioned them during the description of their sample, were not taken into account later to determine whether they influenced the performance of the participants. Knowing the subtypes and including them in the analysis is a relatively underexplored area, even though there is a well-known theory about differences in the performance of neuropsychological tasks by people with ADHD. This theory proposed by Barkley (48) suggests that the deficits of inattentive ADHD tend to occur in memory tasks, focused attention and processing speed, while the deficits of hyperactive ADHD tend to be in aversive delay, problem-solving, cognitive flexibility and sustained attention. In the present review, it was not possible to assess the influence of subtype due to the limited information provided by the selected sample of articles.

In sum, this research compiled open access articles from the last decade that evaluated EF in adults with ADHD, seeking to contribute to the dissemination of studies related to a health problem that remains understudied. The results obtained by the research varied according to their characteristics, but most of them found deficits in executive functioning in adults with ADHD. These results confirm the heterogeneity of the disorder and the need to continue further research on the subject, because as mentioned there are different variables that can influence the results, such as subtypes, instruments used, comorbidities, and medication, among others. In addition, this field of research is even less studied in geriatric population and the information on hot EF is limited, since they are not usually evaluated in a specific and rigorous way.

Conclusions

The study of executive functioning in adults with ADHD is a topic that has recently gained global interest, resulting in a relatively small number of publications to date. In the particular case of Latin America, only 6 articles were obtained, belonging to Brazil, Argentina and Mexico. No articles from Colombia were found that met the inclusion criteria, highlighting a clear need for more research on the subject in the country. According to the results presented here, there is a high percentage of adults with

ADHD who present a deficit or lower performance in EF tests, compared to normal control adults and even adults with other psychiatric disorders. Nonetheless, these deficits vary by processes and specific characteristics of the sample, which confirms the heterogeneity of the disorder and leaves open the field of research.

Variables of interest for this review, such as subtypes, comorbidities and medication, are not usually specified or taken into account during the methodology or results of the studies. The impact of these variables remains unclear and warrants further research, since as illustrated, they can be very influential in how adults with ADHD perform not only in their daily lives, but also in different EF tests.

The instruments used to assess EF were standardized and reliable according to one of the selection criteria. These instruments assessed specific EF processes, or general EF in a primarily self-administered fashion, so performance on these does not provide information about day-to-day functioning in complex situations that demand integrative executive processing. Including ecological executive tests that resemble more closely real-life demands may provide another perspective and yield results that contribute to clarifying the relationship between adult ADHD and EF.

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Authors' contributions. Carlos Francisco Rincón: Conceptualization, methodology, formal analysis, supervision, writing original draft, writing – review and editing; Lady Bernal Morales: Conceptualization, data curation, methodology, investigation, writing – original draft; Sheylla Tello Sandoval: Data curation, investigation, writing – original draft.

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Ethical statement. In the study there is no intervention or direct contact with human beings, but there is a commitment and responsibility in the treatment given to the information collected that makes up the unit of analysis under Law 1090 of 2006, which in its chapter VII refers to scientific research, intellectual property and other publications. This research respects the rights of the authors by making the due citations in the document. Considering that the systematic review is a type of zero risk research, in which no intervention or intentional modification of the biological, physiological, psychological or social variables of the individuals participating in the study is performed, it complies with article 11 of Resolution No. 008430 of 1993, which establishes the scientific, technical and administrative standards for health research. It also complies with article 4 of the same resolution, which highlights the development of actions that contribute to the knowledge of biological and psychological processes in human beings.

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