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ANÁLISIS DE LA RELACIÓN ENTRE EL SUEÑO, EL RENDIMIENTO COGNITIVO Y LOS SÍNTOMAS DE INATENCIÓN, HIPERACTIVIDAD E IMPULSIVIDAD EN NIÑOS

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“*Cada final es un nuevo comienzo*”

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Índice

RESUMEN

Resumen

Esta tesis doctoral surgió de la necesidad de un mayor número de estudios sobre el rendimiento cognitivo y las características del sueño en el trastorno por déficit de atención con hiperactividad (TDAH), y en la impulsividad cognitiva. Necesidad derivada de las discrepancias existentes en la literatura en cuanto a los niños con TDAH, y de la falta de mayor información sobre los problemas a nivel cognitivo y las características del sueño particulares de los niños con impulsividad cognitiva sin ninguna patología psiquiátrica o psicológica asociada.

Por consiguiente, el objetivo general de la tesis doctoral era evaluar los problemas de sueño y el rendimiento cognitivo en niños con TDAH, niños con impulsividad cognitiva, y niños sin TDAH y con un estilo cognitivo más reflexivo. Para la consecución de este objetivo general, desglosado en cuatro objetivos específicos, se llevaron a cabo cinco estudios. A continuación se presentan los resúmenes correspondientes a esos estudios, junto al objetivo específico que se perseguía con los mismos.

Objetivo 1. Examinar el estado de la cuestión sobre el sueño en niños con TDAH

Estudio 1. Características del sueño en niños con trastorno por déficit de atención con hiperactividad: revisión sistemática y metaanálisis.

Objetivos. Las alteraciones del sueño se han asociado con el trastorno por déficit de atención con hiperactividad (TDAH), pero esta relación no está todavía clara. Los resultados de los estudios realizados no proporcionan evidencia suficiente que apoye una fisiología del sueño inherente al TDAH. Este estudio trata de determinar si esa fisiología del sueño realmente existe, comparando a niños con TDAH y niños controles en algunos parámetros del sueño.

Método. Se realizó una búsqueda en varias bases de datos (Web of Science, Scopus, Pubmed and PsycINFO), y una búsqueda manual, para recuperar todos los estudios disponibles desde 1987 hasta marzo de 2014. De los 8.678 estudios no duplicados recuperados, 11 estudios cumplieron los criterios de inclusión y de calidad metodológica. Se realizaron dos metaanálisis con ocho de esos estudios, en función de los datos que proporcionaban: polisomnográficos o actigráficos. En ambos metaanálisis se utilizó un modelo de efectos fijos, y la diferencia de medias estandarizada (DME) como índice del tamaño del efecto.

Resultados. Se encontraron diferencias significativas solo en el metaanálisis con polisomnografía como medida de resultado. Los niños con TDAH pasaron más tiempo en la fase 1 de sueño que los controles (DME ponderada = 0,32, 95% IC = 0,08-0,55, p = 0,009).

Conclusiones. Aunque se han encontrado pocas diferencias en el sueño entre los niños con TDAH y los controles en esta revisión, se requieren más estudios sobre esta temática. Esos estudios deberían tener en cuenta algunas de las variables comentadas en esta revisión para obtener conclusiones útiles y fiables para la investigación y la práctica clínica. En concreto, se debería abordar la influencia de los criterios de evaluación y los subtipos de TDAH sobre las características del sueño de los niños con TDAH.

Objetivo 2. Analizar las diferencias entre los tres grupos respecto al rendimiento cognitivo

Estudio 2. Atención sostenida, inhibición de la respuesta y aprendizaje discriminatorio en el trastorno por déficit de atención con hiperactividad y la impulsividad cognitiva: un estudio controlado en niños.

Objetivo. Este estudio proporciona nuevos datos sobre el rendimiento cognitivo en niños con TDAH y niños con impulsividad cognitiva, en comparación con un grupo control.

Método. Se evaluaron la atención sostenida, la inhibición de la respuesta y el aprendizaje discriminatorio, en 90 niños (30 niños por grupo; entre 7 y 11 años de edad), a través de un *computer performance test* y un *computer reversal test*.

Resultados. No se encontraron diferencias significativas entre los niños con TDAH y los otros dos grupos en ninguno de los tests utilizados. Por el contrario, los niños con impulsividad cognitiva tuvieron una peor ejecución que los controles en el computer reversal test.

Conclusión. A pesar de la falta de diferencias entre los niños con TDAH y los otros dos grupos, y las diferencias encontradas entre los niños con impulsividad cognitiva y los controles, se necesitan más estudios sobre este tema. Concretamente, futuros estudios deberían proporcionar datos, desde un enfoque longitudinal, sobre la influencia de la medicación para el TDAH, entre otras variables, en el rendimiento cognitivo de los niños.

Estudio 3. Memoria de trabajo y rendimiento cognitivo en el trastorno por déficit de atención con hiperactividad y la impulsividad cognitiva: un estudio controlado en niños.

Objetivo. Este estudio analiza las diferencias en rendimiento cognitivo entre niños con TDAH, niños con impulsividad cognitiva, y niños controles.

Método. Se evaluó a 90 niños (30 niños por grupo) de entre 7 y 11 años de edad, a través de dos tareas de n-back y la cuarta edición de la *Wechsler Intelligence Scale for Children*.

Resultados. Los niños con TDAH y los niños con impulsividad cognitiva puntuaron más bajo que los controles en memoria de trabajo fonológica, velocidad de procesamiento, y rendimiento cognitivo global. Los controles también obtuvieron puntuaciones más altas que los niños con TDAH en comprensión verbal, y que los niños con impulsividad cognitiva en razonamiento perceptivo.

Conclusión. El bajo rendimiento encontrado en los niños con TDAH y los niños con impulsividad cognitiva, en comparación con los controles, y la falta de diferencias entre estos dos grupos, deberían ser abordados en más profundidad en futuros estudios. Esos estudios deberían analizar los posibles efectos del sexo, el uso de la medicación, y los subtipos de TDAH, entre otras variables, sobre el rendimiento cognitivo de los niños.

Objetivo 3. Analizar las diferencias entre los tres grupos respecto a sus características del sueño

Estudio 4. Características del sueño en niños con trastorno por déficit de atención con hiperactividad y niños con impulsividad cognitiva.

Antecedentes. Este estudio tenía como objetivo comparar las características del sueño de niños con trastorno por déficit de atención (TDAH), niños con impulsividad cognitiva y un grupo control. Existe todavía poco acuerdo en la investigación sobre los problemas de sueño reales subyacentes al TDAH. También hay una ausencia de estudios que evalúen el sueño en niños con impulsividad cognitiva, a pesar de los problemas de atención asociados a este estilo cognitivo.

Método. Se obtuvieron medidas subjetivas y objetivas de sueño de 90 niños (30 niños por grupo), de entre 7 y 11 años de edad, mediante cuestionarios sobre el sueño y registros polisomnográficos. Se analizaron las diferencias entre los grupos en cada variable de sueño a través de la prueba de Kruskal-Wallis.

Resultados. Los niños con TDAH no se diferenciaron de los niños con impulsividad cognitiva ni de los niños controles en ninguna de las variables subjetivas u objetivas de sueño evaluadas. De manera similar, no se encontraron diferencias significativas entre los niños con impulsividad cognitiva y los controles.

Conclusiones. Los resultados sugieren que tanto los niños con TDAH como los niños con impulsividad cognitiva tienen características del sueño similares a las de los niños sin TDAH y con un estilo cognitivo más reflexivo. Se deduce que la presencia de un diagnóstico de TDAH o de un estilo cognitivo impulsivo no implica directamente problemas de sueño en los afectados. Sin embargo, estos resultados también destacan la importancia de una mayor exploración de la influencia de otras variables cuando se estudian los problemas de sueño en estos niños. En concreto, futuros estudios deberían abordar el potencial impacto de la medicación y los síntomas de TDAH predominantes.

Objetivo 4. Determinar la relación entre el sueño y los problemas cognitivos encontrados en cada grupo

Estudio 5. Niños con trastorno por déficit de atención con hiperactividad y niños con impulsividad cognitiva: rendimiento cognitivo y relación con sus características del sueño.

Objetivo. Este estudio proporciona datos sobre el rendimiento cognitivo de niños con trastorno por déficit de atención (TDAH) y niños con impulsividad cognitiva, en comparación con un grupo control. También proporciona un mayor análisis de la relación entre el sueño y los problemas cognitivos en esos niños, o los síntomas de TDAH y otros problemas relacionados presentados por los niños con TDAH.

Participantes. 30 niños con TDAH, 30 niños con impulsividad cognitiva y 30 niños controles.

Método. Se comparó el rendimiento cognitivo de los niños en varias pruebas. Se calcularon, dentro de cada grupo, las correlaciones entre las variables subjetivas y objetivas de sueño, y las variables cognitivas en las que los niños habían rendido peor. También se calcularon las correlaciones entre las variables de sueño, los síntomas de TDAH y problemas relacionados, dentro de los niños con TDAH.

Resultados. Tanto los niños con TDAH como los niños con impulsividad cognitiva mostraron déficits cognitivos comparados con los controles, pero estos fueron mayores en los niños con TDAH. También apareció una diferencia entre ellos en relación a la memoria de trabajo visual. Algunas variables de sueño correlacionaron con los problemas cognitivos mostrados por esos niños, así como con los síntomas de TDAH y problemas asociados mostrados por los niños con TDAH.

Conclusiones. Los resultados de este estudio parecen sugerir que el sueño puede influir sobre los problemas cognitivos observados en los niños con TDAH y los niños con impulsividad cognitiva, así como sobre los síntomas de TDAH y otros problemas presentados por los niños con TDAH. Sin embargo, para respaldar estos hallazgos, se requieren estudios longitudinales que permitan establecer una relación causal entre todas estas variables.

SUMMARY

Summary

This doctoral thesis was based on the need for a larger number of studies on cognitive performance and sleep characteristics in attention deficit hyperactivity disorder (ADHD), and cognitive impulsivity. Such a need was derived from the existing discrepancies within the literature in respect of children with ADHD, as well as from the dearth of further information on the cognitive problems and particular sleep characteristics of children with cognitive impulsivity without any associated psychiatric or psychological pathology.

Consequently, the general objective of this doctoral thesis was to assess sleep problems and cognitive performance in children with ADHD, children with cognitive impulsivity, and children without ADHD and with a more reflexive cognitive style. In order to achieve this general objective -divided into four specific objectives- five studies were carried out. The abstracts corresponding to those studies, along with the specific goals pursued by them, are given below.

Objective 1. To examine the state of the art of sleep in children with ADHD

Study 1. Sleep characteristics in children with attention deficit hyperactivity disorder: Systematic review and meta-analyses.

Study Objectives. Sleep disturbances have been associated with attention deficit hyperactivity disorder (ADHD), but such relationship is still unclear. The results from the studies conducted do not provide enough evidence to support a sleep physiology inherent to ADHD. This study tries to determine if that sleep physiology really exists by comparing children with ADHD and control children in some sleep parameters.

Methods. A search was conducted in several databases (Web of Science, Scopus, Pubmed and PsycINFO), and a manual search, to retrieve all the articles

available from 1987 until March 2014. Of 8,678 non-duplicate studies retrieved, 11 studies met the inclusion and methodological quality criteria. Two metaanalyses were performed with eight of those studies, depending on data provided by them. polysomnographic or actigraphic. A fixed-effects model, and the standardized mean difference (SMD) as the index of effect size, were used in both meta-analyses.

Results. Significant differences were found only in the meta-analysis with polysomnography as outcome. Children with ADHD were found to spend more time in stage 1 sleep than controls, pooled SMD = 0.32, 95% CI [0.08, 0.55], p = .009.

Conclusions. Although few differences in sleep between children with ADHD and controls have been found in this review, further studies are required on this matter. Those studies should consider some variables discussed in this review, in order to obtain useful and reliable conclusions for research and clinical practice. Particularly, the influence of assessment criteria and ADHD subtypes in the sleep characteristics of children with ADHD should be addressed.

Objective 2. To analyze the differences between the three groups regarding cognitive performance

Study 2. Sustained attention, response inhibition and discrimination learning in attention deficit hyperactivity disorder and cognitive impulsivity: A controlled study in children.

Objective. This study provides new data on cognitive performance of children with ADHD and children with cognitive impulsivity, in comparison with a control group.

Method. Sustained attention, response inhibiton and discrimination learning were assessed in 90 children (30 children per group; age 7-11 years) through a computer performance test and a computer reversal test.

Results. Non-significant differences were found between children with ADHD and the other groups in the tests employed. On the contrary, children with cognitive impulsivity did perform worse than controls in the computer reversal test.

Conclusion. Despite the lack of differences between children with ADHD and the other groups, and the differences found between children with cognitive impulsivity and controls, further studies are needed on this topic. Particularly, future studies should provide data, from a longitudinal approach, about the influence of ADHD medication, amongst other variables, on children's cognitive performance.

Study 3. Working memory and cognitive performance in attention deficit hyperactivity disorder and cognitive impulsivity: A controlled study in children.

Objective. This study analyzes differences in cognitive performance between children with ADHD, children with cognitive impulsivity, and control children.

Method. 90 children (30 children per group) aged from 7 to 11 years were assessed through two n-back tasks and the fourth edition of the Wechsler Intelligence Scale for Children.

Results. Lower scores in phonological working memory, processing speed, and overall cognitive profile were found in children with ADHD and children with cognitive impulsivity, compared to controls. Controls also obtained higher scores than children with ADHD in verbal comprehension, and higher than children with cognitive impulsivity in perceptual reasoning.

Conclusion. The underperformance found in children with ADHD and children with cognitive impulsivity compared to controls, and the lack of differences between these two groups, should be addressed further in future studies. Those studies should analyze possible effects of sex, medication use, and ADHD subtypes, amongst other variables, on children's cognitive performance.

Objective 3. To analyze the differences between the three groups regarding their sleep characteristics

Study 4. Sleep characteristics in children with attention deficit hyperactivity disorder and children with cognitive impulsivity.

Background. This study aimed at comparing sleep characteristics of children with attention deficit hyperactivity disorder (ADHD), children with cognitive impulsivity, and a control group. There is still little agreement within the reseach regarding the actual sleep problems underlying ADHD. There is also an absence of studies assessing sleep in children with cognitive impulsivity, despite the attention problems also associated with this cognitive style.

Methods. Subjective and objective sleep measures of 90 children (30 children per group), aged between 7 and 11 years, were obtained by means of sleep questionnaires and polysomnography recordings. Differences between the groups in every sleep variable were analyzed through Kruskal-Wallis tests.

Results. Children with ADHD did not differ from children with cognitive impulsivity and control children in any of the subjective or objective sleep variables evaluated. Similarly, no significant differences were found between children with cognitive impulsivity and controls.

Conclusions. The results suggest that both children with ADHD and children with cognitive impulsivity have similar sleep characteristics to children without ADHD and with a more reflexive cognitive style. It follows that the presence of an ADHD diagnosis or an impulsive cognitive style do not imply sleep problems in those affected. However, these results also highlight the importance of a further exploration of the influence of other variables when sleep problems are studied in these children. Particularly, future studies should address the potential impact of medication and predominant ADHD symptoms.

Objective 4. To determine the relationship between sleep and the cognitive problems found in each group

Study 5. Children with attention deficit hyperactivity disorder and children with cognitive impulsivity: Cognitive performance and relationship with their sleep characteristics.

Objective. This study provides data on the cognitive performance of children with attention deficit hyperactivity disorder (ADHD) and children with cognitive impulsivity, in comparison to a control group. It also provides a further analysis of the relationship between sleep and the cognitive problems displayed by those children, or the ADHD symptoms and related problems suffered by children with ADHD.

Participants. 30 children with ADHD, 30 children with cognitive impulsivity, and 30 control children.

Methods. The children's cognitive performance in several tasks were compared. Correlations between subjective and objective sleep variables and cognitive variables in which children performed worse were computed within each group. Correlations between sleep variables, ADHD symptoms and related problems were also computed for children with ADHD.

Results. Both children with ADHD and children with cognitive impulsivity showed cognitive deficits compared to controls, but these were higher in children with ADHD. A difference between them also emerged in relation to visual working memory. Some sleep variables correlated with the cognitive problems displayed by those children, as well as with the ADHD symptoms and related problems displayed by children with ADHD.

Conclusions. The results of this study seem to suggest that sleep may have an impact on the cognitive problems seen in children with ADHD and children with cognitive impulsivity, as well as impacting on the ADHD symptoms and other problems suffered by children with ADHD. However, in order to support these findings, longitudinal studies that enable the establishment of a causal relationship between all these variables are required.

INTRODUCCIÓN

Introducción

El trastorno por déficit de atención con hiperactividad (TDAH) se caracteriza principalmente por la presencia de síntomas de inatención, hiperactividad e impulsividad, algunos de los cuales aparecen antes de los 12 años de edad. Estos síntomas se manifiestan en una frecuencia mayor de la esperada para esa etapa del desarrollo evolutivo y en dos o más ambientes, e interfieren negativamente con el funcionamiento de los niños en distintos ámbitos. Además, según el conjunto de síntomas que se presenten en mayor medida, en la cuarta edición del *Diagnostic and Statistical Manual of Mental Disorders* (DSM-V; American Psychiatric Association, 1995) se distinguían entre tres subtipos: a) TDAH con predominio de déficit de atención; b) TDAH con predominio de hiperactividad-impulsividad; y c) TDAH combinado. Actualmente, la quinta edición del DSM sustituye la consideración de subtipos por la de presentaciones clínicas (American Psychiatric Association, 2013).

El TDAH constituye uno de los trastornos del neurodesarrollo más comunes en la infancia y la adolescencia, con una tasa de prevalencia en torno al 3,4% a nivel mundial (Polanczyk, Salum, Sugaya, Caye y Rohde, 2015), y al 5% a nivel europeo (Wittchen et al., 2011). En España, la prevalencia está situada en torno al 6,8%, lo que supone que alrededor de 361.580 niños y adolescentes pueden sufrir de TDAH en este país (Catalá-López et al., 2012). Además, el trastorno presenta un curso crónico, no desapareciendo necesariamente con la edad, pues se estima que más del 50% de los niños diagnosticados con TDAH en la infancia seguirán presentando síntomas significativos en la edad adulta (Biederman y Faraone, 2005). Tanto la alta prevalencia del TDAH, como su cronicidad, y el importante aumento del número de diagnósticos en los últimos años (aproximadamente de un 24% entre 2001 y 2010; Getahun et al., 2013), han convertido a este trastorno en el foco de interés de numerosas investigaciones. Principalmente, por las múltiples consecuencias negativas derivadas de los síntomas del trastorno, y su impacto en diversos ámbitos de la vida diaria, junto a las comorbilidades también asociadas al mismo.

Comorbilidades en el TDAH y consecuencias negativas derivadas de la sintomatología

Por un lado, el TDAH se ha asociado con numerosas condiciones comórbidas en la infancia y en la adolescencia. Entre las más frecuentes encontramos el trastorno bipolar, el trastorno oposicionista desafiante, trastornos de conducta y de abuso de sustancias, y trastornos de alimentación (Biederman et al., 2007, 2008; Donfrancesco et al., 2011; Szobot et al., 2007). Así mismo, el TDAH se ha relacionado también con síntomas de depresión y ansiedad, e incluso con un aumento del riesgo de suicidio (Daviss y Diler, 2014; Manor et al., 2010). Otros de los problemas encontrados en el TDAH han sido las alteraciones en el sueño (Konofal, Lecendreux y Cortese, 2010). De hecho, algunos problemas de sueño eran recogidos como uno de los criterios diagnósticos del TDAH en versiones anteriores del DSM, aunque esto se viese modificado a partir de la publicación de la tercera edición revisada (DSM-III-R; American Psychiatric Association, 1987).

Por otro lado, el TDAH comporta importantes consecuencias en distintos ámbitos, que afectan por igual a ambos sexos, aunque la presencia del trastorno sea mayor en los niños que en las niñas y sus manifestaciones clínicas no sean las mismas para ambos (Biederman, 2005; Biederman et al., 2002). Por ejemplo, el TDAH incide negativamente sobre su nivel de autoestima y de calidad de vida, tanto a corto como a largo plazo (Harpin, 2005), y sobre sus relaciones sociales y familiares (Barkley, Fischer, Smallish y Fletcher, 2006). También la cronicidad del trastorno implica que en numerosas ocasiones sea necesaria la ingesta de medicación. La cual repercute tanto sobre las personas que la toman, por los importantes efectos adversos que puede conllevar (Benner-Davis y Heaton, 2007), como sobre la propia sociedad, en términos de costes económicos. En efecto, los costes anuales de los tratamientos farmacológicos más frecuentes, el metilfenidato y la atomoxetina, llegaron a alcanzar aproximadamente los 700 y 1.600 euros anuales, respectivamente, en 2010 (véase revisión de Catalá-López, Ridao, Sanfélix-Gimeno y Peiró, 2013). Por último, uno de los ámbitos en el que los síntomas del TDAH afectan más negativamente es el escolar.

Así pues, el TDAH se ha relacionado con un menor rendimiento académico (Daley y Birchwood, 2010; Loe y Feldman, 2007), y una alta tasa de fracaso o abandono escolar, de alrededor del 30%, se ha estimado entre los estudiantes con este trastorno (Barbaresi, Katusic, Colligan, Weaver y Jacobsen, 2007; Barkley, Murphy y Fischer, 2008). De hecho, en España, considerado el país con las tasas más altas de abandono escolar (EuroStat, 2016), se estima que el 20% de esos abandonos se deben al TDAH (Proyecto PANDAH, 2013). Tanto la sintomatología propia del TDAH como los déficits cognitivos encontrados en los niños con este trastorno, parecen jugar un papel relevante para la aparición de esos problemas escolares (Daley y Brichwood, 2010).

Rendimiento cognitivo y TDAH

Numerosos estudios han encontrado un peor rendimiento cognitivo de los niños con TDAH en diversas tareas ejecutivas, en comparación con niños sin este trastorno. Por ejemplo, entre los problemas cognitivos observados en estos niños en algunos estudios, encontramos dificultades relacionadas con la atención sostenida, la inhibición o control de la respuesta, y la memoria de trabajo, entre otras funciones ejecutivas.

Atención sostenida y control de la respuesta. El *continuous performance test* (CPT) constituye una de las tareas más empleadas tanto en la investigación como en la práctica clínica, para la evaluación de la atención en el TDAH (Ogundele, Ayyash y Banerjee, 2011). En concreto, esta prueba permite evaluar tanto la capacidad de atención sostenida como de inhibición o control de la respuesta, y ha mostrado una gran utilidad para diferenciar niños con y sin TDAH en varios estudios (véase revisión de Meneres-Sancho, Delgado-Pardo, Aires-González y Moreno-García, 2015).

En este sentido, entre las diferencias encontradas en el CPT entre niños con y sin TDAH en algunos estudios, destacan el mayor número de errores (de comisión y/o de omisión) de los niños con TDAH, y su menor capacidad para mantener la atención (Corbett y Constantine, 2006; Epstein et al., 2003; Kim et al., 2015; Losier, McGrath y Klein, 1996; Moreno-García, Delgado-Pardo y Roldán-Blasco, 2015). Hallazgos que sugieren, en general, una menor capacidad de atención sostenida y de control de la respuesta en los niños con TDAH en comparación con su grupo de iguales. Sin embargo, se han observado discrepancias entre los hallazgos de los distintos estudios, que no permiten determinar con claridad hasta qué punto los niños con TDAH presentan un deterioro cognitivo en ambas funciones.

Por ejemplo, existen estudios en los que se encontraron diferencias entre los niños con TDAH y los controles en cuanto a su capacidad para controlar la respuesta, pero no en cuanto a su capacidad de atención sostenida (Corbett, Constantine, Hendren, Rocke y Ozonoff, 2009). Así como tampoco está claro si el rendimiento de los niños con TDAH en el CPT se ve afectado en la misma medida ante la presentación de estímulos auditivos que visuales. Cabe mencionar que, debido al amplio uso del CPT, han ido apareciendo varias versiones de la prueba a lo largo de los años. Destacando entre esas versiones el *Intermediate Visual and Auditory* (IVA) CPT, por la oportunidad que representa para evaluar el rendimiento de los niños distinguiendo entre ambos tipos de estímulos (Sandford y Turner, 2000). Mediante el uso del IVA CPT, algunos autores encontraron un mejor rendimiento de los niños con TDAH ante estímulos auditivos que visuales (Moreno-García et al., 2015).

Memoria de trabajo. La memoria de trabajo constituye una de las funciones ejecutivas que suscita un mayor interés, debido a su implicación en la comprensión del lenguaje, el razonamiento y el aprendizaje, entre otras habilidades (Baddeley, 2010), y su consiguiente repercusión sobre el rendimiento académico. La mayoría de los estudios que han analizado la memoria de trabajo en niños con TDAH han encontrado una menor capacidad de memoria de trabajo en estos niños que en niños controles sin este trastorno (Martinussen, Hayden, Hogg-Johnson y Tannock, 2005; Willcutt, Doyle, Nigg, Faraone y Pennington, 2005). Una cuestión que parece que es independiente del tipo de memoria evaluada o del tipo de presentación de los estímulos, dado que algunos estudios sugieren problemas de memoria de trabajo en niños con TDAH tanto ante estímulos auditivos como visuales (Alloway y Passolunghi, 2011; Pasini, Paloscia, Alessandrelli, Porfirio y Curatolo, 2007).

En definitiva, la mayoría de las investigaciones realizadas hasta la fecha coinciden en que los niños con TDAH presentan déficits en la memoria de trabajo, aunque existen también investigaciones en los que no se encontraron diferencias en memoria de trabajo entre los niños con TDAH y los controles (Drechsler, Rizzo y Steinhausen, 2008; Fosco, Hawk, Rosch y Bubnik, 2015; Zinke et al., 2010). Tales discrepancias entre los resultados de algunas de esas investigaciones no permiten delimitar el alcance real de esos déficits en niños con este trastorno. Sino que, por el contrario, parecen indicar que algunos factores distintos de la propia sintomatología del TDAH podrían haber repercutido también en los déficits de memoria de trabajo encontrados en estos niños. Factores relacionados, por ejemplo, con las tareas de evaluación empleadas, como el número de ensayos incluidos y el tipo de respuesta (recuerdo o reconocimiento), entre otros aspectos (Kasper, Alderson y Hudec, 2012).

Otros déficits cognitivos vinculados al TDAH. La velocidad de procesamiento es otra de las capacidades en la que los niños con TDAH han manifestado problemas en varios estudios (Mayes y Calhoun, 2006; Thaler, Bello y Etcoff, 2013). De hecho, la velocidad de procesamiento y la memoria de trabajo se han señalado como las principales áreas en las que los niños con TDAH presentarían déficits cognitivos (Mayes y Calhoun, 2006; Wechsler, 2010a). Existiendo incluso resultados en los cuáles se apreció un peor rendimiento de los niños con TDAH a nivel de velocidad de procesamiento que de memoria de trabajo (Yang et al., 2013).

Otros problemas cognitivos que podrían presentar los niños con TDAH están relacionados con el importante papel que juega la dopamina para el apropiado funcionamiento del córtex prefrontal, y el déficit de dopamina asociado a este trastorno (Swanson et al., 2007). Por ejemplo, aunque aún faltan resultados definitivos, se ha apuntado a que el córtex prefrontal cumple una función crucial para un correcto desempeño cognitivo en tareas de aprendizaje invertido o *reversal learning tasks* (Cools, Clark, Owen y Robbins, 2002; Rogers, Andrews, Grasby, Brooks y Robbins, 2000).

Estas tareas consisten básicamente en la presentación de dos posibles respuestas, siendo una de ellas premiada positivamente. Después de un número determinado de ensayos, esa respuesta deja de ser considerada correcta, y la respuesta premiada pasa a ser la respuesta opuesta (Cools et al., 2002; Jocham et al., 2009). Los niños deben, primeramente, aprender cúal es la respuesta premiada y actúar en consecuencia (fase experimental de adquisición o de aprendizaje), y posteriormente, inhibir ese aprendizaje previo y responder de acuerdo a la nueva condición experimental (fase experimental de reversal) (Talbot, Watson, Barrett y Cooper, 2006). En conclusión, las reversal learning tasks podrían ser útiles para evaluar la capacidad de aprendizaje discriminativo de los niños con TDAH en comparación con niños sin este trastorno. Siendo especialmente necesarios estudios a este respecto, debido a la posible influencia de la dopamina en esta capacidad cognitiva.

Posibles explicaciones a los resultados encontrados o variables extrañas. Junto a la posible influencia de las pruebas de evaluación utilizadas en las diferencias en rendimiento cognitivo encontradas entre niños con y sin TDAH en algunos estudios, hay otras variables inherentes a los participantes que podrían haber repercutido también en esos hallazgos. Estas son, entre otras, el cociente intelectual de los niños con TDAH, su uso o no de medicación, su propia sintomatología u otros problemas asociados, y sus características del sueño.

En primer lugar, los niños con TDAH presentaron un menor cociente intelectual que los niños sin TDAH en algunos estudios (Barry, Lyman y Klinger, 2002; Loe y Feldman, 2007). Y algunos autores han sugerido una asociación entre la inteligencia y la memoria de trabajo (Tourva, Spanoudis y Demetriou, 2016), que es precisamente una de las principales capacidades en las que los niños con TDAH han manifestado déficits (Mayes y Calhoun, 2006; Wechsler, 2010a). En segundo lugar, hay estudios en los que se observaron diferencias cognitivas entre niños con TDAH dependiendo de su uso o no de medicación, y sugiriendo un impacto positivo de la misma sobre su rendimiento cognitivo (Coghill et al., 2014; Pietrzak, Mollica, Maruff y Snyder, 2006). En otros estudios, las diferencias entre los niños con TDAH a nivel de rendimiento cognitivo se encontraron en función de su sintomatología predominante o subtipos (Fenollar-Cortés, Navarro-Soria, González-Gómez y García-Sevilla, 2015). Por último, los resultados de otros estudios parecen indicar una relación entre el sueño y el rendimiento cognitivo de los niños con TDAH, sugeriéndose incluso que el impacto de la medicación sobre este último podría ser incluso ser moderado por el sueño (Morash-Conway, Gendron y Corkum, 2016). No obstante, esta cuestión de la posible repercusión del sueño en los niños con TDAH y en su rendimiento cognitivo será abordada en mayor profundidad a continuación.

Sueño y TDAH

Hace casi dos décadas se encontró una tasa de prevalencia de los problemas de sueño en niños con TDAH de en torno al 55% (Corkum, Tannock y Moldofsky, 1998). Desde entonces, han sido muchas las investigaciones realizadas dirigidas a determinar las alteraciones del sueño que presentan los niños con TDAH en comparación con su grupo de iguales. A pesar de que los resultados contradictorios encontrados por las mismas han producido que, todavía hoy, la relación entre el sueño y el TDAH no esté totalmente definida. Principalmente, porque las diferencias en el sueño encontradas entre los niños con y sin TDAH no han sido las mismas en todos los estudios llevados a cabo.

Así pues, algunos autores han encontrado diferencias entre ambos niños en variables relativas a la continuidad, eficiencia y arquitectura del sueño (Owens et al., 2009; Ringli et al., 2013; Scott et al., 2013; Vigliano et al., 2016), otros autores las han encontrado en cuanto a la actividad motora durante el sueño (Konofal, Lecendreux, Bouvard y Mouren-Simeoni, 2001; Silvestri et al., 2009), y otros en relación a los niveles de somnolencia diurna (Bioulac, Micoulaud-Franchi y Philip, 2015; Hansen, Skirbekk, Oerbeck, Richter y Kristensen, 2011). No obstante, tal inconsistencia entre los hallazgos de los estudios podrían deberse a diferencias entre estos relacionadas tanto con la metodología de evaluación seguida, como con los participantes incluidos, entre otras variables.

Un ejemplo es la heterogeneidad que existe entre los estudios en cuanto a su objetivo y a las medidas de evaluación empleadas (Miano, Parisi y Villa, 2012). Mientras que en unos estudios los datos se han obtenido a través de registros polisomnográficos de los propios niños, en un mayor número de estudios se han recogido por medio de cuestionarios cumplimentados por sus progenitores (ej., Silvestri et al., 2009), siendo pocos los estudios que han comparado ambas fuentes de información (Gruber et al., 2012).

Otras variables que han podido intervenir en los hallazgos de algunos autores son: a) el sexo, ya que las diferencias en la frecuencia y características clínicas del TDAH entre ambos (Biederman, 2005; Biederman et al., 2002) podrían repercutir también sobre los patrones del sueño; b) la medicación, si bien hay estudios en los que controlada esta variable extraña se han seguido encontrando alteraciones del sueño en personas con TDAH (Stein, Weiss y Hlavaty, 2012); y c) las enfermedades comórbidas, cuya influencia sobre el sueño en niños con TDAH fue sugerida ya en el metaanálisis de Sadeh, Pergamin y Bar-Haim (2006).

También es de destacar el efecto del ambiente en el que se haya evaluado a los participantes. En algunos estudios se ha apuntado que tanto niños como adultos pueden presentar modificaciones en los patrones del sueño cuando se encuentran en condiciones de laboratorio, y que es necesaria la inclusión de una primera noche de adaptación previa (Sadeh et al., 2006). Esta no siempre se ha incorporado en las investigaciones realizadas, aunque es especialmente importante en el caso del TDAH, por la gran variabilidad en los patrones del sueño que parecen presentar los niños con este trastorno (Gruber, Sadeh y Raviv, 2000). Lo cual requiere, ya de por sí, una evaluación más continuada para obtener conclusiones más certeras.

Por último, se observa también una mayor necesidad de evaluar adecuadamente a los niños controles en cada investigación, para evitar que estos presenten algunos de los síntomas del TDAH, aunque no les haya sido diagnosticado. Lo que podría repercutir sobre los resultados, dando lugar a una subestimación de las posibles diferencias existentes entre ambos grupos respecto al sueño. Si bien en algunos de los estudios realizados podría haberse dado también el caso contrario. Concretamente, varios estudios han señalado una mayor presencia de movimientos periódicos de las piernas o problemas respiratorios durante el sueño en niños con TDAH (véanse revisiones de Cortese, Faraone, Knonofal y Lecendreux, 2009; Cortese, Konofal, Yateman, Mouren y Lecendreux, 2006; Sadeh et al., 2006). Sin embargo, esas características podrían haberse debido a la presencia de trastornos primarios del sueño entre los niños evaluados. Contribuyendo, así, a un aumento de las diferencias en el sueño entre niños con TDAH y controles, no realmente debidas a los síntomas del TDAH como tales.

En conclusión, las posibles limitaciones metodológicas de los estudios derivadas de las variables mencionadas anteriormente, y las discrepancias entre sus resultados, no permiten determinar claramente los problemas del sueño de los niños con TDAH. Suponiendo una limitación importante para el manejo de los mismos y la prevención de sus consecuencias negativas asociadas. Especialmente, porque el sueño influye sobre la atención y el comportamiento de los niños, y sobre su somnolencia diurna (Fallone, Acebo, Seifer y Carskadon, 2005; Sadeh, Gruber y Raviv, 2003). Factores que, a su vez, repercuten negativamente sobre el rendimiento cognitivo o académico, ya afectado en los niños con TDAH, como se ha comentado con anterioridad. Por lo que las alteraciones del sueño en estos niños podrían actuar como un mecanismo de retroalimentación positiva, aumentando los problemas que presentan a consecuencia de su sintomatología.

Relación entre el sueño y el rendimiento cognitivo en el TDAH. En general, una cantidad de sueño insuficiente se ha asociado a un menor rendimiento cognitivo en diversos estudios (véase metaanálisis de Astill, Van der Heijden, Van IJzendoorn y Van Someren, 2012). Y, aunque no hay muchos estudios que hayan analizado la relación entre el sueño y el rendimiento cognitivo en niños con TDAH, los resultados encontrados en los mismos parecen corroborar el impacto de la duración del sueño sobre el rendimiento cognitivo (Cho et al., 2015; Moreau, Rouleau y Morin, 2013). De hecho, algunos hallazgos sugieren que incluso pequeñas alteraciones en la duración del sueño serían suficientes para producir cambios a nivel cognitivo en estos niños (Gruber et al., 2011; Vriend et al., 2013).

También se ha encontrado una relación entre el rendimiento cognitivo y otros parámetros del sueño, como la eficiencia y la latencia de sueño (Steenari et al., 2003). O el número o gravedad de los problemas de sueño mostrados por los niños con TDAH (Hansen, Skirbekk, Oerbeck, Wentzel-Larsen y Kristensen, 2014; Sciberras, DePetro, Mensah y Hiscock, 2015). Si bien, al contrario de lo que sucede con la duración del sueño, los resultados de los estudios en relación a estas últimas variables no han sido tan consistentes. Así, hay estudios en los que tales variables no mostraron ninguna relación significativa con el rendimiento cognitivo (Cho et al., 2015; Moreau et al., 2013).

En definitiva, tanto se observan diferencias entre los estudios respecto a las alteraciones del sueño en los niños con TDAH, como respecto al posible impacto de estas sobre el rendimiento cognitivo de estos niños. Y ambas circunstancias dificultan la obtencion de conclusiones que podrían ayudar a mejorar la calidad de vida de los niños con este trastorno. Sobre todo teniendo en cuenta la influencia del rendimiento cognitivo sobre el fracaso o abandono escolar (Daley y Brichwood, 2010), y las consecuencias negativas derivadas de este tanto a corto como a largo plazo (Chen y Kaplan, 2003; Lansford, Dodge, Pettit y Bates, 2016; Townsend, Flisher y King, 2007). Además, en este sentido, serían necesarias investigaciones que, tanto ayudaran a determinar la relación entre el sueño, el rendimiento cognitivo, y el TDAH, como que aportaran datos de esta relación en comparación con otras condiciones. Otras condiciones distintas del TDAH, pero vinculadas en mayor o menor medida al mismo o, más concretamente, a los problemas de atención asociados a los niños con este trastorno. Como es el caso de la impulsividad cognitiva.

Impulsividad cognitiva y relación con el TDAH

La impulsividad cognitiva, entendida como un estilo cognitivo dentro de un continuo reflexividad-impulsividad (Salkind y Wright, 1977), es considerada una entidad distinta al TDAH o a la impulsividad conductual ligada a este (Buela-Casal, Carretero-Dios y De los Santos-Roig, 2001a). Sin embargo, ambas condiciones tienen en común la dificultad para mantener la atención (Buela-Casal et al., 2001a), lo que produce que los niños con este estilo cognitivo o impulsividad cognitiva también manifiesten dificultades en su vida diaria.

Por ejemplo, la impulsividad cognitiva se ha relacionado también con problemas en algunas funciones ejecutivas, como la memoria de trabajo, a consecuencia de los problemas de atención (Arán y Richaud, 2012). Así como se ha observado que los niños con impulsividad cognitiva pueden presentar también, al igual que sucede con los niños con TDAH, un menor rendimiento académico (Bornas, Severa y Llabrés, 1997; Buela-Casal, Carretero-Dios y De los Santos-Roig, 2000). Lo cual no tendría que venir determinado necesariamente por su cociente intelectual, pues aunque algunos hallazgos parecían sugerir un nivel de inteligencia más bajo en los niños con impulsividad cognitiva frente a los reflexivos (Buela-Casal, De los Santos-Roig y Carretero-Dios, 2002; Fitzpatrick, Parr y Butler, 1977), otros no apuntan a diferencias claras entre ambos en cuanto a su capacidad intelectual (Montero, Navarro y Ramiro, 2005).

Conviene destacar que la impulsividad cognitiva se considera una conducta aprendida que puede tender a la cronicidad si no interviene sobre ella (Buela-Casal et al., 2001a), y que comporta un riesgo ya no solo para el fracaso escolar a largo plazo a consecuencia de la bajada del rendimiento académico, sino también para otras condiciones perjudiciales. Como son la presencia de síntomas depresivos, la ingesta de alcohol y drogas, la agresividad, o la comisión de actos delictivos (Banca et al., 2016; Buela-Casal et al., 2001a, 2001b; Clark, Robbins, Ersche y Sahakian, 2006; Pichardo, Arco y Fernández, 2005; Wardell, Quilty y Hendershot, 2016).

A pesar todos los problemas que podrían derivarse de este estilo cognitivo, se aprecian una falta de más estudios en la literatura que analicen esta cuestión en profundidad. O de estudios que analicen las posibles diferencias entre los niños con TDAH y los niños con impulsividad cognitiva tanto en cuanto a su rendimiento cognitivo como a sus características del sueño. Sobre todo, porque hay resultados recientes que parecen sugerir una relación entre el sueño y la impulsividad cognitiva (Lee et at., 2014; Um et al., 2016). Si bien no nos consta ningún estudio realizado hasta la fecha en el que esa relación se haya evaluado en niños normativos sin ningún trastorno. Y, por consiguiente, tanto si los niños con impulsividad cognitiva presentan características del sueño específicas, como si estas pueden afectar negativamente a su rendimiento cognitivo, está aún por determinar.

Importancia y finalidad de la presente tesis doctoral

En general, todas las cuestiones comentadas a lo largo de esta introducción reflejan la necesidad de una mayor investigación sobre el TDAH y la impulsividad cognitiva en niños que subsane las limitaciones de las investigaciones previas. Sobre esta base se propone la realización de esta tesis doctoral, cuyos resultados podrían contribuir al avance del conocimiento sobre el rendimiento cognitivo y el sueño en niños con TDAH y en niños con impulsividad cognitiva. Aportando datos que podrían ayudar, en el caso de los primeros, a arrojar alguna luz en torno a las discrepancias surgidas entre los estudios llevados a cabo hasta la fecha. Y, en el caso de los segundos, a conocer en mayor medida las dificultades a nivel cognitivo de estos niños y sus características del sueño particulares.

En definitiva, los resultados de la tesis doctoral que aquí se presenta podrían contribuir, entre otros aspectos, a: 1) un mejor manejo de los problemas cognitivos o de sueño de los niños con TDAH y los niños con impulsividad cognitiva; 2) el desarrollo posterior de medidas de prevención eficaces e individualizadas, atendiendo a las características específicas de sueño y rendimiento cognitivo de cada grupo de niños; y 3) la consiguiente reducción del riesgo de fracaso escolar y la mejora de la calidad de vida de ambos niños. Además, conviene recordar que, en el caso del TDAH, cabe la posibilidad de que el sueño repercuta sobre la exarcebación de la sintomatología propia del trastorno y/o de otros problemas asociados. Por lo que la intervención sobre los problemas de sueño en niños con TDAH, posibilitada por una correcta delimitación de estos problemas, podría contribuir a una menor necesidad de tratamiento farmacológico. Lo que se traduciría en beneficios sociales derivados de la reducción de los costes que este tratamiento implica. Tratamiento que ha sido además ampliamente criticado y cuya eficacia a largo plazo ha demostrado ser cuestionable (Timimi, 2004, 2014). Por lo que toda investigación que proporcione datos que permitan la implementación de otros tipos de tratamientos no farmacológicos es deseable.

Por consiguiente, se proponen con esta tesis doctoral los objetivos detallados a continuación.

OBJETIVOS

Objetivos

El objetivo general de esta tesis doctoral es evaluar las alteraciones en el sueño y en el rendimiento cognitivo de tres grupos de niños: a) niños con TDAH, b) niños con impulsividad cognitiva, y c) niños sin TDAH y sin impulsividad cognitiva.

De este objetivo general se derivan los siguientes objetivos específicos:

1) Examinar el estado de la cuestión sobre el sueño en niños con TDAH:
    - Estudio 1. *Características del sueño en niños con trastorno por déficit de atención con hiperactividad: revisión sistemática y metaanálisis*.
2) Analizar las diferencias entre los tres grupos respecto al rendimiento cognitivo:
    - Estudio 2. *Atención sostenida, inhibición de la respuesta y aprendizaje discriminatorio en el trastorno por déficit de atención con hiperactividad y la impulsividad cognitiva: un estudio controlado en niños.*
    - Estudio 3. *Memoria de trabajo y rendimiento cognitivo en el trastorno por déficit de atención con hiperactividad y la impulsividad cognitiva: un estudio controlado en niños*.
3) Analizar las diferencias entre los tres grupos respecto a sus características del sueño:
    - Estudio 4. *Características del sueño en niños con trastorno por déficit de atención con hiperactividad y niños con impulsividad cognitiva*.
4) Determinar la relación entre el sueño y los problemas cognitivos encontrados en cada grupo:
    - Estudio 5. *Niños con trastorno por déficit de atención con hiperactividad y niños con impulsividad cognitiva: rendimiento cognitivo y relación con sus características del sueño*.

ESTUDIO 1

Sleep Characteristics in Children with Attention Deficit Hyperactivity Disorder: Systematic Review and Meta-Analyses

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Abstract

Study Objectives: Sleep disturbances have been associated with attention deficit hyperactivity disorder (ADHD), but such relationship is still unclear. The results from the studies conducted do not provide enough evidence to support a sleep physiology inherent to ADHD. This study tries to determine if that sleep physiology really exists by comparing children with ADHD and control children in some sleep parameters. **Methods:** A search was conducted in several databases (Web of Science, Scopus, Pubmed and PsycINFO), and a manual search, to retrieve all the articles available from 1987 until March 2014. Of 8,678 non-duplicate studies retrieved, 11 studies met the inclusion and methodological quality criteria. Two metaanalyses were performed with eight of those studies, depending on data provided by them: polysomnographic or actigraphic. A fixed-effects model, and the standardized mean difference (SMD) as the index of effect size, were used in both meta-analyses. **Results:** Significant differences were found only in the meta-analysis with polysomnography as outcome. Children with ADHD were found to spend more time in stage 1 sleep than controls, pooled SMD = 0.32, 95% CI [0.08, 0.55], p = .009. **Conclusions:** Although few differences in sleep between children with ADHD and controls have been found in this review, further studies are required on this matter. Those studies should consider some variables discussed in this review, in order to obtain useful and reliable conclusions for research and clinical practice. Particularly, the influence of assessment criteria and ADHD subtypes in the sleep characteristics of children with ADHD should be addressed.

Keywords: sleep, attention deficit hyperactivity disorder, ADHD, children, systematic review, meta-analysis.

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders in childhood and adolescence, with a worldwide prevalence rate of about 5.3% (Polanczyk, Silva, Horta, Biederman, & Rohde, 2007) and 5% in Europe (Wittchen et al., 2011). The considerable increase in ADHD diagnosis for the last few years (around 24% between 2001 and 2010) (Getahun et al., 2013), has made this disorder a topic of great interest for many researchers and clinicians. Mainly because of its numerous effects on the social, emotional and cognitive functioning. ADHD symptomatology interferes negatively with academic performance (Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010), levels of self-esteem and quality life (Harpin, 2005), and social and family relationships (Barkley, Fischer, Smallish, & Fletcher, 2006), of children who suffer from it. In addition, ADHD is related to numerous comorbid conditions in childhood and adolescence, including bipolar disorder, oppositional defiant disorder, behavioral and substance use disorders, and eating disorders (Biederman et al., 2007, 2008; Donfrancesco et al., 2011; Szobot et al., 2007). It has been also associated with depression and anxiety symptoms and even identified as a major risk factor for suicide (Daviss & Diler, 2012; Manor et al., 2010).

Other problems related to this disorder have been sleep disturbances. Although rates estimated have varied over the years, it has been reported that up to 55% of children with ADHD may have sleep problems (Corkum, Tannock, & Moldofsky, 1998). In general, sleep disturbances have negative consequences in different areas of a child's life. For instance, sleep problems have a negative impact on attention and/or behavior, and on daytime sleepiness levels of children (Fallone, Acebo, Seifer, & Carskadon, 2005; Sadeh, Gruber, & Raviv, 2003). Given that these factors have repercussions on academic or cognitive performance, which were already affected in children with ADHD, sleep disturbances in these children might be acting as a positive feedback mechanism, exacerbating their symptomatology. Therefore, the relationship between sleep characteristics and ADHD in children needs to be examined for the development of effective intervention or treatment programs for ADHD that could improve their quality of life. Nevertheless, such relationship is not totally determined yet, because the results obtained until now are contradictory.

Although numerous authors have found differences between children with and without ADHD in several sleep descriptors, such differences have not been consistent enough. Whereas some authors have found differences on sleep continuity and architecture (Owens et al., 2009; Scott et al., 2013), other authors have found them regarding motor activity during sleep (Konofal, Lecendreux, Bouvard, & Mouren-Simeoni, 2001; Silvestri et al., 2009), and others in daytime sleepiness levels (Hansen, Skirbekk, Oerbeck, Richter, & Kristensen, 2011). However, the discrepancies between the results of the previous studies might be due to the differences between them with regard to: a) the type of measure (objective or subjective) employed to obtain data, and the little comparison between both information sources; b) the age ranges covered; c) the consideration of sex differences in the clinical symptomatology of ADHD; d) the control of participants' medication and of their comorbid conditions; e) the distinction made between the three subtypes of ADHD; and f) the ADHD assessment itself, because there is not a common assessment protocol to all the studies (Silvestri et al., 2009; Biederman et al., 2002; Gruber et al., 2012; Sadeh, Pergamin, & Bar-Haim, 2006; Sung, Hiscock, Sciberras, & Efron, 2008).

Besides the limitations resulting from those differences between the studies, another important limitation is the lack of rigorous inclusion and exclusion criteria for participants in several studies. For instance, participants with primary sleep disorders, like apnea or restless legs syndrome, were not excluded in some studies (Golan, Shahar, Ravid, & Pillar, 2004; Gruber et al., 2009; Hansen, Skirbekk, Oerbeck, Wentzel-Larsen, & Kristensen, 2014; Kirov et al., 2004, 2012; Moreau, Rouleau, & Morin, 2014). This limitation makes it difficult to conclude if sleep disturbances in those children with ADHD were actually due to ADHD symptomatology, or if their primary sleep disorders might be biasing the results; for instance, regarding sleep physiology. Given that those primary sleep disorders suffered from children with ADHD may be changing their sleep architecture regardless their ADHD symptoms, it is not possible to ensure that the sleep architecture found in such studies is a distinctive feature of ADHD. This question was not taken into account either in the reviews and/or meta-analyses conducted until now (Cortese, Faraone, Konofal, & Lecendreux, 2009; Cortese, Konofal, Yateman, Mouren, & Lecendreux, 2006; Sadeh et al., 2006). Therefore, the results of these reviews should be also interpreted with a certain caution.

Considering these aspects, the main goal of this study is to determine the relationship between sleep and ADHD, taking into account the limitations of earlier studies. Particularly, we will analyse if there are differences in sleep characteristics between children with and without ADHD. Furthermore, we will study if the possible differences between them might be influenced by variables inherent to participants or methodology followed in the studies included: sex, subtypes, medication use, comorbidities, assessment measures and inclusion criteria for participants.

Method

This systematic review was conducted according to a previously established protocol drawn up following the recommendations of the MOOSE statement (Stroup et al., 2000).

Search Strategy

A search was conducted in Pubmed, Web of Knowledge, PsycINFO and Scopus, entering the following search terms in Spanish or in English depending on the database: <<*ADHD OR "attention deficit" OR hyperactivity AND sleep**>>. Search fields were title, abstract and keywords. No search limit was established by language, but by publication year, in or after 1987. This is the year in which the third revised edition of the *Diagnostic and statistical manual of mental disorders* (DSM-III-R) was published and sleep disturbances stopped being one of the diagnostic criteria of ADHD (American Psychiatric Association, 1987).

Subsequently, the literature search was completed with a manual search, reviewing the references included in the selected articles, and the citations that they had received.

We employed the RefWorks bibliographic management program to manage the references found.

Selection Criteria

Studies available from 1987 until March 2014 were selected if they: a) included children with ADHD, according to the diagnostic criteria of DSM or any other diagnostic manual, in which sleep disturbances were not one of the symptoms of the disorder; b) were comparative studies (randomised or non-randomised) in which the control group was composed of children without ADHD and the evaluation had been performed simultaneously in both groups by the research team itself (what guarantees an identical and less biased assessment for both groups); c) did not include children with primary sleep disorders; d) assessed differences in sleep between children with and without ADHD; e) provided data in relation to age, sex, medication use and comorbid diseases of participants; and f) were not just abstracts or conference papers.

Titles and abstracts of all the articles retrieved, after excluding duplicates, were examined to check if they fulfilled the inclusion criteria previously described; and those in which there were some doubts were assessed in full text length.

Selected studies were assessed in terms of risk of bias or methodological quality through the Scottish intercollegiate guidelines network (SIGN 50; 2011) scale designed for cohort studies, that has a wide acceptance (Bai, Shukla, Bak, & Wells, 2012). The assessment was performed blindly, as a mean of guaranteeing the preciseness of this process. This scale enables three assessment categories –high quality, medium quality and low quality-, on the basis of risk of bias. Due to the fact that some items of the scale were not applicable to the type of studies selected (1.3-1.6 and 1.12), we decided to obtain a weighted score by subtracting one degree of quality from each of the studies. Thus, we made sure that the assessment was not biased due to the loss of items (Díaz-Román, Perestelo-Pérez, & Buela-Casal, 2015). Only those studies that, after subtracting that degree of quality, belonged to the second category (medium quality) were included in the review.

From each study included, the following data were collected: first author and publication year of the article, country in which the study was performed, number of participants in each group (along with age, sex, medication use, subtypes and comorbidities), study design, assessment measures employed and main results obtained.

Studies were assessed for inclusion criteria and methodological quality, and the data extracted, by two of the three authors independently, and discrepancies between them were resolved by a third author.

Data Analysis

Two meta-analyses were performed following the steps proposed by Botella and Gambara (2006): one of them with polysomnographic data and the other with actigraphic data. The most common variables among studies were selected as dependent variables: total sleep time, sleep latency, sleep efficiency, wake time, stage 1 NREM (non-rapid eye movement) sleep, stage 2 NREM sleep, slow wave sleep, REM (rapid eye movement) sleep and REM latency. The independent variable was always the presence or absence of ADHD.

Both meta-analyses were carried out using Review Manager 5.3. software, with a fixed-effects model and a 95% confidence interval (CI). The index of effect size used was the standardized mean difference (SMD), applying the correction proposed by Hedges (1981) to avoid bias due to sample size. The weighted mean effect size (pooled SMD) was obtained through the inverse variance method, and its statistical significance by the Z statistic. Heterogeneity between studies was also analysed by means of the Q and I^2 statistics (Higgins & Thompson, 2002), interpreting the percent value of this last one according to the levels suggested by Higgins, Thompson, Deeks, and Altman (2003): low ($I^2 < 25\%$), medium ($25\% < I^2 < 50\%$) and high heterogeneity ($I^2 > 50\%$).

Sensibility and publication bias analyses could not be performed because the number of studies included was not enough (Higgins & Green, 2011). Such circumstance did not allow us to carry out any other analysis according to the variables of interest mentioned in our goals (age, sex, ADHD subtypes, medication use, comorbidities and assessment measures employed), being only possible to describe them by means of a narrative synthesis.

Results

Studies Included

We retrieved 12,495 studies through databases (Figure 1). From 8,678 non-duplicate studies, only 11 were included in the review, after removing those that did not meet the inclusion criteria or presented overlapping data. Those 11 studies passed the assessment of risk of bias, obtaining a medium methodological quality level (Galland, Tripp, & Taylor, 2010; Gruber & Sadeh, 2004; Gruber et al., 2012; Konofal et al., 2001; Mullin, Harvey, & Hinshaw, 2011; Owens, Maxim, Nobile, McGuinn, & Msall, 2000; Prehn-Kristensen et al., 2011, 2013; Příhodová, Paclt, Kemlink, & Nevšímalová; Ringli et al., 2013; Wiebe, Carrier, Frenette, & Gruber, 2013). No new study was retrieved through the manual search.

The main characteristics of the studies included and their participants are shown in Tables 1 and 2. In all the studies, a cross-sectional assessment of participants had been performed, six performed it with objective measures of sleep uniquely, one study used subjective measures, while in four were employed both.

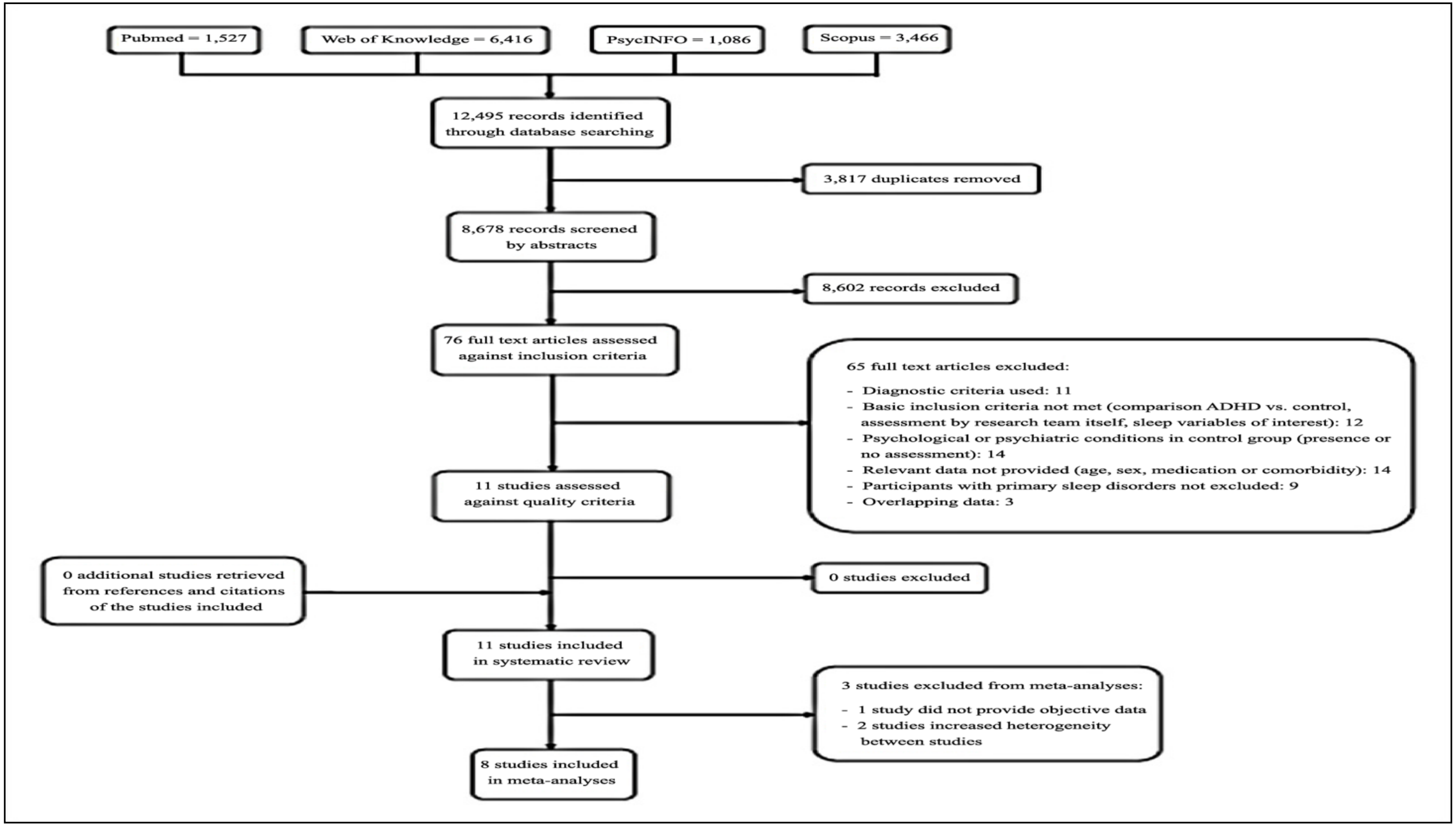

Figure 1. Results of the search and selection of studies.

Table 1

Characteristics of the Included Studies

Author, year	Country	Measure	Main results found (95% CI)
*Galland, 2010	New Zealand	PSG, subjective	↑ SL and restless sleep according to a sleep questionnaire
*Gruber, 2004	Canada	ACTG	↑ intraindividual variability of sleep-onset time, sleep duration and true sleep time
*Gruber, 2012	Canada	PSG, subjective	↑ evening tendency (↓ score on the Child morning-evening preference scale) ↑ total CSHQ score ↑ scores on the CSHQ subscales of Sleep onset delay, Sleep duration, Sleep anxiety, Night wakings, and Daytime sleepiness
*Konofal, 2001	France	PSG, video analysis	↑ number of limb movements ↑ movements associated with behavioral awakening ↓ motionless episodes
*Mullin, 2011	USA	ACTG, subjective	No significant differences were found between both groups
Owens, 2000	UK	Subjective	↑ total CSHQ score ↑ scores on all the CSHQ subscales (except on the Sleep-disordered breathing subscale) ↓ average of sleep amount (CSHQ) ↑ disturbed sleep (Sleep Self-report)
Prehn-Kristensen, 2011	Germany	PSG	↑ sleep onset latency and REM sleep ↓ SWS latency and SE
*Prehn-Kristensen, 2013	Germany	PSG	No significant differences were found between both groups
*Příhodová, 2012	Czech Republic	PSG	No significant differences were found between both groups
Ringli, 2013	Switzerland	PSG	↓ amount of S1
*Wiebe, 2013	Canada	PSG, ACTG, MSLT, subjective	No significant differences were found between both groups

Note. Studies included in the meta-analyses are marked with an asterisk. PSG = polysomnography; ACTG = actigraphy; MSLT = Multiple Sleep Latency Test; CI = confidence interval; ↑ = higher in ADHD group; ↓ = lower in ADHD group; SL = sleep latency; CSHQ = Children Sleep Habit Questionnaire; REM = rapid eye movement; SWS = slow wave sleep; SE = sleep efficiency; S1 = stage 1 sleep.

Table 2

Participant Characteristics of the Included Studies

Study	Sex and mean age (SD)	Subtype[a]	Medication	Comorbidity[c]
*Galland, 2010	ADHD = 21M/6F, 10 years 6 months; age range: 6 years 7 months – 12 years 4 months Control = 21M/6F, 10 years 4 months; age range: 6 years 6 months – 12 years 3 months	6 Inattentive, 21 combined	No[b]	Nine had ODD and one had a specific phobia
*Gruber, 2004	ADHD = 24M, 8.94 (1.25) Control = 25M, 8.83 (1.01)	2 Inattentive, 4 hyperactive-impulsive, 18 combined	No	No
*Gruber, 2012	ADHD = 17/9, 8.46 (1.5) Control = 30M/19F, 8.69 (1.2)	8 Inattentive, 1 hyperactive-impulsive, 17 combined	No[b]	Eight had ODD and two had conduct disorder
*Konofal, 2001	ADHD = 30M, 7.8 (1.6) Control = 19M, 8.4 (1.4)	11 Inattentive, 5 hyperactive-impulsive, 14 combined	No	No
*Mullin, 2011	ADHD = 11M/3F, 15.1 (2.1) Control = 11M/10F, 14.1 (2.0)	14 Combined	Some children	No
Owens, 2000	ADHD = 34M/12F, 89.4 (18.7) months Control = 32M/14F, 86.5 (16.9) months	Not provided	No	Three had ODD and one had conduct disorder
Prehn-Kristensen, 2011	ADHD = 12M, 12.99 (0.52) Control = 12M, 12.64 (0.24)	Not provided	No[b]	Three had ODD
*Prehn-Kristensen, 2013	ADHD = 16M, 10.6 (0.95) Control = 16M, 11.1 (0.95)	8 Inattentive, 8 combined	No[b]	Four had ODD
*Příhodová, 2012	ADHD = 12M/2F, 9.6 (1.6) Control = 8M/4F, 9.0 (1.6)	2 Inattentive, 12 combined	No	No
Ringli, 2013	ADHD = 8M/1F, 11.9; age range: 9.7-13.4 Control = 8M/1F, 11.6; age range: 9.6-14.2	9 Combined	Two bhildren	No
*Wiebe, 2013	ADHD = 13M/7F, 9.2 (1.6) Control = 28M/18F, 8.7 (1.1)	13 Inattentive, 3 hyperactive-impulsive, 4 combined	No[b]	No

Note. Studies included in the meta-analyses are marked with an asterisk. ADHD = attention deficit hyperactivity disorder; M = males; F = females; ODD = oppositional defiant disorder.

[a] All the diagnoses were based on the DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition) or on its text revision (DSM-IV-TR). [b] Medication was cut-off at least 48 hours before evaluation. [c]Disorders with no direct effects on sleep, such as learning disability, were not taken into account in our data extraction.

For the meta-analyses, studies were considered according to the measure employed for sleep assessment. At first time, eight studies were included in the first meta-analysis, that performed a sleep assessment through polysomnography (PSG), and three studies in the second meta-analysis, that used actigraphy to assess sleep. One study employed both objective measures to assess to the participants, so it was included in both meta-analyses (Wiebe et al., 2013). On the contrary, the study that only provided subjective measures was not included in any meta-analysis (Owens et al., 2000), because no meta-analysis was carried out on the basis of subjective measures, since subjective measures were too varied between studies to be summarized in a meta-analysis. Thus, only 10 out of the 11 studies included in the review were included in the meta-analyses. However, from those 10 studies included initially, two studies were excluded from the meta-analysis with PSG as outcome (Prehn-Kristensen et al., 2011; Ringli et al., 2013), because they increased significantly the heterogeneity between the studies. In particular, when those studies were included, the percent values of heterogeneity according to the I^2 statistic ranged between 53 and 76% in five out of the nine sleep variables considered. The decision of excluding those studies was taken because it was not possible to employ a random-effects model or to perform a meta-regression because of the sparse number of studies included (Higgins & Green, 2011).

The final sample of each meta-analysis was composed of 133 (PSG) and 58 (actigraphy) children with ADHD, and 169 (PSG) and 92 (actigraphy) controls, whose most relevant characteristics are shown in Table 3.

Table 3

Main Characteristics of the Children Included in the Meta-Analyses

	Meta-analyses	
Characteristics	PSG (*n*)	ACTG (*n*)
ADHD sex		
Male	109	48
Female	24	10
Control sex		
Male	122	64
Female	47	28
Subtype		
Inattentive	48	15
Hyperactive-impulsive	9	7
Combined	76	36
Medication		
Yes	0	4[a]
No	133	54
Comorbidity		
No	109	58
ODD	21	0
Conduct disorder	2	0
Other	1	0

Note. ADHD = attention deficit hyperactivity disorder; ODD = oppositional defiant disorder; PSG = polysomnography; ACTG = actigraphy.

[a] This is an approximate number because the exact number of children taking medication in one study (Mullin et al., 2012) was not reported.

Regarding the meta-analysis with PSG as outcome, the Rechtschaffen and Kales criteria (1968) were applied as scoring rules in all the studies included, except for one of the studies (Gruber et al., 2012) in which the American Academy of Sleep Medicine criteria (Iber, Ancoli-Israel, Chesson, & Quan, 2007) were applied. A difference between both scoring rules that could have affected our results is the consideration of stage 3 and stage 4 sleep as the stage of slow wave sleep as a whole, but this last variable was also provided by the studies in which the Rechtschaffen and Kales criteria had been applied. In addition, although some significant differences have been pointed out between both scoring systems in sleep data (Novelli, Ferri, & Bruni, 2010), there are no reasons to think that such differences might have affected our results. Mainly because, besides the fact a different system criteria was applied only in one study of the meta-analysis at issue (Gruber et al., 2012), the same procedure of scoring was also followed in all the studies for both children with ADHD and control children. Differences in sleep data depending on scoring criteria would have affected both groups of children equally, with no repercussion on the differences found between them in sleep parameters.

In all the studies, the proper procedure was carried out in order not to include children with primary sleep disorders (even snoring or sleep-disordered breathing). Both in the studies with PSG and in the studies with actigraphy, children with ADHD and controls were excluded if they displayed some sleep disorder or if this disorder was known before taking part in the study. Even in the study in which only subjective measures were employed to obtain sleep data (Owens et al., 2000), parents of children were interviewed on this matter prior to their participation.

Meta-Analyses

In the meta-analysis with PSG as outcome, only one of the nine variables assessed approached statistical significance, the stage 1 sleep, pooled SMD = 0.32, 95% CI [0.08, 0.55], $p = .009$. Children with ADHD spend more time in that sleep stage than control children (Table 4, Figure 2). In the rest of the variables, although the differences between both groups were not significant, that tendency is also observed, primarily in the case of sleep latency, so a higher sleep latency is observed in children with ADHD compared with the control group, pooled SMD = 0.23, 95% CI [-0.01, 0.46], $p = .06$.

Table 4

Results of the Meta-Analysis With Polysomnography as Outcome (N = 302)

Variable	SMD (95% CI)[a]	Q	p [b]	I^2	Z	p	k
TST	0.14 (-0.12, 0.40)	0.82	.94	0	1.09	.28	5
SL	0.23 (-0.01, 0.46)	0.91	.97	0	1.89	.06	6
SE	-0.12 (-0.35, 0.12)	10.95	.05	54	0.98	.33	6
TA	0.05 (-0.27, 0.37)	3.10	.38	3	0.30	.77	4
S1	0.32 (0.08, 0.55)	0.46	.99	0	2.63	.01	6
S2	0.10 (-0.13, 0.34)	3.18	.67	0	0.85	.40	6
SWS	-0.08 (-0.35, 0.19)	4.58	.33	13	0.61	.54	5
REM sleep	0.08 (-0.15, 0.31)	1.52	.91	0	0.68	.50	6
REM latency	0.15 (-0.20, 0.49)	0.44	.80	0	0.81	.42	3

Note. TST = total sleep time; SL = sleep latency; SE = sleep efficiency; TA = time awake; S1 = stage 1 sleep; S2 = stage 2 sleep; SWS = slow wave sleep; REM = rapid eye movement; SMD = pooled standardized mean difference; CI = confidence interval; Q = heterogeneity test; I^2 = heterogeneity index (%); Z = test for overall standardized mean difference; k = number of studies included.

[a] A negative SMD indicates that this variable was higher in the control group. [b] This p-value corresponds to the heterogeneity degree found between the studies included.

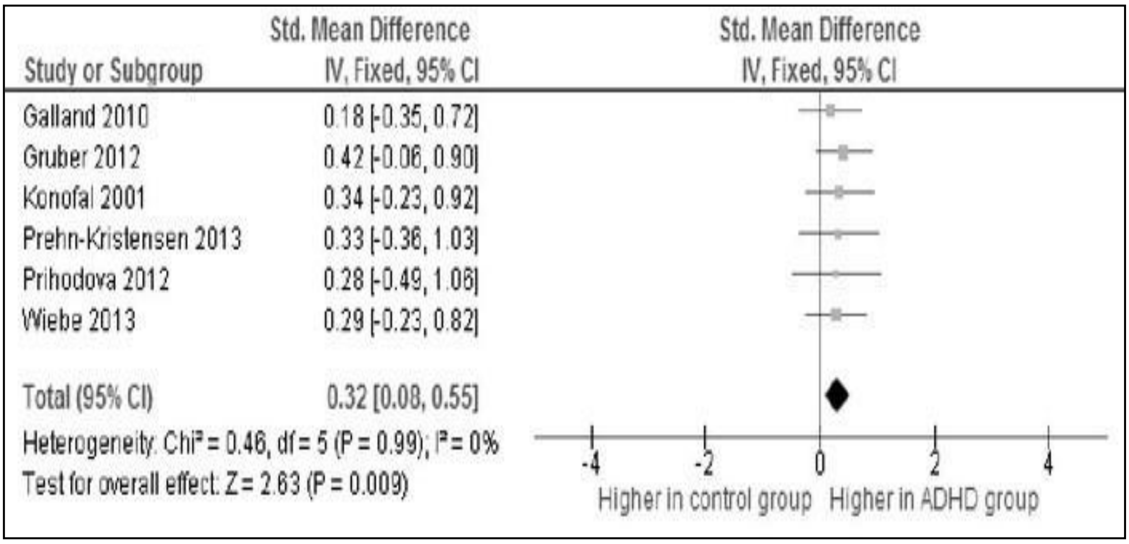

Figure 2. Forest plot of the standardized mean differences (SMD) obtained in the meta-analysis with polysomnography as outcome for stage 1 sleep. IV = inverse variance method; Fixed = fixed-effects model; CI = confidence interval; Chi^2 = heterogeneity test; df = degrees of freedom; I^2 = heterogeneity index; Z = test for overall standardized mean difference; ADHD = attention deficit hyperactivity disorder.

The heterogeneity percent between the studies was zero in all the variables, except for the wake time (I^2 = 3%, p = .38), slow wave sleep (I^2 = 13%, p = .33), and sleep efficiency (I^2 = 54%, p = .05) variables. Although the heterogeneity found in those sleep parameters could be supposed to affect to the proportion of stage 1 sleep, the I^2 values obtained are into the limits considered for low heterogeneity (Higgins et al., 2003). Only the heterogeneity percent found in sleep efficiency is considered high (Higgins et al., 2003). This high heterogeneity, although requires the results in sleep efficiency to be interpreted with extreme caution, cannot affect to the proportion of stage 1 sleep. Basically, because sleep efficiency is a parameter obtained as the result of (TST/TIB) x 100, considering all sleep stages (1, 2, 3, 4 and REM) in TST as a whole (Iber et al., 2007).

Otherwise, in the meta-analysis with actigraphy as outcome, significant differences between children with ADHD and controls were not observed in any variable (Table 5). The heterogeneity degree between the studies of this meta-analysis was always within the acceptable limits (I^2 = 0%-21%, p > .05).

Table 5

Results of the Meta-Analysis With Actigraphy as Outcome (N = 150)

Variable	SMD (95% CI)[a]	Q	p [b]	I^2	Z	p	k
TST	-0.09 (-0.43, 0.24)	1.33	.51	0	0.53	.59	3
SL	0.23 (-0.11, 0.57)	2.52	.28	21	1.34	.18	3
TA	0.09 (-0.32, 0.51)	0.04	.85	0	0.45	.66	2

Note. TST = total sleep time; SL = sleep latency; TA = time awake; SMD = pooled standardized mean difference; CI = confidence interval; Q = heterogeneity test; I^2 = heterogeneity index (%); Z = test for overall standardized mean difference; k = number of studies included.

[a] A negative SMD indicates that this variable was higher in the control group. [b] This p-value corresponds to the heterogeneity degree found between the studies included.

Discussion

This study aimed at determining the relationship between sleep characteristics and ADHD in children, analysing the differences in sleep physiology between children with and without ADHD through the meta-analysis, and defining strict inclusion and exclusion criteria that considered the limitations from preceding studies previously mentioned. In particular, we intended to compare children with ADHD and control children in sleep, excluding of them those who suffered from primary sleep disorders. This is a novel criteria in this study, in comparison with previous systematic reviews and meta-analyses, and that was adopted to determine the sleep architecture of ADHD itself, distinguishing it from the sleep architecture inherent to primary sleep disorders.

In this regard, it is observed that just the percent of stage 1 sleep approaches the statistical significance when the assessment is performed by PSG. Thus, these results enable to conclude that children with ADHD spend more time in stage 1 NREM sleep than children without this pathology. It means that children with ADHD show a lighter sleep than controls. These results are not consistent with the results corresponding to the two studies that were not included in the meta-analyses (because of heterogeneity) but they were in this review (Prehn-Kristensen et al., 2011; Ringli et al., 2013). In one of those studies, differences in stages of NREM sleep between children with ADHD and controls were not found (Prehn-Kristensen et al., 2011). Moreover, in that study, children with ADHD, besides a higher sleep onset latency and a lower sleep efficiency, spent more time in stage REM sleep than controls (Prehn-Kristensen et al., 2011). According to that study, children with ADHD would have a deeper sleep that controls and not the opposite. In the other study included, children with ADHD were found to spend less time in stage 1 NREM sleep than controls (Ringli et al., 2013). Definitely, results from both studies were contrary to what we have found. However, these incoherencies between our results and the results from those two studies mentioned may be due to some aspects that are discussed below.

We also wanted to determine if other variables might be having an impact on sleep characteristics, such as age, sex, ADHD subtypes, medication use, comorbidities and assessment measures employed. In this sense, a certain similarity was observed between the studies included in the meta-analyses regarding age, medication use (children who were taking medication stopped taking it at least 48 hours before evaluation, with the exception of four children in one study; Mullin et al., 2011), comorbidities of participants, and the type of objective assessment employed (PSG-actigraphy) (Tables 1, 2 and 3). In addition, even though a greater number of boys than girls is observed in all the studies included in the meta-analyses, this superiority of masculine sex is found both in children with ADHD and in control children (Table 3). Therefore, it is just possible to discuss the influence of ADHD subtypes in sleep disturbances.

In fact, although few studies have analysed the differences between the ADHD subtypes regarding sleep patterns, the results found indicate that sleep disturbances are different depending on the subtype or the predominant symptomatology in ADHD. Children with the inattentive subtype appear to have fewer sleep problems, being those children with the hyperactivity-impulsivity subtype who show more problems in this area (Mayes et al., 2009; Wagner & Schlarb, 2012). In this regard, the distribution of ADHD subtypes between the participants of the studies included in the two meta-analyses of this review was not homogeneous. The number of children with ADHD with the inattentive subtype was higher than the number of children with the hyperactivity-impulsivity subtype (Table 3), mainly in the meta-analysis with PSG as outcome. Therefore, if children with the inattentive subtype predominate, who show fewer sleep problems, the results might be under the influence of this variable. As regards to the other two studies that did not distinguish between subtypes (Owens et al., 2000; Prehn-Kristensen et al., 2011), these were not included in the meta-analyses, so they cannot have influenced our results.

In summary, on the basis of all the above, it seems plausible that the differences in sleep found in this review between control children and children with ADHD were impacted by the ADHD subtypes of the children included. Or, moreover, that the absence of greater significant differences in sleep between both groups has been conditioned by this variable.

Other variable that may have had an influence in the results obtained in the meta-analysis is the sample size in each study. Although the total sample of each meta-analysis was composed of an acceptable number of participants in each group (Table 3), undoubtedly the sample sizes of each study included were not too high (Table 2). Noteworthy, above all, the studies of Mullin et al. (2011), Prehn-Kristensen et al. (2013), and Příhodová et al. (2012), with 14, 16 and 14 participants with ADHD respectively. This low sample size might have determined the lack of statistical significance in other variables, because although not significant, some tendencies are appreciated in the rest of the variables (Tables 4 and 5).

In addition, there are other variables also related to sleep that have not been taken into account in our meta-analyses. In this sense, some of the studies included in this review provided subjective sleep data. Due to the lack of analogy between those studies with regard to the sleep variables considered and the subjective assessment measures employed, no meta-analysis could be performed with subjective sleep measures. Nevertheless, significant differences were found in those studies included between children with ADHD and controls in some subjective sleep variables that are important to be noted. For instance, one of these variables is daytime sleepiness. Children with ADHD showed a higher daytime sleepiness than controls in two of the studies (Gruber et al., 2012; Owens et al., 2000), according to their scores in the Children Sleep Habit Questionnaire (CSHQ). On the contrary, daytime sleepiness was not found to be affected by ADHD in two other studies included, according to a sleep questionnaire (Galland et al., 2010) or a modified Epworth Sleepiness Scale (Wiebe et al., 2013). Such discrepancies, even in this subjective variable, deserves a deeper analysis in future studies. For that reason, although both meta-analyses presented in this review were performed focused on nocturnal sleep characteristics, further research is needed to pay attention to some other sleep variables, like daytime sleepiness, that might be also affected by ADHD symptomatology.

Finally, although ADHD is currently a topic of great interest, there is a debate in relation to the disorder, leading some authors even to question its own existence (García, González, & Pérez, 2014). Other authors suggest that the big problem might be an overdiagnosis of the disorder (Bruchmüller, Margraf, & Schneider, 2012; Thomas, Mitchell, & Batstra, 2013), that would be the responsible for the increase in the number of children diagnosed with ADHD, growing the number of false positives. Although the latter is not totally clear (Sciutto & Eisenberg, 2007), in that case, this could be a factor that impacts on the controversy about the existence of sleep disturbances in children with ADHD. Since a high number of false positives in the group with ADHD would lead the differences between the groups with regard to sleep disturbances to disappear.

This requires that the future studies include an assessment of the child by a specialist that covers different areas (school, social and family), to corroborate, thus, the diagnosis. In this sense, there were not enough data provided in all the studies included in this review in order to confirm that the diagnosis of children with ADHD had been appropriately corroborated (example, Mullin et al., 2011), and in the cases in which it was corroborated, nor was a common assessment protocol.

In general, this systematic review has several limitations. Among them, the small sample size of the studies, like the sparse number of studies included in the review and in the meta-analyses. Other limitation is the unequal distribution of ADHD subtypes between the participants of those studies. These limitations do not enable to generalize the results, not even make possible to obtain convincing conclusions. To the contrary, such limitations highlight the importance of further studies on this topic.

This review has also some strengths to be noted. In the first place, the development of a previous protocol guaranteed the methodological rigorosity of the following review. Secondly, a very complete search of all the studies available in the literature was carried out, avoiding bias by publication language. In the way, the blind assessment of the quality of the studies avoided the presence of methodological bias in them and in the evaluation itself. Also, rigorous inclusion criteria were followed, which enabled to obtain valid and feasible results. For instance, those studies in which some participants showed primary sleep disorders were excluded, along with those in which a control group composed of children with no disorders was not included. These two criteria avoided that if differences in sleep between children with ADHD and controls were found, these could be attributed to other factors different from the pathology studied itself. Finally, when meta-analyses were performed, the opportune corrective measures were taken in order to avoid that the results obtained were conditioned by the heterogeneity between the studies or the different assessment measures of sleep parameters.

Conclusions

The results obtained with this systematic review and meta-analyses suggest that children with ADHD show few differences in sleep with regard to children without this pathology. However, such differences might be stressed if some of the limitations previously discussed would be taken into account. For that reason, a higher number of studies on the relationship between sleep and ADHD are still required. Above all, these studies will have to: a) assess if the predominant subtype or symptomatology in these children leads to particular sleep patterns; b) count on an appropriate sample size that enables to generalize the results; c) consider both objective and subjective sleep variables and perform a comparison between them; d) avoid that the presence in the sample of children with primary sleep disorders, or control children with medical or psychological problems, affects the results obtained; and e) confirm the ADHD diagnosis, guaranteeing the absence of false positives in the group with ADHD.

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ESTUDIO 2

Sustained Attention, Response Inhibition and Discrimination Learning in Attention Deficit Hyperactivity Disorder and Cognitive Impulsivity: A Controlled Study in Children

Abstract

Objective: This study provides new data on cognitive performance of children with attention deficit hyperactivity disorder (ADHD) and children with cognitive impulsivity, in comparison with a control group. **Method:** Sustained attention, response inhibiton and discrimination learning were assessed in 90 children (30 children per group; age 7-11 years) through a computer performance test and a computer reversal test. **Results:** Non-significant differences were found between children with ADHD and the other groups in the tests employed. On the contrary, children with cognitive impulsivity did perform worse than controls in the computer reversal test. **Conclusion:** Despite the lack of differences between children with ADHD and the other groups, and the differences found between children with cognitive impulsivity and controls, further studies are needed on this topic. Particularly, future studies should provide data, from a longitudinal approach, about the influence of ADHD medication, amongst other variables, on children's cognitive performance.

Keywords: sustained attention, respose inhibition, discrimination learning, attention deficit hyperactivity disorder, ADHD, cognitive impulsivity, children.

Introduction

Attention deficit hyperactivity disorder (ADHD) has been associated with school impairment in children with this disorder (Daley & Birchwood, 2010; Loe & Feldman, 2007) and with high school dropout rates throughout their years of education (Barbaresi et al., 2007; Barkley, Murphy, & Fischer, 2008; Fredriksen et al., 2014). These academic difficulties have an impact on these children's quality of life, either in the short or long term (Baweja, Mattison, & Waxmonsky, 2015). Inattention, a core deficit in ADHD (American Psychiatric Association, 2013), seems to play a decisive role in the poorer academic achievement of children with this disorder compared to normative children (Sonuga-Barke, 2002). This has led to a focus on the assessment of attention in these children in comparison to their peers by means of several tasks.

One of the tasks more frequently employed, both in research and in the clinical practice, to evaluate children with ADHD is the continuous performance test (CPT) (Ogundele, Ayyash, & Banerjee, 2011). This is a reliable neuropsychological measure of sustained attention that has been used to assess either attention disturbance or treatment effect on cognitive function in several conditions (See Meneres-Sancho, Delgado-Pardo, Aires-González, & Moreno-García, 2015, for a review). Particularly in the case of ADHD, the CPT has been shown to be useful in differentiating children with this disorder from children without it (eg. Epstein et al., 2003; Kim et al., 2015; Losier, McGrath, & Klein, 1996; Moreno-García, Delgado-Pardo, & Roldán-Blasco, 2015). Moreover, the CPT can be used in different age ranges (Raz, Bar-Haim, Sadeh, & Dan, 2014; Suhr, Sullivan, & Rodriguez, 2011; Tinius, 2003).

The widespread implementation of this type of task for research and clinical purposes has led to the appearance of different versions of the CPT over the years.

These versions can differ either in the type of target or stimulus presented (animals, numbers or letters) or in numerous other aspects, such as the interval between stimuli or the outcome measures provided (Allan, Allan, Lerner, Farrington, & Lonigan, 2015; Riccio, Reynolds, Lowe, & Moore, 2002). For instance, since 2000, a new CPT version has been available, the Integrated Visual and Auditory (IVA) CPT, which enables assessment of both auditory and visual attention at the same time (Sandford & Turner, 2000). Thus, the IVA CPT is quite useful not only for obtaining data on sustained attention in children with ADHD, but also for comparing either their auditory or visual performance with normative groups of children. Although some of these data suggest that children with ADHD perform poorly with visual stimuli compared to auditory ones (Moreno-García et al., 2015), the evidence for this is still inconclusive and further studies are required on this matter.

Another question that remains unclear is related to the usefulness of the CPT to differentiate between different conditions. Despite the fact that the CPT seems to be useful to distinguish between children with ADHD and control children (Meneres-Sancho et al., 2015), there is a lack of studies comparing the performance of children with ADHD and children with other conditions associated with attentional difficulties. For instance, there is no evidence that supports the CPT usefulness to distinguish between children with ADHD (or behavioral/motor impulsivity) and children with an impulsive cognitive style (or cognitive impulsivity), who also display attention deficits (Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2001). Even in studies in which children with ADHD have been compared to normative control groups in CPT tasks, the cognitive style of the control participants was not assessed. This lack of CPT measures in children with an impulsive cognitive style overlooks an opportunity to compare both groups of children in this neuropsychological task. Such comparison might provide useful results for the management of attention deficits in children with this cognitive style.

In addition to that, although CPT is mainly employed as a measure of attention, this task is also useful to evaluate response inhibition or impulsivity (Egeland & Kovalik-Gran, 2010; Ogundele et al., 2011; Raz et al., 2014). Concerning this point, it would be interesting to know not only if children with ADHD and children with cognitive impulsity are different in relation to their ability to keep attention on the CPT, but also if the differences between behavioral and cognitive impulsivity are reflected in the CPT's scores. In conclusion, determining if the CPT is useful for the assessment of children with cognitive impulsivity could help in the design of interventions targeted at the enhancement of school achievement in these children too. Especially, given the central role of executive functions in academic performance (Visu-Petra, Cheie, Benga, & Miclea, 2011).

Moreover, despite the large number of studies that have used CPT tasks to assess children with ADHD (Hasson & Fine, 2012; Meneres-Sancho et al., 2015; Ogundele et al., 2011), there are few studies that have compared the attention scores obtained in the CPT with the scores obtained in other types of executive tasks. For instance, other tools that provide us with data on executive function in children with ADHD are reversal learning tasks. In reversal tasks, two possible responses are presented and one of these is positively rewarded. Children must learn what is the reward response and perform according to this. However, after an established number of trials, the experimental conditions change and the reward response is the opposite (Cools, Clark, Owen, & Robbins, 2002; Jocham et al., 2009). By means of this procedure, reversal tasks enable us to assess the ability of children to discriminate between the previous reward response and the new one, and to inhibit the previously learned response (Talbot, Watson, Barrett, & Cooper, 2006).

A poor performance in reversal learning tasks has been associated with damage or impairment in the functioning of some neural regions (Hampshire, Chaudhry, Owen, & Roberts, 2012). Particularly, the prefrontal cortex (PFC) has been pointed out as a crucial region involved in the reversal task performace, although the findings of previous studies are not consistent enough and further research is needed. (Cools et al., 2002; Rogers, Andrews, Grasby, Brooks, & Robbins, 2000). Given the important role of dopamine in the cognitive functioning of the PFC, and the deficit of dopamine linked to ADHD (Swanson et al., 2007), the evaluation of children with ADHD by means of reversal tasks is quite convenient and desirable. Furthermore, a link between attention and discrimination learning has been suggested (Halliday, Taylor, Edmondson-Jones, & Moore, 2008). Therefore, any possible attention problems displayed by children with ADHD and children with cognitive impulsivity in CPT tasks, in comparison with control children (without ADHD or cognitive impulsivity), could also affect their performance in reversal tasks. Or, in other words, the differences in CPT scores between children with ADHD and children with cognitive impulsivity might correlate with the differences between them in reversal task scores. Furthermore, the comparison between the performance of both groups of children, along with a control group in reversal and CPT tasks may provide new insights that help in the improvement of their academic achievement, guaranteeing the implementation of the most appropriate actions in each case.

On the basis of all the above, our study had three main goals: 1) to compare the performance of children with ADHD, children with cognitive impulsivity and control children in a CPT task; 2) to compare their performance in a reversal task; and 3) to determine if there is a relationship between their differences in execution in both tasks. Alongside these aims, we also wanted to analyze if the possible differences found between their scores in both tasks might be affected by other variables, such as age and sex.

Method

Participants

Participants were 30 children with ADHD, 30 children with cognitive impulsivity, and 30 control children. For the total number of participants, 35.56% were girls and 64.44% were boys, with a mean age of 8.69 (*SD* = 1.51) and 8.93 (*SD* = 1.35) respectively (Table 1). Children were recruited from schools, associations and public institutions from Andalusia (Spain), and we also counted on the collaboration of their parents and tutors for data collection, with the provision of prior written informed consent.

Children with ADHD must had been diagnosed by a clinical specialist according to the *Diagnostic and Statiscal Manual of Mental Disorders* (DSM) or another diagnostic manual. Furthermore, their clinical diagnosis was also correborated by means of a clinical interview for ADHD based on the fourth edition of the DSM (DSM-IV; American Psychiatric Association, 1995), administered to their parents, and the ADHD symptoms reported by their parents and teachers through the questionnaires employed.

Table 1

Demographic Characteristics of the Three Groups of Participants (N = 90)

Variable	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)
Age	9.07 (1.53)	9.00 (1.37)	8.47 (1.28)
Sex	22 boys, 8 girls	20 boys, 10 girls	16 boys, 14 girls
Medication	25 (22 methylphenidate, 3 atomoxetine, 1 aripiprazole, 1 lisdexamfetamine, 1 valproate)		
Subtype	4 inattentive, 3 combined, 23 non-specified		

Note. ADHD = attention deficit hyperactivity disorder.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2002).

Cognitive impulsivity was defined on the basis of the impulsivity scores obtained from the participants without ADHD in the Matching Familiar Figures Test-20 (MFFT-20; Buela-Casal et al., 2002). Those children whose scores were equal or higher than the 76th quantile, were clasified into the group with cognitive impulsivity, and those children whose scores were lower than this quantile were clasified into the control group.

Inclusion criteria for children with cognitive impulsivity and control children were the following: a) must not have any psychiatric or psychological disorder or medical illness, b) must not have ADHD symptoms reported by their parents and teachers, and c) must not have any diagnosis of mental retardation or any learning disability that might impact in our results. The same criteria were applied to children with ADHD, except for the presence of the ADHD itself and the possible comorbidity of any oppositional defiant disorder or conduct disorder, given the high prevalence rate associated with both conditions in these children (Biederman et al., 2008).

The study was approved by the Human Research Ethics Committee of the University of Granada (Spain).

Instruments and Measurements

Screening measures.

Questionnaire on socio-demographic data. This instrument was developed ad-hoc to obtain data regarding several participants' socio-demographic characteristics, such as age, sex, academic level, medical history report and medication use, amongst others.

Structured Clinical Interview for ADHD based on the DSM-IV (American Psychiatric Association, 1995). This was administered to the parents as a screening tool. It comprises 18 items regarding the symptoms of inattention, hyperactivity and impulsivity established in the DSM-IV for ADHD, and whether they have been displayed by the child over the past six months. The response options for these 18 items are *yes*, *no*, and *don't know*. There are also four other items regarding the age of onset and the environments in which the symptoms are displayed, and whether medication was currently in use.

Conners' Parents Rating Scale-Revised (CPRS-48; Goyette, Conners, & Ulrich, 1978). This is composed of 48 items rated on a 4-point scale ranging from 0 (*never*) to 3 (*very often*). The instrument provides a total score and other subscores correponding to five subscales: Conduct Problems, Learning Problems, Psychosomatic, Impulsive-Hyperactive, and Anxiety.

Conners' Teachers Rating Scale (CTRS-10; Conners, 1973; Werry, Sprague, & Cohen, 1975). This consists of 10 items rated on a 4-point scale ranging from 0 (*never*) to 3 (*very often*). The scale has a unidimensional factorial structure, providing a global hyperactivity index.

Home Situations Questionnaire-Revised (HSQ-R; DuPaul & Barkley, 1992). This is composed of 14 items about potential attention problems displayed by the child in a family environment. Items are scored between 0 and 9 points depending on the degree of severity of these problems. The total score was computed in this study. DuPaul and Barkley (1992) found an internal consistency of .93 and a test-retest reliability of .91.

School Situations Questionnaire-Revised (SSQ-R; DuPaul & Barkley, 1992). This comprises eight items about potential attention problems displayed by the child in several school situations. Items are scored between 0 and 9 points according to the degree of severity associated with those problems. The total score was computed in this study. DuPaul and Barkley (1992) found an internal consistency of .95 and a test-retest reliability of .88.

Child Behavior Checklist (CBCL/6-18; Achenbach & Rescorla, 2001). This instrument was designed to assess the presence of potential problems over the last six months, and it is completed by the parents through a response scale ranging from 0 (*not true*) to 2 (*very true or often true*). It is composed of 113 items divided into six scales: Affective Problems, Anxiety Problems, Attention Deficit Hyperactivity Problems, Conduct Problems, Oppositional Defiant Problems, and Somatic Problems. The scale has shown appropriate psychometric properties in Spanish populations (Lacalle, Ezpeleta, & Doménech, 2012).

Teacher's Report Form (TRF/6-18; Achenbach & Rescorla, 2001). This is the teachers' version of the CBCL, which has also shown good psychometric properties (Achenbach & Rescorla, 2001). Both versions have the same response rate and quite similar factorial structures, except for the ensemble of some items. This questionnaire evaluates the child's functioning during the previous two months.

Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). It is composed of 25 items divided into five scales: Emotional Symptoms, Behavioral Problems, Hyperactivity, Peer Relationship Problems and Prosocial Behaviors. Items are rated on a 3-point scale ranging from 0 (*not true*) to 2 (*totally true*), with the exception of the items 7, 11, 14, 21 and 25, that are reverse scored. The total score is obtained by adding up the scores from all the scales excluding the Prosocial Behavior scale. The Spanish versions for parents and teachers were employed in this study, which have shown adequate indexes of internal consistency (Rodríguez-Hernández et al., 2012).

Neuropsychological assessment measures.

MFFT-20 (Cairns & Cammock, 1978). The Spanish adaptation of Buela-Casal et al. (2002), with adequate psychometric properties (Buela-Casal, Carretero-Dios, De los Santos-Roig, & Bermúdez, 2003), was used in this study. This instrument measures the cognitive style of reflexivity-impulsivity, and it consists of two training items and 20 measure items. Every item includes a model drawing and six versions of it. The child must select which of the versions is exactly the same as the model, with a maximum of six attempts per item. The response latency for the first attempt and the number of errors for each item are registered. Afterwards, the mean response latency and the total number of errors are calculated. From these data, the standard scores for impulsivity and inefficiency are computed, following the formulation proposed by Salkind and Wright (1977), and are then transformed into quantiles according to the normative rates provided by Buela-Casal et al. (2002). The cut-off point for impulsivity used in this study was the 76th quantile.

IVA CPT. An adaptation of the original IVA CPT (Sandford & Turner, 2000), was developed to be used in this study. This adapted computerized test also included both visual and auditory stimuli, and the main difference with respect to the original version was a reduction in the total number of trials. The CPT employed in this research comprised a practice block with 16 trials, and four experimental blocks with 60 trials per block (30 with auditory stimuli and 30 with visual stimuli). The targets and non-targets presented were randomly distributed across the trials and the number of them varied depending on the block (16 vs. 44, or vice versa). The children were instructed to respond following the same procedure as in the original version of the CPT. The children's performance scores on this CPT were not transformed into standardized scores given the characteristics of the version employed, so the total scores corresponding to the Response Control, Attention and Attribute scales were not obtained, either for visual or auditory modality. However, the scores of Prudence, Consistency and Stamina (Response Control subscales), Vigilance, Focus and Speed (Attention subscales), and Balance and Readiness (Attribute/Learning Style subscales) were computed for both presentation modalities.

Computer reversal test. A computer reversal test, consisting of pairs of familiar animals as stimuli, was employed to measure the executive function of the children in terms of their discrimination learning/ability. This test took approximately 15 minutes to complete, and it consisted of a practice block with 14 trials and four experimental blocks with 30 trials per block. From these four experimental blocks, two were learning or acquisition blocks and the other two were reversed. Each pair of animals was presented for 2000 ms, and the children were instructed to select one of the animals by pressing the button of the mouse corresponding to its placement on the screen. Positive or negative feedback was given immediately to the children according to their responses (they earned 100 points for every correct response and lost 100 points for every mistake or non-response). The variables computed for acquisition or reversal conditions separately were: the mean response times for correct responses, and the percentages of correct responses, mistakes, and non-responses.

Procedure

Once potentially eligible participants were recruited from schools, associations and institutions, researchers contacted their parents and provided them with all the information they requested about the investigation. Later, the parents and children interested in taking part were called to the laboratory for a first session. This first session was used for the MFFT-20, the IVA CPT, and the computer reversal test. In some children, the MFFT-20 had been already applied in their schools during the participant recruitment, so this session was shorter for these children. During the first session the questionnaire on socio-demographic data and the clinical interview for ADHD were also administered to the parents of the children. The other questionnaires to be completed during the research were also provided, as well as the questionnaires corresponding to the children’s tutors. A written informed consent was required for parents and teachers prior to their self-completion of questionnaires. Inclusion criteria for participants were then assessed using either the parents’ clinical interview or the other data collected from both information sources. Simultaneously, the children without ADHD were classified into the other two groups according to their impulsivity scores on the MFFT-20.

Data Analysis

Several analyses of variance (ANOVAs) were performed to assess differences between the three groups of children in their scores in the questionnaires completed by their parents and teachers, in the MFFT-20, the IVA CPT and the computer reversal test. Age and sex differences were also evaluated by means of ANOVA and Pearson's chi-square test to ensure that there were not statistically significant differences between the groups that could be affecting our results. When statistical differences between the groups were found in some variable, *post-hoc* multiple comparisons were also computed, performing either Tukey or T3-Dunnett tests depending on the results of the Levene's test. All data analyses were conducted using the IBM SPSS statistics version 23.0 software, and a 95% confidence interval.

Results

Demographic Participants' Characteristics and MFFT-20 scores

No differences between the three groups of participants were found regarding age, $F(2, 90) = 1.67$, $p = .195$, or sex, $\chi^2(2) = 2.72$, $p = .257$. In relation to children with ADHD, given that most of them were using medication and did not have any ADHD subtype specified (Table 1), no statistical analysis was performed with regards to both these variables.

Mean scores in the MFFT-20, evaluated in terms of quantiles, were statistically different between all the groups, $F(2, 90) = 35.47$, $p < .001$. Particularly, the children that were classified into the impulsive group scored significantly higher in cognitive impulsivity than children with ADHD ($p < .001$) and control children ($p < .001$).

Children with ADHD also obtained a higher score in the MFFT-20 than control children ($p < .01$) (Table 2).

Subjective Measures Reported by Parents and Teachers

No significant differences were found between the groups of impulsive children and controls in any questionnaire employed (Table 2), whereas important differences emerged when both groups of children were compared with children with ADHD. Children with ADHD obtained higher scores than impulsive and control children in all the subscales of the CPRS-48, except for the Psychosomatic and Anxiety subscales (Table 2). They also obtained a significantly higher score than control children in the CPRS-10 ($p < .01$), but not in comparison with impulsive children ($p = .124$). Regarding the HSQ-R and the SSQ-R, the scores of children with ADHD were also higher than those obtained by the other two groups ($.000 < p < .01$). In the CBCL, the scores of children with ADHD were higher in most of the subscales when they were compared with either impulsive and control children (Table 2). However, with regard to the TRF, scores were less different between the groups. Thus, the group of children with ADHD scored higher than the other two groups only in three out of the seven dimensions assessed: Affective Problems, Anxiety Problems, and Inattention subscale. Statistical differences were also found between children with ADHD and control children in the ADHD subscale ($p < .05$), but they were not between children with ADHD and impulsive children ($p = .253$). Finally, in the version of the SDQ completed by parents, children with ADHD differed from control children in all the scales, apart from the Prosocial scale ($p = .102$). On the contrary, differences between both groups were only statistically significant for the Total scale ($p < .01$) and the Hyperactivity scale ($p < .001$) in the version for teachers. Children with ADHD and impulsive children did significantly differ in almost the same scales (the Total and Hyperactivity scales) in both SDQ versions. The only opposition that arose was in the Peer Problems scale, in which the difference between both groups was not significant in the version for teachers, but it was in the version for parents (Table 2).

IVA CPT Scores

Differences between the groups were not statistically significant in any of the variables measured by means of the IVA CPT (Table 3).

Computer Reversal Test Scores

The three groups of children did not differ in relation to the learning/acquisition blocks, but they did in the reversal blocks (Table 4). Specifically, impulsive children had a lower percentage of correct responses and a higher percentage of mistakes than control children ($p < .01$) (Figure 1). The performance of impulsive children was also significantly worse in the reversal blocks than in the acquisition blocks compared to control children, according to their percentage of correct responses ($p < .05$). However, children with ADHD showed a similar performance to the other two groups in both blocks of the computer reversal test (Table 4).

Table 2

Mean Scores (SD) Obtained by the Three Groups of Participants (N = 90) in the Matching Familiar Figures Test-20 (MFFT-20) and in the Questionnaires Completed by Their Parents and Teachers

	Group			Post hoc comparisons between groups (*p*)		
Questionnaire	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
MFFT-20	62.47 (31.81)	88.47 (6.31)	41.27 (19.14)	**.000**	**.009**	**.000**
CPRS-48						
Conduct Problem	7.59 (5.13)	3.12 (3.91)	2.72 (2.39)	**.001**	**.000**	.949
Learning Problem	7.73 (2.82)	3.33 (2.59)	2.13 (2.18)	**.000**	**.000**	.166
Psychosomatic	1.50 (1.55)	1.43 (1.43)	0.77 (1.22)	.982	.114	.164
Impulsive-Hyperactive	7.04 (3.36)	4.06 (2.36)	4.47 (2.88)	**.000**	**.003**	.850
Anxiety	2.41 (2.05)	1.60 (1.73)	1.72 (1.91)	.234	.347	.967
ADHD Index	14.84 (5.95)	7.51 (5.59)	6.42 (4.93)	**.000**	**.000**	.724
CTRS-10	9.92 (6.76)	6.63 (7.51)	4.35 (4.63)	.124	**.004**	.367
HSQ-R total score	52.15 (29.92)	14.53 (14.81)	11.89 (14.13)	**.000**	**.000**	.858
SSQ-R total score	27.68 (18.40)	14.13 (17.79)	9.99 (16.36)	**.010**	**.001**	.639
CBCL/6-18						
Affective Problems	6.57 (4.61)	2.49 (2.31)	2.02 (2.15)	**.000**	**.000**	.794
Anxiety Problems	4.74 (2.53)	2.35 (1.93)	2.13 (2.61)	**.001**	**.000**	.933
Somatic Problems	1.48 (1.72)	1.54 (1.71)	0.82 (1.28)	.991	.274	.215
ADHD Problems	9.46 (3.06)	4.76 (4.85)	3.67 (2.88)	**.000**	**.000**	.493
Oppositional Problems	5.38 (3.15)	3.20 (2.78)	2.43 (2.31)	**.009**	**.000**	.534
Conduct Problems	4.77 (3.49)	2.64 (3.62)	1.51 (1.85)	.068	**.000**	.355
TRF/6-18						
Affective Problems	3.98 (3.50)	1.53 (1.81)	1.62 (2.55)	**.002**	**.004**	.991
Anxiety Problems	2.71 (1.87)	1.39 (1.79)	1.50 (2.10)	**.026**	**.048**	.975
Somatic Problems	0.93 (1.41)	0.55 (1.39)	0.35 (0.92)	.487	.185	.802

Table 2 (*Continued*)

	Group			Post hoc comparisons between groups (*p*)		
Questionnaire	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
TRF/6-18						
Innattention subscale	6.13 (2.81)	2.13 (2.37)	1.94 (2.59)	**.000**	**.000**	.954
ADHD subscale	4.08 (3.90)	2.63 (3.78)	1.65 (2.71)	.253	**.026**	.534
Oppositional Problems	2.72 (2.66)	2.20 (2.97)	1.25 (2.03)	.720	.081	.341
Conduct Problems	3.19 (4.74)	1.78 (3.02)	1.83 (3.58)	.336	.368	.999
SDQ parents						
Total scale	18.98 (6.31)	11.40 (7.29)	8.33 (6.04)	**.000**	**.000**	.178
Emotional Symptoms scale	4.12 (2.35)	2.70 (2.28)	1.90 (2.17)	.053	**.001**	.369
Behavioural Problems scale	3.48 (1.95)	2.63 (2.57)	1.70 (1.91)	.301	**.007**	.231
Hyperactivity scale	7.82 (1.89)	4.50 (2.98)	3.55 (2.47)	**.000**	**.000**	.461
Peer Problems scale	3.57 (2.29)	1.57 (1.50)	1.17 (1.23)	**.000**	**.000**	.654
Prosocial scale	6.88 (2.42)	8.00 (2.15)	8.03 (1.66)	.112	.102	.998
SDQ teachers						
Total scale	13.27 (6.39)	7.72 (6.79)	6.70 (5.71)	**.004**	**.001**	.813
Emotional Symptoms scale	2.38 (2.15)	1.32 (1.62)	1.31 (1.60)	.070	.072	1.000
Behavioural Problems scale	1.97 (2.20)	1.19 (2.01)	1.18 (1.70)	.301	.303	1.000
Hyperactivity scale	6.42 (2.56)	3.62 (3.21)	2.82 (2.58)	**.001**	**.000**	.527
Peer Problems scale	2.51 (2.31)	1.59 (1.71)	1.39 (2.01)	.200	.103	.927
Prosocial scale	6.40 (2.22)	7.41 (2.19)	7.61 (1.87)	.168	.087	.931

Note. SDQ scores were not available for two children with ADHD and one control child. ADHD = attention deficit hyperactivity disorder; CPRS-48 = Conners' Parents Rating Scale-Revised; CTRS-10 = Conners' Teachers Rating Scale; HSQ-R = Home Situations Questionnaire-Revised; SSQ-R = School Situations Questionnaire-Revised; CBCL/6-18 = Child Behavior Checklist; TRF/6-18 = Teacher's Report Form; SDQ = Strength and Difficulties Questionnaire.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the MFFT-20 (Buela-Casal et al., 2002).

Table 3

Mean Scores (SD) Obtained by the Three Groups of Children (N = 90) in an Adapted Version of the Integrated Visual and Auditory Continuous Performance Test (IVA CPT)

Scale	ADHD (n = 30)	Impulsive (n = 30)[a]	Control (n = 30)	F	p
Full Scale Response Control Quotient					
Auditory Response Control Quotient					
Auditory Prudence	7.30 (11.83)	3.43 (4.51)	3.83 (10.54)	1.50	.229
Auditory Consistency	214.71 (79.81)	186.40 (57.35)	200.91 (59.04)	1.37	.259
Auditory Stamina[b]	-59.61 (138.69)	-71.86 (95.03)	-55.56 (134.60)	0.14	.870
Visual Response Control Quotient					
Visual Prudence	6.90 (14.75)	1.30 (1.51)	3.03 (10.07)	2.30	.106
Visual Consistency	223.83 (81.18)	189.17 (53.64)	198.16 (66.74)	2.09	.130
Visual Stamina[b]	-45.83 (118.66)	-19.46 (86.86)	-3.26 (110.63)	1.23	.298
Full Scale Attention Quotient					
Auditory Attention Quotient					
Auditory Vigilance	0.90 (2.92)	0.03 (0.18)	1.30 (7.12)	0.64	.531
Auditory Focus	198.37 (67.51)	184.09 (56.52)	198.04 (57.85)	0.54	.585
Auditory Speed	796.89 (155.54)	835.23 (123.81)	845.54 (106.61)	1.16	.318
Visual Attention Quotient					
Visual Vigilance	2.47 (10.33)	0.07 (0.25)	0.17 (0.75)	1.55	.219
Visual Focus	212.77 (82.81)	186.33 (55.89)	199.36 (70.66)	1.05	.354
Visual Speed	738.66 (133.73)	738.61 (119.86)	750.65 (116.98)	0.09	.910
Attribute (learning style)					
Balance[c]	56.90 (90.51)	89.87 (66.32)	105.49 (94.03)	2.58	.081
Balance_CR[c]	58.22 (93.83)	96.62 (64.77)	94.90 (72.45)	2.32	.104
Readiness[d]	-44.58 (67.22)	-57.10 (54.22)	-30.34 (79.11)	1.18	.313
Readiness_CR[d]	-36.09 (63.48)	-57.56 (55.90)	-37.72 (90.75)	0.84	.437

Note. The means and standard deviations shown in the table were directly obtained from the children's data, with no transformation into standardized scores. ADHD = attention deficit hyperactivity disorder; CR = correct responses.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal et al., 2002). [b] A negative value means that the children's processing speed was affected by the length of time elapsed. [c] A positive value means that children processed visual information quicker than auditory information. [d] A negative value means that children processed information quicker when the demand was higher than when it was lower.

Table 4

Mean Scores (SD) Obtained by the Three Groups of Children (N = 90) in the Computer Reversal Test

	Group			Post hoc comparisons between groups (*p*)		
Variable	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
Acquisition/Learning						
Correct responses (%)	67.61 (12.36)	64.33 (11.13)	65.39 (10.51)	.506	.730	.931
Mistakes (%)	31.33 (11.64)	34.67 (11.03)	32.56 (9.62)	.459	.900	.730
Non-responses (%)	1.06 (1.42)	1.00 (1.67)	2.06 (2.99)	.994	.173	.142
RT	632.57 (222.52)	625.12 (190.07)	660.96 (169.04)	.988	.840	.757
Reversal						
Correct responses (%)	53.72 (11.82)	47.94 (13.29)	58.33 (9.86)	.143	.286	**.003**
Mistakes (%)	44.56 (11.39)	50.28 (13.43)	39.28 (9.87)	.144	.191	**.001**
Non-responses (%)	1.72 (2.72)	1.78 (3.06)	2.39 (4.30)	.998	.733	.770
RT	670.31 (202.08)	647.84 (201.88)	728.43 (179.34)	.896	.483	.250
Difference (*d*) between both tasks						
*d*_correct responses [b]	13.89 (15.11)	16.39 (18.70)	7.06 (8.16)	.919	.099	**.048**
*d*_mistakes [c]	-13.22 (14.87)	-15.61 (18.49)	-6.72 (8.80)	.926	.127	.064
*d*_RT [d]	-37.75 (119.77)	-22.72 (114.93)	-67.47 (128.85)	.881	.611	.331

Note. Mean response times (RT) were obtained only for correct responses. ADHD = attention deficit hyperactivity disorder.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal et al., 2002). [b] A positive value in this variable means that children obtained a higher number of correct responses (accuracy) in the acquisition/learning task than in the reversal task. [c] A negative value in this variable means that children committed a higher number of mistakes in the reversal task than in the acquisition/learning task. [d] A negative value in this variable means that mean response times were higher in the reversal task than in the acquisition/learning task.

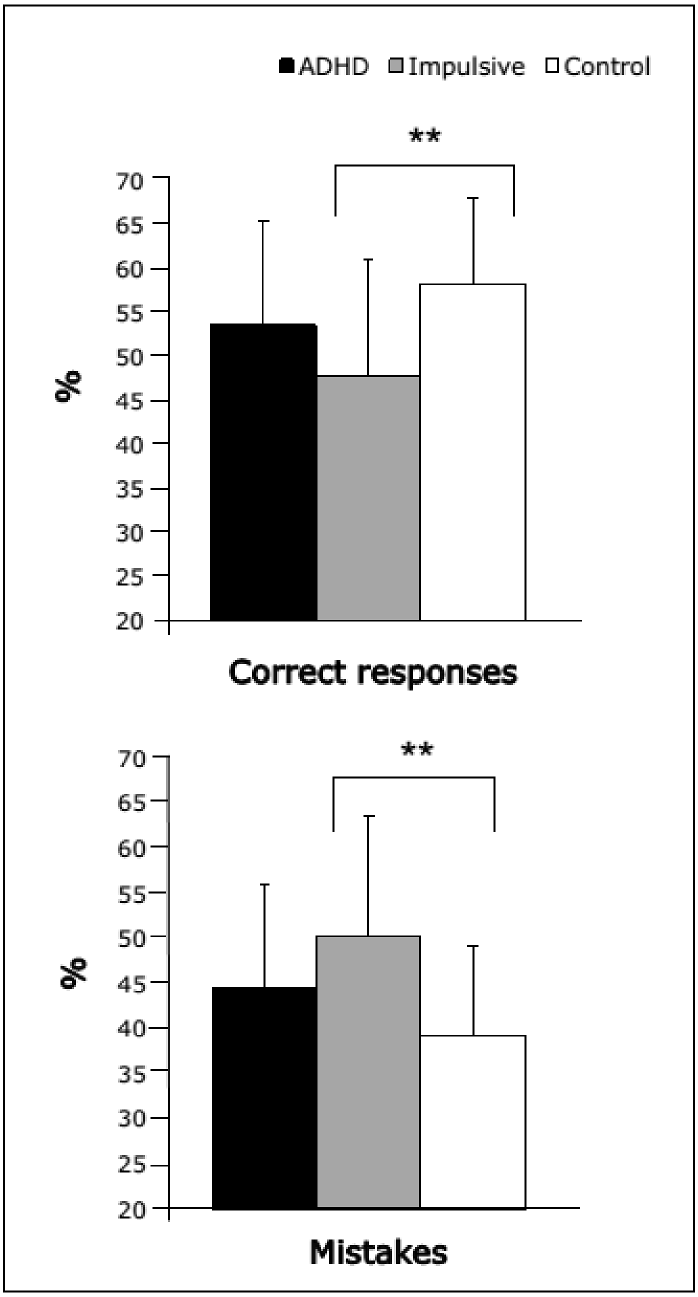

Figure 1. Percentages of correct responses and mistakes of children with attention deficit hyperactivity disorder (ADHD), children with cognitive impulsivity (or impulsive children), and controls in the reversal tasks of the computer reversal test. $^{**}p < .01$.

Discussion

Two main goals of this study were to compare the performance of children with ADHD, children with cognitive impulsivity and control children in a CPT task and in a reversal task. In relation to the CPT, no statistical significant differences were found between any of the groups under study in any of the variables assessed (Table 3). On the contrary, in the computer reversal task, although the performance of the three groups was relatively similar in the acquisition/learning stage, it was different in the reversal stage (Table 4). Particularly, differences between the groups emerged regarding their percentages of mistakes and correct responses. Children with cognitive impulsivity obtained a lower number of correct responses and committed a higher number of mistakes than control children. In fact, when compared with the control group, impulsive children also performed significantly worse in the reversal stage than in the acquisition/learning one, according to their percentage of correct responses. However, the performance of children with ADHD was not different from the performance of the other two groups in any stage of the computer reversal task.

In addition to the two primary goals of the study, we also wanted to analyze if children's performance on either task could be linked to their performance on the other. As well as whether any differences found between their scores in both tasks might be affected by other confounding variables. Our interest in this regard was particularly focused on age, sex, and medication use. On the one hand, given that differences between the groups were found only in the reversal task, their performance on both tasks do not seem to be related to each other. At least, regarding children with cognitive impulsivity and controls, because they did not differ from children with ADHD in any of the tasks employed. On the other hand, similar age and sex distributions were found between the three groups, so no analysis of these variables was performed, as was the case for medication use, due to the fact that most children with ADHD were using medication (Table 1).

Although the high variability of the type of CPT employed in the studies does not allow an appropriate comparison between our results and those obtained in earlier studies, some discrepancies were found. Several studies have suggested the usefulness of this task to distinguish between children with ADHD and children without this disorder. For instance, in the study of Epstein et al. (2003), children with ADHD displayed a higher number of commission and omission mistakes than controls. In the study of Kim et al. (2015), children with ADHD also differed from control children in many of the variables assessed through the CPT. However, in those two studies, children had been diagnosed by means of clinical interviews for ADHD at the time of their participation. This means that they were not under clinical assessment or under any psychological or pharmacological treatment for ADHD, whereas 25 out of the 30 children with ADHD of our study (83.33%) were (Table 1). So, it is plausible to find some discrepancies between the results found in those two studies and our results.

Other studies in which the IVA CPT was employed to assess children with ADHD were conducted by Corbett and Constantine (2006), and by Corbett, Constantine, Hendren, Rocke, and Ozonoff (2009). In the study of Corbett and Constantine (2006), children with ADHD obtained lower mean scores than controls on response control and attention quotients, for both auditory and visual modalities. The same finding was reported in the study of Corbett et al. (2009), except for the attention response quotients, in which no significant differences were found between ADHD group and controls. However, those authors did not report data regarding children's mean scores and differences between groups in the subscales included in each quotient separately (e.g., prudence, consistency, stamina, etc.). In our study, the use of an adapted version of the IVA CPT did not allow us to transform children's direct mean scores into standardized ones. For this reason, our data analysis was focused on every subscale (Table 3), and global auditory and visual quotients for each scale were not computed. This difference between our study and the study of Corbett and Constantine (2006), or the study of Corbett et al. (2009), in terms of data analyses and reports might have contributed to the different results found. Moreover, going back to the medication issue, although in those two studies some children with ADHD were also using medication, but this was removed 24 hours before the CPT assessment (Corbett & Constantine, 2006; Corbett et al., 2009). Besides that, the proportion of children using medication in those studies was lower (38.88-46.66%) than the proportion found in our study (Table 1). As a result, the impact of medication use on their results and on ours would not be the same, especially taking into account that only mean scores for the whole ADHD group were computed.

The importance of considering medication use, when comparing our results with others obtained in earlier studies, resides in the fact that medication proved to impact positively on cognitive performance in some studies (Coghill et al., 2014; Pietrzak, Mollica, Maruff, & Snyder, 2006). Regarding CPT tasks, the results of a meta-analytic review revealed a considerable effect of medication intake on CPT performance, with a lower number of omission and commission mistakes in children with ADHD under medication use than in medication-naive children (Losier et al., 1996). The results of the study of Bédard et al. (2015) also suggested similar effects of medication on CPT measures in participants with ADHD. Furthermore, the changes observed in performance with medication in that study did not correlate with changes in ADHD symptoms (Bédard et al., 2015). This might also explain the absence of differences between the performances of children with ADHD and the other two groups in our study, even though differences were found between the groups in terms of the parents' and teachers' reports (Table 2).

In conclusion, the effect of medication use is worth further discussion, given the findings of other studies carried out in this area. The use of medication could explain the lack of differences found between children with ADHD and impulsive and control children in the CPT task employed in our study. It could also explain the absence of differences found between children with ADHD and the other two groups in the computer reversal task. As well as the significant differences found between children with cognitive impulsivity and control children in percentages of correct responses and mistakes in the reversal blocks of this last task.

In regards to this, a large number of studies support the role of the PFC in reversal task performance (Evers et al., 2005; Hampshire et al., 2012). And, both behavioral impulsivity (or ADHD impulsivity) and cognitive impulsivity have been linked to impairments in that brain region (See Arce & Santisteban, 2006, for a review). According to this, it would be expected that either children with ADHD or children with cognitive impulsivity display a lower performance than controls in the computer reversal task. However, the mechanism of action of methylphenidate has a direct repercussion on the PFC (Rubio-Morell et al., 2008), and most children with ADHD of our study were using this medication (Table 1). When taking this into account, it does not seem strange that their performance in the computer reversal task was better than it may have been without medication, to the point of not differing significantly from control children in their performance in this task. Children with cognitive impulsivity, on the other hand, whose impairments in the PFC were not under pharmacological treatment, did perform significantly worse than controls (Table 4).

In general, several limitations are deduced from this study. The first one, the cross-sectional approach of this research did not allow any observation of changes in the cognitive performance of children with ADHD as a result of medication use. In other words, the fact that these children did not differ from impulsive or control children in any of the cognitive measures assessed may have been due to their pharmacological treatment. Another limitation is that an assessment of the participants' intelligence quotient (IQ) was not carried out. This made it impossible to analyze the effect this variable had on the absence of differences between children with ADHD and impulsive and control children, or on the differences found between impulsive children and controls in the computer reversal task. Especially as research has demonstrated an impact of IQ on the performance of children with ADHD in a CPT task (Park et al., 2011). Moreover, there is another limitation that has not been discussed above, but which should be also considered in further studies on this topic. This is the unequal distribution of ADHD subtypes amongst the participants of this study or, more specifically, the higher number of children without a clinical subtype appropriately specified (Table 1). This prevents a comparison being made between children with ADHD and the other two groups of children, separately, depending on their subtypes. It may be useful to analyze, for example, whether children with an inattentive subtype of ADHD differ from impulsive children to the same extent as those children with ADHD who show a predominance of hyperactive-impulsive symptoms.

Despite those limitations, this study also has some important strengths to be noted. The most important one is the inclusion of a group of children with cognitive impulsivity. In fact, this is, to our knowledge, the first study in which children with ADHD and children with cognitive impulsivity were compared by means of a CPT or a computer reversal task. Such comparison provides useful knowledge for further research in this regard. Another strength is that a previous clinical diagnosis of ADHD was mandatory for children with ADHD to take part in the study, even when children's symptomatology was later checked through parents' and teachers' reports. The fact that they had been already diagnosed by a specialist means that their inclusion in the study was not determined only on the basis of cut-off scores on subjective questionnaires. Furthermore, the involvement of parents and teachers also provided us with the opportunity of obtaining more reliable data on the ADHD symptoms displayed by the children in the impulsive and control groups. That prevented the inclusion of participants with subthreshold ADHD in any of those groups of children.

Conclusions

In summary, the results of this study provide interesting data on the cognitive performance of children with ADHD and children with cognitive impulsivity, comparing between them and with a control group. According to our results, children with ADHD do not differ from impulsive and control children in any of the cognitive variables assessed: response inhibition and sustained attention (by the CPT), and discrimination learning (by the computer reversal task). Neither do they seem to perform worse than the other two groups depending on visual or auditory presentation of stimuli, given that differences were not found between them in any of the CPT presentation modalities. On the contrary, children with cognitive impulsivity did perform worse than controls on the computer reversal task, suggesting that children with this cognitive style have difficulties in discrimination learning. The performance of this group of children could be due to the impairment in ventromedial prefrontal cortex associated with cognitive impulsivity, and the involvement of PFC in reversal task performance. However, in the absence of data regarding the children's IQ scores, it is not possible to ensure that those differences between them in terms of discrimination learning were only due to their differences in cognitive style. Similarly, without the inclusion of IQ scores, one cannot be sure that the lack of siginificant differences between the ADHD group and the controls was because of their pharmacological treatment. It is possible that the performance of children with ADHD could have also been affected by either their IQ or their baseline cognitive levels before starting medication. Other variables like ADHD subtypes or sex distribution amongst participants may also have had an effect. As a result, it would be desirable to analyze if children with ADHD display differences in cognitive performance, in comparison with children with cognitive impulsivity, depending on their predominant ADHD symptoms. Or, if the same differences found or not found between the groups in this study would remain with a higher number of female participants. Longitudinal studies that compare the cognitive performance of children with ADHD, children with cognitive impulsivity, and control children, are required in order to obtain more conclusive results on this matter. Especially, given the implications of cognitive performance for school failure and the consequences of this for children's self-esteem and quality of life in the long term.

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ESTUDIO 3

Working Memory and Cognitive Performance in Attention Deficit Hyperactivity Disorder and Cognitive Impulsivity: A Controlled Study in Children

Abstract

Objective: This study analyzes differences in cognitive performance between children with attention deficit hyperactivity disorder (ADHD), children with cognitive impulsivity, and control children. **Method:** 90 children (30 children per group) aged from 7 to 11 years were assessed through two n-back tasks and the fourth edition of the Wechsler Intelligence Scale for Children. **Results:** Lower scores in phonological working memory, processing speed, and overall cognitive profile were found in children with ADHD and children with cognitive impulsivity, compared to controls. Controls also obtained higher scores than children with ADHD in verbal comprehension, and higher than children with cognitive impulsivity in perceptual reasoning. **Conclusion:** The underperformance found in children with ADHD and children with cognitive impulsivity compared to controls, and the lack of differences between these two groups, should be addressed further in future studies. Those studies should analyze possible effects of sex, medication use, and ADHD subtypes, amongst other variables, on children's cognitive performance.

Keywords: working memory, cognitive performance, attention deficit hyperactivity disorder, ADHD, cognitive impulsivity, children.

Introduction

Attention deficit hyperactivity disorder (ADHD) is characterised by symptoms of inattention, hyperactivity and impulsivity, that lead to consequences in several fields (American Psychiatric Association, 2013). One of the fields affected is their academic performance, where it is estimated that the rate of school dropout amongst students with ADHD is about 30% (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2007; Barkley, Murphy, & Fischer, 2008). In Spain, which is considered the country with the highest school dropout rates according to EuroStat (2016), it is estimated that the 20% of the dropout cases are due to ADHD (Proyecto PANDAH, 2013).

The cognitive deficits associated with children with ADHD, in comparison with children without ADHD, are found to be amongst the main causes for that high rate of school failure or dropout, in combination with the inattention symptoms characteristic of this disorder (Daley & Brichwood, 2010). For instance, impairments in children with ADHD have been pointed out in response inhibition, regulation of motivation, executive control, processing speed and working memory (WM) (Barkley, 1997; Schneider, Lam, & Mahone, 2016). WM is one of the executive functions worthy of greater interest, given its notable involvement in language comprehension, reasoning and learning, amongst other skills (Baddeley, 2010) and, thus, its repercussion on academic performance.

Most of the studies conducted in attempting to analyze WM performance in children with ADHD have found important impairments in these children in comparison with typically developing or control children (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). These impairments were observed in relation to both phonological and visual WM (eg.

Alloway & Passolunghi, 2011; Pasini, Paloscia, Alessandrelli, Porfirio, & Curatolo, 2007). However, despite differences in WM between children with ADHD and control children being pointed out in the majority of studies published, the question about the actual scope of WM problems in children with this disorder remains unsolved. Mainly, because the range of differences found between children with ADHD and controls might have varied across studies, depending on diverse factors related to the assessment tasks employed. For instance, the number of trials within the tasks, the kind of memory response (recall or recognition), and the modality (visual or phonological) in which stimulus are presented are amongst the variables that may be involved in the differences found between these children and controls (Kasper, Alderson, & Hudec, 2012).

Another explanation for the results of previous studies could be the influence of other confounding factors inherent to participants that were not always controlled. Along with possible effects of age, sex and medication use (Coghill et al., 2014; Pelegrina et al., 2015), a link between WM and intelligence has been also suggested (Tourva, Spanoudis, & Demetriou, 2016). In regard to this, a lower intelligence quotient (IQ) was found in children with ADHD compared to control children in some studies (Barry, Lyman, & Klinger, 2002; Loe & Feldman, 2007). Such findings support the growing interest in analyzing family correlates in ADHD, on the basis of the heritability of the IQ (Biederman, Fried, Petty, Mahoney, & Faraone, 2012; Wood et al., 2011). Nevertheless, the relationship between intelligence, or overall cognitive profile, and WM is still inconclusive, given that a poorer academic performance was found in children with ADHD compared to control even when intelligence was controlled in studies (See review of Daley & Brichwood, 2010). So, further research is necessary regarding this point.

In any case, the correct determination of the nature or scope of WM impairment in ADHD and its impact on other executive functions is required, given the importance of facilitating appropriate school achievement in children with this disorder. It is important to be noted that school failure or dropout is associated with negative adolescent and adult outcomes, such as higher risks of deviant behavior and lower status attainment (Chen & Kaplan, 2003; Lansford, Dodge, Pettit, & Bates, 2016; Townsend, Flisher, & King, 2007). Similar negative long-term consequences have also been shown in people diagnosed with ADHD due to their symptomatology itself (Barkley, Fischer, Smallish, & Fletcher, 2006; Harpin, 2005; Szobot et al., 2007). Therefore, improving executive function in children with ADHD is crucial as a means to prevent school failure or dropout and, thus to decrease the risk of other negative long term consequences. A training focused on WM, with its subsequent enhancement, has also been suggested as a positive mechanism to improve ADHD symptomatology (Klingberg et al., 2005; Klingberg, Forssberg, & Westerberg, 2002).

There is another matter that has not been appropriately addressed in the literature until now. This is related to the impulsive cognitive style. Children with an impulsive cognitive style show attention deficits and lower school performance in comparison with children with a more reflexive cognitive style (Bornas, Severa, & Llabrés, 1997; Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2001). Despite these similarities between children with a cognitive impulsive style (or cognitive impulsivity) and children with ADHD, there is a lack of studies in which both groups of children are compared in terms of their WM, or in other executive functions. This lack of comparison between these two groups of children in the literature means it is not clear whether the attention problems found in these children impact equally on their WM, or even on their overall cognitive performance. Critically, if WM affects academic progress (Gathercole & Pickering, 2000), and poor academic achievement increases the likelihood of dropping out of school (Ramsdal, Bergvik, & Wynn, 2015), not only would children with ADHD be at risk of this, but also children with cognitive impulsivity. For this reason, studies comparing these children in either WM or cognitive tasks are needed, given that these could provide useful results for the management of WM or cognitive deficits in both children from schools or clinical care. Furthemore, these studies should not only focus on analyzing if children with cognitive impulsivity differ from children with ADHD in this regard. They should also focus on determining if children with cognitive impulsivity really perform differently from a cognitive perspective compared to more reflexive children.

Therefore, the main goals of this study are: 1) to compare the performance of children with ADHD, children with cognitive impulsivity and control children in WM tasks; 2) to distinguish between the WM execution of the three groups, and the differences between them, depending on the modality (phonological or visual) of stimulus presentation; 3) to examine the extent in which their WM performance impacts on other executive abilities or on their overall cognitive performance; and 4) to analyze if their performance in the different tasks is affected by other factors, such as age, sex, or ADHD symptomatology.

Method

Participants

Thirty children with ADHD, 30 children with cognitive impulsivity, and 30 control children were recruited from schools, associations and public institutions from Andalusia (Spain), to take part in the study. Participant's age ranged between 7 and 11 years old (*M* = 8.88, *SD* = 1.40). Regarding sex, 34.40% were girls and 65.60% were boys (Table 1). Their parents and tutors also participated in the study by completing several questionnaires, after they signed a written informed consent.

Table 1

Demographic Characteristics of the Three Groups of Participants (N = 90)

Variable	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)
Age	9.07 (1.53)	9.13 (1.33)	8.43 (1.28)
Sex	22 boys, 8 girls	21 boys, 9 girls	16 boys, 14 girls
Medication	25 (22 methylphenidate, 3 atomoxetine, 1 aripiprazole, 1 lisdexamfetamine, 1 valproate)		
Subtype	4 inattentive, 3 combined, 23 non-specified		

Note. ADHD = attention deficit hyperactivity disorder.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2002).

Children with ADHD must had been diagnosed by a clinical specialist according to the *Diagnostic and Statiscal Manual of Mental Disorders* (DSM) or another diagnostic manual. We also confirmed such clinical diagnosis through a clinical interview for ADHD based on the fourth edition of the DSM (DSM-IV; American Psychiatric Association, 1995), administered to their parents, and data on ADHD symptomatology reported by their parents and teachers through the questionnaires that they completed.

Children without ADHD were classified into the group with cognitive impulsivity or the control group depending on their impulsivity scores in the Matching Familiar Figures Test-20 (MFFT-20; Buela-Casal et al., 2002). Inclusion to the cognitive impulsivity condition was established when their scores were equal or higher than the 76th quantile. Furthermore, children without ADHD had to meet the following criteria to be included in the study: a) have no history of psychiatric or psychological disorder or medical illness, b) have no ADHD symptoms reported by their parents and teachers, and c) not have any diagnosis of mental retardation or any learning disability that might impact on our results.

Those same criteria were also required for children with ADHD, with the exception for the presence of the ADHD itself, as well as any possible oppositional defiant disorder or conduct disorder, given the high prevalence rate associated with both conditions in these children (Biederman et al., 2008).

This research was approved by the Human Research Ethics Committee of the University of Granada, Spain.

Instruments and Measurements

Screening measures.

Questionnaire on socio-demographic data. This instrument was developed ad-hoc to obtain data from participants regarding their age, sex, academic level, medical history report and medication use, alongside other information.

Structured Clinical Interview for ADHD based on the DSM-IV (American Psychiatric Association, 1995). This was administered to the parents as a screening tool. It is composed of 18 items regarding whether the symptoms of inattention, hyperactivity and impulsivity established in the DSM-IV for ADHD, had been displayed by the child over the previous six months. The response options for these 18 items are *yes*, *no*, and *don't know*. There are also four other questions to obtain information about the age of onset and the environments in which the symptoms are displayed, as well as whether the child's symptoms were managed with the use of medication.

Conners' Parents Rating Scale-Revised (CPRS-48; Goyette, Conners, & Ulrich, 1978). This consists of 48 items rated on a 4-point scale ranging from 0 (*never*) to 3 (*very often*). This instrument provides a total score and other subscores correponding to five subscales: Conduct Problems, Learning Problems, Psychosomatic, Impulsive-Hyperactive, and Anxiety.

Conners' Teachers Rating Scale (CTRS-10; Conners, 1973; Werry, Sprague, & Cohen, 1975). This is composed of 10 items rated on a 4-point scale ranging from 0 (*never*) to 3 (*very often*). The scale has a unidimensional factorial structure, providing a global hyperactivity index.

Home Situations Questionnaire-Revised (HSQ-R; DuPaul & Barkley, 1992). This comprises 14 items in relation to potential attention problems displayed by the child in a family environment. Items are scored between 0 and 9 points depending on the degree of severity of those problems. The total score was computed in this study. DuPaul and Barkley (1992) found an internal consistency of .93 and a test-retest reliability of .91.

School Situations Questionnaire-Revised (SSQ-R; DuPaul & Barkley, 1992). This instrument is composed of eight items regarding potential attention problems displayed by the child in several school situations. Items are scored between 0 and 9 points according to the degree of severity associated with those problems. The total score was computed in this study. DuPaul and Barkley (1992) found an internal consistency of .95 and a test-retest reliability of .88.

Child Behavior Checklist (CBCL/6-18; Achenbach & Rescorla, 2001). This instrument was developed to assess the presence of potential problems over the last six months, and it is completed by the parents through a response scale ranging from 0 (*not true*) to 2 (*very true or often true*). It comprises 113 items divided into six scales: Affective Problems, Anxiety Problems, Attention Deficit Hyperactivity Problems, Conduct Problems, Oppositional Defiant Problems, and Somatic Problems. The scale has shown appropriate psychometric properties in Spanish populations (Lacalle, Ezpeleta, & Doménech, 2012).

Teacher's Report Form (TRF/6-18; Achenbach & Rescorla, 2001). This is the version for teachers of the CBCL, which has also shown to have good psychometric properties (Achenbach & Rescorla, 2001). Both versions have the same response rate and a quite similar factorial structure, except for the combination of some items. This questionnaire evaluates the child's functioning during the previous two months.

Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). It is composed of 25 items divided into five scales: Emotional Symptoms, Behavioral Problems, Hyperactivity, Peer Relationship Problems and Prosocial Behaviors. Items are rated on a 3-point scale ranging from 0 (*not true*) to 2 (*totally true*), with the exception of the items 7, 11, 14, 21 and 25, that are reverse scored. The total score is obtained by adding up the scores from all the scales excluding the Prosocial Behavior scale. The Spanish versions for parents and teachers were employed in this study, which have shown adequate indexes of internal consistency (Rodríguez-Hernández et al., 2012).

Neuropsychological assessment measures.

MFFT-20 (Cairns & Cammock, 1978). The Spanish adaptation of Buela-Casal et al. (2002), with adequate psychometric properties (Buela-Casal, Carretero-Dios, De los Santos-Roig, & Bermúdez, 2003), was employed. This instrument measures the cognitive style of reflexivity-impulsivity, and it consists of two training items and 20 measure items. Every item includes a model drawing and six similar versions of it. The child must select which of the versions is exactly the same as the model with a maximum of six attempts per item. The response latency for the first attempt, and the number of errors for each item, are registered. Afterwards, the mean response latency and the total number of errors are computed. From these data, the standard scores for impulsivity and inefficiency are calculated, following the formulation proposed by Salking and Wright (1977), and are then transformed into quantiles according to the normative rates provided by Buela-Casal et al. (2002). The cut-off point for impulsivity used in this study was the 76th quantile.

Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV; Wechsler, 2010b). This assessment battery has 10 core subtests which provides four functioning indexes: 1) Verbal Comprehension index (Similarities, Vocabulary and Comprehension subtests); 2) Perceptual Reasoning index (Block Design, Picture Concepts and Matrix Reasoning subtests); 3) Working Memory index (Digit Span and Letter-Numer Sequencing subtests); and 4) Processing Speed index (Coding and Symbol search subtests). The sum of the four index scores provides the Full Scale Intelligence Quotient (FSIQ) or the overall cognitive profile.

N-Back. This is a computerized test designed to evaluate working memory. Two n-back task conditions were used (n-back 1 and n-back 2) to analysis the effect of memory load on the children's performance. During the first condition, children had to press the right or left button of the mouse when the number shown on the screen was or not the same as the number presented one trial before. In the second condition, children were required to press the correct button depending on whether the number shown on the screen was the same as the number presented two trials before. Prior to the beginning of the experiment, a practice block was presented with 70 trials. In addition, each n-back condition also included 20 practice trials before the experimental block itself, which was composed of 30 trials in both conditions. The variables computed for each n-back condition were: mean response times for correct responses to targets and non-targets, and percentages of correct responses (hits and correct rejections), mistakes (false alarms and misses) and non-responses.

Procedure

Once potentially eligible participants were recruited from schools, associations and institutions, their parents were contacted and provided with all the relevant information they requested about the investigation. Afterwards, three laboratory sessions were arranged with the parents and children interested in taking part, where the executive tasks were completed. One session was dedicated to the MFFT-20 and the n-back test, and two sessions were used for the application of the WISC-IV. In some cases, the MFFT-20 had been already applied to children without ADHD in their schools during the participant recruitment, so the first session was shorter for these children. Furthermore, the parents were provided with the questionnaire on socio-demographic data and the clinical interview for ADHD at the first session. They also received any other questionnaires that would need to be completed during the research, which were given to the teachers too. A written informed consent was required for parents and teachers prior to their self-completion of questionnaires. Inclusion criteria for participants were then assessed using either the parents' clinical interview or the rest of the data collected from both information sources. Simultaneously, the children without ADHD were classified into the other two groups according to their impulsivity scores on the MFFT-20. Finally, when their participation in the study was completely finished, the parents were rewarded with a cognitive profile report reflecting their children's results.

Data Analysis

Differences between the scores obtained by the three groups of children in the questionnaires completed by their parents and teachers, in the MFFT-20, and in the n-back and the WISC-IV, were assessed by analyses of variance (ANOVAs). ANOVA and Pearson's chi-square test were also performed to evaluate if there were significant differences in age and sex between the groups that could affect our results. Post-hoc multiple comparisons were also computed, performing either Tukey or T3-Dunnett tests depending on the results of the Levene's test, when statistically significant differences between the groups were found in any variable. The IBM SPSS statistics version 23.0 software, and a 95% confidence interval, were used to conduct all data analyses.

Results

Participants' Characteristics and MFFT-20 scores

The three groups of participants did not significantly differ in age, $F(2, 90) = 2.34$, $p = .103$, or sex, $\chi^2(2) = 3.05$, $p = .218$. With regards to the use of medication and the ADHD symptomatology of participants with ADHD, most of the participants from this group were taking medication for their symptoms and did not have any ADHD subtype specified (Table 1), so no statistical analysis was conducted regarding both these variables.

Mean scores in the MFFT-20 in quantiles were statistically different between all the groups, $F(2, 90) = 35.79$, $p < .001$. The children classified into the impulsive group scored higher in cognitive impulsivity than both children with ADHD ($p < .001$) and control children ($p < .001$). Children with ADHD also scored higher than control children in the MFFT-20 ($p < .05$) (Table 2).

Questionnaire Scores Reported by Parents and Teachers

Scores of impulsive children and control children were not significantly different in any of the questionnaires employed (Table 2), whereas several important differences emerged when they were compared with children with ADHD. Scores obtained by children with ADHD were higher than those obtained by impulsive and control children in all the subscales of the CPRS-48 except for the Psychosomatic and Anxiety subscales (Table 2). Children with ADHD also obtained a higher score than impulsive and control children in the CPRS-10 ($.001 < p < .05$). Significant differences were also found between children with ADHD and the other two groups in the HSQ-R and the SSQ-R ($p < .01$). Regarding the CBCL, children with ADHD scored higher than both impulsive and control children in all the subscales except for the Somatic Problems ($p = .937$, and $p = .201$, respectively). However, when the teachers' version of this questionnaire was employed (the TRF), scores between the groups did not vary as much. Thus, the unique significant differences found in this questionnaire between children with ADHD and impulsive children were in the Affective Problems, the Anxiety Problems, and the Innattention subscale (Table 2). Children with ADHD and controls also scored differently in those same subscales, together with the ADHD subscale (Table 2). With regards to the SDQ, children with ADHD and impulsive children had different scores in the Total scale, the Emotional Symptoms scale, the Hyperactivity scale, and the Peer Problems scale (Table 2). Such differences emerged regardless of who completed the questionnaire. On the contrary, differences between children with ADHD and controls did differ depending on who completed it. A greater difference was noted between the scores for these two groups in the version for parents than in the version for teachers. In the first version, children with ADHD scored higher than controls in most of the subscales (except for the Prosocial subscale, p = .246), whereas in the version completed by their teachers, their scores varied only in three out of the six subscales (Table 2).

Table 2

Mean Scores (SD) Obtained by the Three Groups of Participants (N = 90) in the Matching Familiar Figures Test-20 (MFFT-20) and in the Questionnaires Completed by Their Parents and Teachers

	Group			Post hoc comparisons between groups (*p*)		
Questionnaire	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
MFFT-20	61.97 (31.40)	89.20 (6.19)	42.07 (19.59)	**.000**	**.015**	**.000**
CPRS-48						
Conduct Problem	7.82 (5.26)	3.08 (3.95)	2.92 (2.80)	**.001**	**.000**	.997
Learning Problem	7.73 (2.82)	3.47 (2.90)	2.13 (2.08)	**.000**	**.000**	.126
Psychosomatic	1.47 (1.53)	1.40 (1.52)	0.70 (0.95)	.980	.080	.120
Impulsive-Hyperactive	7.15 (3.21)	4.07 (2.75)	4.71 (2.94)	**.000**	**.006**	.684
Anxiety	2.21 (2.15)	1.93 (1.87)	1.65 (1.85)	.849	.509	.838
ADHD Index	15.24 (5.66)	7.34 (5.92)	6.80 (5.01)	**.000**	**.000**	.925
CTRS-10	10.07 (6.86)	5.57 (6.80)	4.65 (4.74)	**.017**	**.003**	.835
HSQ-R total score	53.56 (29.16)	14.51 (16.84)	12.27 (13.96)	**.000**	**.000**	.923
SSQ-R total score	27.68 (18.03)	12.95 (16.16)	10.69 (16.99)	**.004**	**.001**	.866
CBCL/6-18						
Affective Problems	6.63 (4.56)	2.50 (2.40)	2.19 (2.22)	**.000**	**.000**	.932
Anxiety Problems	4.67 (2.61)	2.53 (2.08)	2.41 (2.79)	**.004**	**.002**	.979
Somatic Problems	1.59 (1.78)	1.44 (1.65)	0.86 (1.27)	.937	.201	.356
ADHD Problems	9.57 (3.20)	4.64 (4.83)	3.91 (2.86)	**.000**	**.000**	.725
Oppositional Problems	5.40 (3.17)	2.87 (2.84)	2.58 (2.29)	**.002**	**.001**	.914
Conduct Problems	4.76 (3.46)	2.48 (3.62)	1.79 (1.99)	**.045**	**.001**	.741
TRF/6-18						
Affective Problems	3.79 (3.37)	1.34 (1.50)	1.70 (2.71)	**.002**	**.031**	.888
Anxiety Problems	2.77 (1.75)	1.34 (1.64)	1.50 (2.06)	**.009**	**.023**	.943
Somatic Problems	1.01 (1.41)	0.60 (1.44)	0.38 (0.96)	.429	.146	.794

Table 2 (*Continued*)

	Group			Post hoc comparisons between groups (*p*)		
Questionnaire	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
TRF/6-18						
Innattention subscale	6.21 (2.88)	2.27 (2.36)	2.12 (2.53)	**.000**	**.000**	.974
ADHD subscale	4.29 (4.00)	2.33 (3.51)	1.70 (2.65)	.136	**.014**	.818
Oppositional Problems	2.65 (2.60)	1.75 (2.73)	1.37 (2.08)	.344	.119	.824
Conduct Problems	3.33 (4.79)	1.40 (2.49)	1.85 (3.33)	.108	.266	.881
SDQ parents						
Total scale	18.88 (6.31)	10.54 (7.12)	8.53 (5.79)	**.000**	**.000**	.456
Emotional Symptoms scale	4.04 (2.35)	2.60 (2.21)	1.76 (1.91)	**.035**	**.000**	.298
Behavioural Problems scale	3.38 (1.95)	2.13 (2.33)	1.80 (1.90)	.063	**.014**	.813
Hyperactivity scale	7.79 (1.85)	4.18 (2.95)	3.72 (2.42)	**.000**	**.000**	.885
Peer Problems scale	3.67 (2.28)	1.62 (1.56)	1.24 (1.27)	**.000**	**.000**	.681
Prosocial scale	6.99 (2.44)	7.79 (2.12)	7.90 (1.74)	.325	.246	.981
SDQ teachers						
Total scale	13.82 (6.62)	6.97 (5.99)	7.04 (5.59)	**.000**	**.000**	.999
Emotional Symptoms scale	2.33 (2.23)	1.21 (1.51)	1.33 (1.62)	.052	.100	.960
Behavioural Problems scale	2.11 (2.14)	0.93 (1.60)	1.27 (1.71)	**.040**	.194	.750
Hyperactivity scale	6.53 (2.62)	3.37 (2.89)	2.90 (2.51)	**.000**	**.000**	.779
Peer Problems scale	2.85 (2.26)	1.46 (1.83)	1.53 (1.97)	**.029**	**.042**	.991
Prosocial scale	6.27 (2.26)	7.22 (2.22)	7.63 (2.23)	.243	.060	.757

Note. SDQ scores were not available for two children with ADHD and one control child. ADHD = attention deficit hyperactivity disorder; CPRS-48 = Conners' Parents Rating Scale-Revised; CTRS-10 = Conners' Teachers Rating Scale; HSQ-R = Home Situations Questionnaire-Revised; SSQ-R = School Situations Questionnaire-Revised; CBCL/6-18 = Child Behavior Checklist; TRF/6-18 = Teacher's Report Form; SDQ = Strength and Difficulties Questionnaire.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the MFFT-20 (Buela-Casal et al., 2002).

N-back Scores

No significant differences were found between the groups in any of the variables evaluated by the n-back in each one of the n-back loads (Table 3).

WISC-IV Scores

Differences between children with ADHD and impulsive children were not found in most of the measures of the WISC-IV. In fact, impulsive children only had a better performance than children with ADHD in the Coding subtest ($p < .05$), which is part of the Processing Speed index. However, several differences were found in the execution of both groups when they were compared with control children.

More specifically, children with ADHD obtained lower scores than control children in Digit Span, Coding, Vocabulary, Letter-Number Sequencing, Comprehension, and Symbol Search subtests ($.000 < p < .05$). Consequently, the performance scores of children with ADHD were lower than those of the control group in almost all of the WISC-IV indexes, including the FSIQ, apart from the Perceptual Reasoning index ($p = .456$) (Table 4, Figure 1).

In relation to impulsive children, they also scored significantly lower than control children in several subtests: Digit Span, Picture Concepts, Letter-Number Sequencing, Matrix Reasoning, Comprehension, and Symbol Search (Table 4). Statistically significant differences between these two groups were also found in all the indexes assessed, with the exception of the Verbal Comprehension index ($p = .209$) (Figure 1).

Table 3

Means (SD) Obtained by the Three Groups of Children (N = 90) in the N-Back

Variables	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	*F*	*p*
			n-back 1		
Correct responses (%)	64.33 (19.56)	68.33 (21.37)	64.11 (21.44)	0.39	.677
Hits	21.11 (7.29)	21.56 (8.15)	17.00 (10.63)	2.44	.093
Correct rejections	43.22 (15.57)	46.78 (16.36)	47.11 (15.26)	0.56	.572
Mistakes (%)	22.67 (17.73)	16.56 (17.43)	22.00 (18.12)	1.07	.348
False alarms	12.56 (14.11)	7.33 (11.59)	9.11 (11.28)	1.38	.258
Misses	10.11 (7.35)	9.22 (7.72)	12.89 (10.57)	1.46	.237
Non-responses (%)	13.00 (14.55)	15.11 (17.37)	13.89 (19.32)	0.11	.892
Mean RT	743.63 (217.75)	743.84 (218.03)	737.13 (191.95)	0.01	.990
Targets	705.21 (226.63)	714.93 (247.99)	727.22 (228.45)	0.07	.936
Non-targets	782.04 (241.87)	772.75 (203.14)	747.03 (205.65)	0.21	.812
			n-back 2		
Correct responses (%)	51.22 (21.66)	52.33 (15.66)	52.22 (15.96)	0.04	.966
Hits	13.78 (9.21)	14.78 (6.99)	12.44 (7.92)	0.63	.536
Correct rejections	37.44 (16.85)	37.56 (13.78)	39.78 (14.49)	0.23	.797
Mistakes (%)	23.56 (13.81)	23.56 (14.09)	23.78 (13.72)	0.00	.997
False alarms	11.00 (10.14)	10.89 (10.24)	9.22 (7.91)	0.33	.720
Misses	12.56 (9.46)	12.67 (8.90)	14.56 (10.26)	0.42	.662
Non-responses (%)	25.22 (25.21)	24.11 (22.75)	24.00 (22.60)	0.03	.976
Mean RT	885.54 (318.25)	861.77 (311.72)	831.85 (264.90)	0.24	.785
Targets	906.51 (442.77)	854.41 (336.32)	836.05 (297.73)	0.30	.740
Non-targets	864.57 (234.31)	869.13 (319.97)	827.65 (268.39)	0.20	.817

Note. Mean response times (RT) were obtained only for correct responses. ADHD = attention deficit hyperactivity disorder.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal et al., 2002).

Table 4

Mean Scores (SD) Obtained by the Three Groups of Children (N = 90) in the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV)

	Group			Post hoc comparisons between groups (*p*)		
Scores	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
BO	9.33 (3.54)	8.87 (3.12)	10.13 (2.89)	.838	.597	.279
SI	11.23 (3.72)	12.83 (2.97)	12.30 (3.83)	.191	.474	.828
DS	2.00 (2.60)	8.77 (2.60)	11.10 (3.11)	.536	**.000**	**.005**
PCn	9.50 (3.95)	8.10 (2.82)	10.47 (3.71)	.279	.541	**.029**
CD	7.67 (3.06)	9.47 (2.40)	10.60 (2.76)	**.035**	**.000**	.253
VO	9.67 (3.67)	10.67 (3.07)	12.27 (3.31)	.484	**.010**	.161
LN	6.83 (3.46)	8.50 (3.50)	10.83 (3.25)	.144	**.000**	**.025**
MR	8.67 (3.52)	7.43 (2.50)	9.47 (3.07)	.268	.571	**.031**
CO	10.07 (4.43)	10.67 (3.10)	13.13 (3.25)	.800	**.004**	**.028**
SS	8.27 (3.03)	9.10 (3.39)	11.43 (3.54)	.597	**.001**	**.021**
VCI[b]	102.60 (18.18)	108.67 (13.50)	115.13 (14.21)	.378	**.013**	.209
PRI[b]	94.50 (17.69)	88.27 (9.61)	100.13 (14.77)	.260	.456	**.002**
WMI[b]	83.77 (15.09)	92.03 (14.97)	104.57 (15.00)	.089	**.000**	**.005**
PSI[b]	90.70 (14.53)	96.80 (13.86)	106.63 (14.31)	.227	**.000**	**.024**
FSIQ[b]	91.20 (16.77)	94.80 (12.55)	108.17 (14.08)	.606	**.000**	**.002**

Note. ADHD = attention deficit hyperactivity disorder; BO = Block Design; SI = Similarities; DS = Digit Span; PCn = Picture Concepts; CD = Coding; VO = Vocabulary; LN = Letter-Number Sequencing; MR = Matrix Reasoning; CO = Comprehension; SS = Symbol Search; VCI = Verbal Comprehension index; PRI = Perceptual Reasoning index; WMI = Working Memory index; PSI = Processing Speed index; FSIQ = Full Scale Intelligence Quotient.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal et al., 2002). [b] Composite scores.

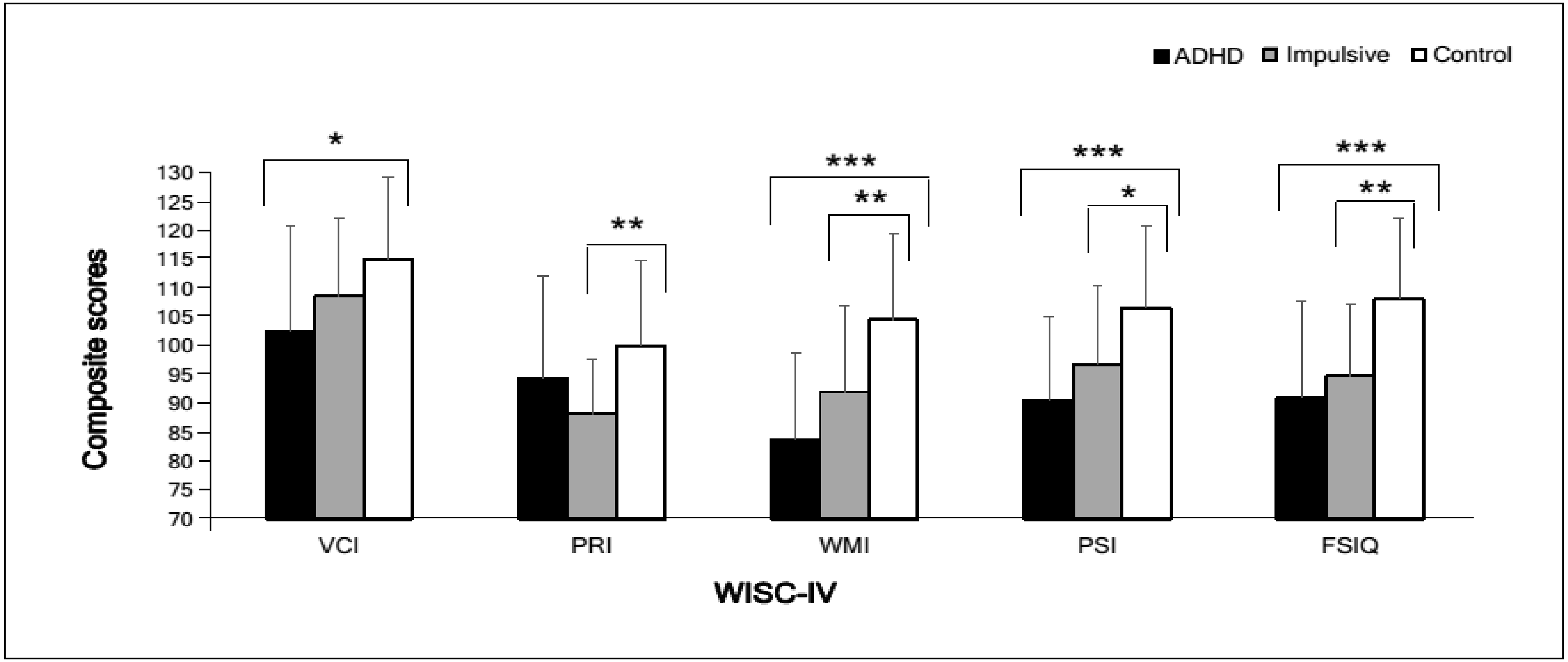

Figure 1. Composite scores obtained by children with attention deficit hyperactivity disorder (ADHD), children with cognitive impulsivity (or impulsive children), and controls in the fourth edition of the Wechsler Intelligence Scale for Children (WISC-IV). VCI = Verbal Comprehension index; PRI = Perceptual Reasoning index; WMI = Working Memory index; PSI = Processing Speed index; FSIQ = Full Scale Intelligence Quotient. *$p < .05$. **$p < .01$. ***$p < .001$.

Discussion

This study was aimed at comparing the WM performance of three groups of children: children with ADHD, children with cognitive impulsivity, and control children. As well as to analyze whether possible differences in executive function found between these groups could vary depending on the modality (phonological or visual) of stimulus presentation. We also wanted to evaluate if their WM performance had an impact on or was linked to other executive functions or their overall cognitive performance. In addition, this study aimed to examine whether differences in performance between the three groups could be affected by other participant characteristics (like age, sex, and medication). Unfortunately, similar age and sex distributions were found between the groups, and most children with ADHD were medication users (Table 1). For this reason, no analysis was performed in this regard, and further discussion on this matter is not possible. Nevertheless, interesting results emerged in our study in relation to our main goals.

On the one hand, we did not find statistical significant differences between the three groups in any of the variables assessed by the n-back, regardless of the memory load (Table 3). However, when children were evaluated by the WISC-IV, children with ADHD and children with cognitive impulsivity obtained significant lower scores than controls (Table 4). Differences between children with ADHD and children with cognitive impulsivity were not found in any of the WM tasks. According to our results, both children with ADHD and children with cognitive impulsivity display deficits in their phonological WM, in comparison to control children. However, neither children with ADHD nor children with cognitive impulsivity show difficulties in relation to their visual WM when compared to controls. The WM performances of children with ADHD and children with cognitive impulsivity do not differ significantly based on whether stimuli are presented either visually or phonologically. This finding is the same regardless of the type of stimuli employed, if we pay attention to their scores in the two subtests included in the WM index (Table 4).

On the other hand, several differences between the groups were found in some of the other executive abilities assessed by the WISC-IV. In general, and considering only their composite scores, significant lower scores in processing speed were obtained by children with ADHD and impulsive children, in comparison with controls. Also the overall cognitive profiles or intelligence quotients of those children were lower than the intelligence quotient of control children. On the contrary, the performance of children with ADHD and children with cognitive impulsivity did not differ significantly ,in any of the main executive functions evaluated, nor in their intelligence quotients. Although, whereas children with ADHD scored lower than controls in verbal comprehension, children with cognitive impulsivity did not, instead scoring lower in perceptual reasoning. So, on the basis of our results, children with ADHD and children with cognitive impulsivity, both show deficits in their phonological WM, as well as showing impairments in other important executive functions. Both their phonological WM deficits and their deficits in the other executive functions assessed in this study may simultaneously contribute to the fact that these children show a lower cognitive profile or intelligence quotient.

Comparing our results in WM with those found in earlier studies, some discrepancies emerge in relation to the n-back. Thus, whereas a lower performance in children with ADHD than in control children was found in some studies (Marx et al., 2010; Strand et al., 2012), no statistical differences between them were found in other studies (Drechsler, Rizzo, & Steinhausen, 2008; Fosco, Hawk, Rosch, & Bubnik, 2015; Zinke et al., 2010). This lack of consistency between the results of the studies carried out, including our own study, could be due to differences related to participants' characteristics and type of n-back employed.

Regarding participants for example, whereas children with ADHD were medication-naive in some studies, the participants in other studies were taking medication to mediate their symptoms. Even in the studies in which medication was removed 24 hours prior to testing, a residual effect of it would be admissible. It is crucial to consider medication when our results and the results of other studies are discussed, because a significant effect of medication on WM has been found in literature (See Coghill et al., 2014, for a review). Such an effect also seems to be suggested by the results of some studies in which children with ADHD were compared to controls in n-back tasks, but a distinction was made between medicated and non-medicated children. For instance, in the study of Kobel et al. (2009), only medication-naive children with ADHD performed worse than controls in the n-back tasks, whereas performance between medicated children with ADHD and controls was more similar. In our study, a high proportion of children with ADHD were medication users.(75%, Table 1), and, besides that, we did not require medication to be removed prior to testing. Therefore, taking into account both facts, it is reasonable to conclude that the use of such medication could have contributed to the absence of significant differences between the groups in the 1- and 2-back tasks.

Other differences between studies regarding the n-back itself, that might have also produced mismatched results, are mainly related to: type of stimuli used, complexity of the task or number of n-back conditions included, and instructions to be followed by children (Cubillo et al., 2014, Kobel et al., 2009; Li et al., 2014; Marx et al., 2010; Strand et al., 2012; Zinke et al., 2010). This lack of similarity between studies regarding the variables mentioned, amongst others, could also lead to different findings in terms of the performance of children with ADHD in n-back tasks. This makes it more difficult to obtain conclusive results about the real visual WM deficits of children with this disorder.

Similarly, differences between studies appear regarding phonological WM too. Although a large number of studies have employed the WISC to evaluate WM in children with ADHD, they differ with regards to the variables taken into account and the outcome measures reported. One of the main reasons for this is the appearance of several versions of the WISC over the years, that have resulted in differences between studies concerning the specific subtests used to assess children. For instance, even amongst the latest studies carried out on this topic, we found that some of them used the third version of the WISC (e.g., Coutinho, Mattos, & Malloy-Diniz, 2009; Drechsler et al., 2008), and others employed the fourth one (e.g., O'Brien, Dowell, Mostofsky, Denckla, & Mahone, 2010; Styck & Watkins, 2014). This makes it difficult to compare the results of the studies regarding WM, given that this cognitive ability is not assessed using the same procedure in both versions of the WISC. Specifically, whereas WM is evaluated only by one subtest (Digit Span) in the WISC-III, it is evaluated by two subtests (Digit Span and Letter-Number Sequencing) in the WISC-IV (Prifitera & Saklofske, 1998; Prifitera, Saklofske, & Weiss, 2005). The WISC-IV gives the opportunity to obtain two separate scores of children's WM performance, and a total score corresponding to the WM index, that is not equal to the WM score computed through the WISC-III. The WISC-III has been the most frequently used version amongst recent studies, and so this does not allow a reliable comparison between our study and numerous previous studies. Furthermore, even when our study is compared to other studies paying attention only to the children's score in the Digit Span subtest, there are still differences in the way this score has been reported. Due to the fact that it is possible to obtain two separate subtest scores (Digit Span forwards and Digit Span backwards), some authors have computed both scores separately (Coutinho et al., 2009; Nyman et al., 2010), instead of a total score as we did. Therefore, although our results are consistent with the results found in earlier studies (O'Brien et al., 2010; Styck & Watkins, 2014), suggesting phonological WM deficits in children with ADHD, further studies are needed to obtain more conclusive findings about the nature of these deficits.

Apart from our findings on WM, our results also seem to be consistent, to a greater or lesser extent, to the results of previous studies regarding the other executive functions evaluated in this study. For instance, there is a large volume of literature suggesting deficits in processing speed in children with ADHD (e.g. Mayes & Calhoun, 2006; Thaler, Bello, & Etcoff, 2013; Wechsler, 2010a). In fact, WM and processing speed are widely considered the main WISC indeces in which children with ADHD have a lower performance (Mayes & Calhoun, 2006; Wechsler, 2010a). There is even one study in which processing speed was the domain in which children with ADHD showed the lowest performance (Yang et al., 2013). So, the worse processing speed performance found in children with ADHD in our study is widely supported by the results of those studies. More interestingly, a relationship between processing speed score in the WISC-IV and inattention has been pointed out in some studies (Mayes, Calhoun, Chase, Mink, & Stagg, 2009; Thaler et al., 2013). Such a relationship could also explain the underperformance in processing speed that was also found in the group of children with cognitive impulsivity, given the attention problems associated with this cognitive style (Buela-Casal et al., 2001). But, unfortunately, the lack of larger research data in this specific area prevents us drawing any conclusion.

Concerning verbal comprehension and perceptual reasoning, our results are not supported by the results of earlier studies to the same extent. Specifically, because it has been suggested that these are the two WISC-IV indices in which children with ADHD have the best performance (Wechsler, 2010a). Thus, the lack of significant differences, in our study, between children with ADHD and controls in perceptual reasoning is consistent with those results, unlike our findings that children with ADHD underperform in verbal comprehension in comparison with control children.Similarly, the lower IQ that we found in children with ADHD compared to controls is not largely explained by other studies conducted up until now. This is mainly because although children with ADHD do seem to have lower IQ scores when compared to their verbal comprehension and perceptual reasoning scores in the WISC-IV, their IQ scores do not seem to be as low as their scores in WM and processing speed (Wechsler, 2010a). Therefore, the degree to which the significant impairment in the overall cognitive performance of children with ADHD impacts on their performance in other executive functions is still not clear. Moreover, it is important to note that children with ADHD were not compared to a matched control group in most of the studies carried out using the WISC. This does not enable us to discuss the possible discrepancies that have arisen between our study and other studies, from an objective and comparative perspective. Neither is it possible to compare differences between studies regarding participants' ADHD symptomatology. Particularly as differences in subtypes amongst children with ADHD seem to impact on their cognitive performance assessed by the WISC-IV

(Fenollar-Cortés, Navarro-Soria, González-Gómez, & García-Sevilla, 2015; Mayes et al., 2009). Given that we did not conduct any statistical analysis according to ADHD subtypes, we cannot determine if this variable could explain why there was not greater agreement between the results of previous studies and our own.

Overall, the lack of any subtype-based analysis as a result of the number of children that did not have an appropriately specified ADHD subtype (Table 1) is one of the main limitations of this study. This prevents us from examining whether children with ADHD differ in cognitive performance more or less depending on their predominant symptoms compared to a control group, or compared to children with cognitive impulsivity. Furthermore, the cross-sectional methodology of this study leads to an absence of cognitive data for the medicated children before they started to use medication. This represents a limitation because it prevents us from determining if the performance of children with ADHD might have been affected by medication use, either in the n-back, as we suggested above, or in the WISC-IV. Another limitation of this study, and of other studies conducted until now, is a greater proportion of boys than of girls amongst participants. Even when no differences were found between the three groups of our study regarding this variable, this presents a problem when generalizing our results to the whole child population with ADHD. Especially taking into account that some studies point out the importance of considering both sexes separately when making an assessment of cognitive performance in children with ADHD (O'Brien et al., 2010). Additionally, the lack of studies that have compared the differences in cognitive performance between children with cognitive impulsivity and controls also means that it is difficult to explore our findings in this area with any depth.

Nevertheless, that last limitation also represents one of the most important strengths of our research. This study provides novel data regarding the cognitive performance of children with cognitive impulsivity in comparison with children with ADHD and controls, to be explored further in future studies. Another strength is that children with ADHD had to have been diagnosed by a clinical specialist before their inclusion in our study, even when their diagnosis was checked later through parents' and teachers' symptomatology reports. That inclusion criteria prevented children with ADHD from taking part in the study only on the basis of cut-off scores on subjective questionnaires. Furthermore, the data provided by parents and teachers also helped us to avoid including children with subthreshold ADHD in any of the other groups of participants.

Conclusions

The results of this study suggest that both children with ADHD and children with cognitive impulsivity have a lower performance in phonological WM and processing speed when compared to controls, as well as a lower overall cognitive profile. Children with ADHD also seem to have more difficulties than controls in verbal comprehension, whilst children with cognitive impulsivity present with more difficulties in perceptual reasoning. On the contrary, no differences in cognitive performance are observed between children with ADHD and children with cognitive impulsivity. Neither are differences observed in visual WM between any of the three groups of children. However, although according to our results children with ADHD and children with cognitive impulsivity have problems with important cognitive functions in comparison to children without ADHD and with a more reflexive cognitive style, more research is required on this matter. Specifically, it would be advisable for more studies that compare the cognitive performance of these three groups of children, to pay more attention to some of the confounding factors that may have an impact. For instance, future studies should address the possible effects of sex, medication use, and ADHD subtypes, on cognitive performance. They should also employ different measures of WM, to obtain more reliable results about the visual and phonological execution of these children.

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ESTUDIO 4

Sleep Characteristics in Children With Attention Deficit Hyperactivity Disorder and Children With Cognitive Impulsivity

Abstract

Background: This study aimed at comparing sleep characteristics of children with attention deficit hyperactivity disorder (ADHD), children with cognitive impulsivity, and a control group. There is still little agreement within the reseach regarding the actual sleep problems underlying ADHD. There is also an absence of studies assessing sleep in children with cognitive impulsivity, despite the attention problems also associated with this cognitive style. **Methods:** Subjective and objective sleep measures of 90 children (30 children per group), aged between 7 and 11 years, were obtained by means of sleep questionnaires and polysomnography recordings. Differences between the groups in every sleep variable were analyzed through Kruskal-Wallis tests. **Results:** Children with ADHD did not differ from children with cognitive impulsivity and control children in any of the subjective or objective sleep variables evaluated. Similarly, no significant differences were found between children with cognitive impulsivity and controls. **Conclusions:** The results suggest that both children with ADHD and children with cognitive impulsivity have similar sleep characteristics to children without ADHD and with a more reflexive cognitive style. It follows that the presence of an ADHD diagnosis or an impulsive cognitive style do not imply sleep problems in those affected. However, these results also highlight the importance of a further exploration of the influence of other variables when sleep problems are studied in these children. Particularly, future studies should address the potential impact of medication and predominant ADHD symptoms.

Keywords: sleep, attention deficit hyperactivity disorder, ADHD, cognitive impulsivity, cognitive style, children.

Introduction

As sleep problems were found in around the 55% of children diagnosed with attention deficit hyperactivity disorder (ADHD) (Corkum, Tannock, & Moldofsky, 1998), numerous studies have been performed in order to gain a better understanding of these sleep difficulties in order to manage them more appropriately. Because sleep has a major impact on the quality of life and functioning of the general population (Baldwin et al., 2010), research has sought to investigate the possible repercussions of sleep on ADHD symptomatology. Particularly, it has even been suggested that sleep problems in children with ADHD might act as a positive feedback mechanism for the exacerbation of their symptoms (Díaz-Román, Hita-Yáñez, & Buela-Casal, 2016). Given the growing worldwide prevalence rate of ADHD in children and adolescents (Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015), a rigorous and complete delimitation of sleep disturbances in children with this disorder is essential.

However, almost two decades after that high rate of sleep problems was found in children with ADHD (Corkum et al., 1998), there is still little agreement about the actual sleep problems underlying ADHD. In fact, numerous discrepancies are observed across studies in relation to the nature of these sleep problems. For instance, it is not even clear yet whether the main sleep disturbances in ADHD are related to sleep efficiency or sleep architecture (Díaz-Román et al., 2016; Ringli et al., 2013; Vigliano et al., 2016; Virring, Lambek, Thomsen, Moller, & Jennum, 2016). Especially, because other studies suggest these disturbances could lie in other subjective sleep descriptors like daytime sleepiness (Bioulac, Micoulaud-Franchi, & Philip, 2015; Schneider, Lam, & Mahone, 2016). There are also studies in which the main sleep problems found may not be directly due to the ADHD itself. For example, several studies have pointed out that children with ADHD display a greater amount of periodic limb movements or sleep breathing problems (See reviews of Cortese, Faraone, Konofal, & Lecendreux, 2009; Cortese, Konofal, Yateman, Mouren, & Lecendreux, 2006; Sadeh, Pergamin, & Bar-Haim, 2006), but these features could also have been linked to primary sleep disorders. So, it remains unclear if such sleep disturbances found in children with ADHD are really core symptoms of this disorder, or if these were indicating the presence of some primary sleep disorders amongst the participants.

Along with the lack of convincing conclusions about the nature of sleep disturbances in children with ADHD, there is another question to be considered. A recent systematic review pointed out that in some studies, participants did not have a clinical diagnosis of ADHD (See Díaz-Román et al., 2016, for a review). Instead, their diagnosis or placement in the ADHD condition group was purely based on their scores in several ratings completed by their parents or teachers. The requirement of assessing ADHD symptomatology in two or more environments before making a diagnosis, is reflected in the *Diagnostic and Statiscal Manual of Mental Disorders* (DSM; American Psychiatric Association, 2013). However, this requirement does not mean that the clinical evaluation itself can be avoided or replaced by subjective measures of ADHD symptoms reported by non-health professionals. Before making a diagnosis, an appropriate and reliable assessment of ADHD symptomatology needs to be made. Especially, given the overdiagnosis associated to ADHD over the last few years (Bruchmüller, Margraf, & Schneider, 2012), and the debate that has arisen around the nature or existence of this disorder (García, González, & Pérez, 2014).

In conclusion, all these questions highlight the importance of further studies in order to reach a conclusion on the sleep problems inherent to ADHD in order for them to be correctly managed. This is precisely the main goal of the present study, but with the inclusion of another relevant line of research that also deserves special attention: the impulsive cognitive style or cognitive impulsivity. Particularly, we want to analyze and compare not only the sleep patterns of children with ADHD and control children, but also compare their sleep patterns with those displayed by children with cognitive impulsivity. Our interest in studying the sleep characteristics of children with cognitive impulsivity lies mainly in the relationship found between this cognitive style and attention deficits (Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2001). Herein, it is important to recall that it has been suggested that sleep problems in children with ADHD might act as a positive feedback mechanism for the exacerbation of ADHD symptoms (Díaz-Román et al., 2016). In case of that being proved, if children with cognitive impulsivity also suffer from sleep problems, these could lead to an exacerbation of their attention problems too.

Therefore, the objectives of this study are: 1) to analyze the sleep characteristics of children with ADHD and children with cognitive impulsivity; 2) to compare the sleep characteristics found in those groups of children with a control group (children without ADHD or cognitive impulsivity); and 3) to examine or control the influence of potential variables involved in the results obtained in previous studies that have been conducted regarding sleep in children with ADHD. In line with this last objective, variables including diagnostic criteria, medication, age and sex will be considered for each participant.

Method

Participants

Thirty children with ADHD, 30 children with cognitive impulsivity, and 30 control children aged between 7 and 11 years were enrolled in this study. The mean age of the participants was 8.81 (*SD* = 1.38), and 36.70% were girls and 63.30% were boys (Table 1). Their parents and tutors also took part in the study by means of the completion of several questionnaires, after prior written informed consent was provided.

Table 1

Demographic Characteristics of the Three Groups of Participants (N = 90)

Variable	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)
Age	8.97 (1.54)	8.87 (1.36)	8.60 (1.25)
Sex	22 boys, 8 girls	19 boys, 11 girls	16 boys, 14 girls
Medication	25 (22 methylphenidate, 3 atomoxetine, 1 aripiprazole, 1 lisdexamfetamine, 1 valproate)		
Subtype	4 inattentive, 2 combined, 24 non-specified		

Note. ADHD = attention deficit hyperactivity disorder.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2002).

A full clinical diagnosis of ADHD was required for children within the ADHD condition, according to according to the DSM or another diagnostic manual. This diagnosis was also confirmed through the administration of a parental clinical interview for ADHD based on the fourth edition of the DSM (DSM-IV; American Psychiatric Association, 1995), and the ADHD symptoms collected by means of the questionnaires completed by their parents and teachers.

The cognitive impulsivity condition was established on the basis of the impulsivity scores obtained by the participants without ADHD in the Matching Familiar Figures Test-20 (MFFT-20; Buela-Casal et al., 2002). When these children scored equal or higher than the 76th quantile, they were classified into the group with cognitive impulsivity, and when they obtained a lower score, they were classified into the control group.

Children without ADHD were selected to partipate in the study if they: a) had no history of psychiatric or psychological disorder or medical illness, b) had no ADHD symptoms reported by their parents and teachers, and c) had no diagnosis of mental retardation or any learning disability that might impact in our results. Children with ADHD were required to meet these same inclusion criteria, albeit allowing for the presence of the ADHD itself and the possible comorbidity of any oppositional defiant disorder or conduct disorder, given the high prevalence rate associated with both conditions in these children (Biederman et al., 2008).

This study was approved by the Human Research Ethics Committee of the University of Granada (Spain).

Instruments and Measurements

Screening measures.

Questionnaire on socio-demographic data. This instrument was developed ad-hoc to obtain information on several participants' socio-demographic characteristics, such as age, sex, academic level, medical history report and medication use, amongst others.

Structured Clinical Interview for ADHD based on the DSM-IV (American Psychiatric Association, 1995). This was administered to the parents as a screening tool. It comprised 18 items regarding whether the symptoms of inattention, hyperactivity and impulsivity established in the DSM-IV for ADHD had been displayed by the child over the past six months. Those items were answered as *yes*, *no*, and *don't know*.there were also four open-answer questions regarding the age of onset and the environments in which the symptoms are displayed, and whether medication was currently used to manage symptoms.

Conners' Parents Rating Scale-Revised (CPRS-48; Goyette, Conners, & Ulrich, 1978). This is composed of 48 items rated on a 4-point scale ranging from 0 (*never*) to 3 (*very often*). The instrument provides a total score and other subscores correponding to five subscales: Conduct Problems, Learning Problems, Psychosomatic, Impulsive-Hyperactive, and Anxiety.

Conners' Teachers Rating Scale (CTRS-10; Conners, 1973; Werry, Sprague, & Cohen, 1975). This scale has a unidimensional factorial structure composed of 10 items, rated on a 4-point scale ranging from 0 (*never*) to 3 (*very often*), that provide a global hyperactivity index.

Home Situations Questionnaire-Revised (HSQ-R; DuPaul & Barkley, 1992). This is composed of 14 items about potential attention problems displayed by the child in a family environment. Items are scored between 0 and 9 points depending on the degree of severity corresponding to those problems. The total score was computed in this study.

School Situations Questionnaire-Revised (SSQ-R; DuPaul & Barkley, 1992). This instrument is composed of eight items regarding potential attention problems displayed by the child in several school situations. Items are scored between 0 and 9 points according to the degree of severity associated with those problems. The total score was computed in this study.

Child Behavior Checklist (CBCL/6-18; Achenbach & Rescorla, 2001). This instrument is useful to assess the presence of potential problems over the last six months, and it is completed by the parents through a response scale ranging from 0 (*not true*) to 2 (*very true or often true*). It comprises 113 items divided into six scales: Affective Problems, Anxiety Problems, Attention Deficit/Hyperactivity Problems, Conduct Problems, Oppositional Defiant Problems, and Somatic Problems.

Teacher's Report Form (TRF/6-18; Achenbach & Rescorla, 2001). This is the teachers' version of the CBCL. Both versions have the same response rate and a quite similar factorial structure, except for the ensemble of some items. This questionnaire evaluates the child's functioning during the last two months.

Strength and Difficulties Questionnaire (SDQ; Goodman, 1997). This is composed of 25 items divided into five scales: Emotional Symptoms, Behavioral Problems, Hyperactivity, Peer Relationship Problems and Prosocial Behaviors. Items are rated on a 3-point scale ranging from 0 (*not true*) to 2 (*totally true*), with the exception of the items 7, 11, 14, 21 and 25, that are reverse scored. The total score is obtained by adding up the scores from all the scales except for the Prosocial Behavior scale.

MFFT-20 (Buela-Casal et al., 2002). This instrument evaluates the cognitive style of reflexivity-impulsivity, and it consists of two training items and 20 measure items. Every item includes a model drawing and six versions of it. The child has to select which of the versions is exactly the same as the model with a maximum of six attempts per item. The response latency for the first attempt, and the number of errors for each item were registered. Afterwards, the mean response latency and the total number of errors were calculated. From these data, the standard scores for impulsivity and inefficiency were computed, following the formulation proposed by Salkind and Wright (1977), and they were transformed into quantiles according to the normative rates provided by Buela-Casal et al. (2002). The cut-off point for impulsivity employed in this study was the 76th quantile.

Sleep measures.

Pediatric Daytime Sleepiness Scale (PDSS; Drake et al., 2003). This is a questionnaire to be completed by the parents. It is composed of eight items with a 5-point response scale ranging from 0 (*never*) to 4 (*always*). This scale is reversed for the last item of the instrument. The total score ranges from 0 to 32 points, and a higher score indicates a higher level of daytime sleepiness.

Pediatric Sleep Questionnaire (PSQ; Tomás, Miralles, & Beseler, 2007). The Part A of the questionnaire was employed. This consists of 43 items related to the behavior displayed by the child during the night and while sleeping. Six of the items present an open-response format, and the other 37 items are answered using a *yes*/*no*/*don't know* response format.

Sleep diary. This includes eight questions on several child's sleep habits (e.g., time to go sleep, time spent before falling asleep, time to wake and get up in the morning, and number of times awake during the night). This ad hoc questionnaire was developed to obtain information about some subjective sleep parameters, such as sleep efficiency, total sleep time, and time awake. Data regarding an entire week were recorded by the parents.

Polysomnography (PSG) recordings. Home PSG recordings (with a SomnoScreen PSG-Tele system from SomnoMedics, Germany) were performed to evaluate sleep. Electrodes for electroencephalogram (EEG), electrooculogram (EOG) and electromiogram (EMG) recordings were placed according to the International 10-20 System (Fz-A1, Cz-A1, Pz-A1, Oz-A1, EOG1-EOG2, EMG1, EMG2). Respiratory variables (oral and nasal airflow, pulse oximetry and thoracic effort), anterior tibial EMG, and body position during the night were also registered. Electrophysiological and PSG signals were analysed using the DOMINO software, and sleep stages were divided into 30-second epochs according to the Rechtschaffen and Kales criteria (1968). These same scoring criteria were also applied to classified manually either sleep stages or other sleep parameters. The following objective sleep parameters were assessed: time in bed, sleep period time, total sleep time, sleep efficiency, sleep latency, wake time, sleep stages 1, 2, 3, 4, slow wave sleep (SWS) and rapid eye movement (REM) sleep, REM latency, arousal index, and index of periodic limb movements (PLMS). A complete description of these parameters is shown in Table 2.

Table 2

Objective Sleep Parameters Recorded by Polysomnography

Sleep parameter	Definition
Time in bed (TIB; in min)	Time between lights off and lights on.
Sleep period time (SPT; in min)	Time from sleep onset to final awakening.
Total sleep time (TST; in min)	Actual sleep time in a sleep period (SPT less movement and awake time).
Sleep latency (in min)	Time between lights off and the beginning of S1.
Sleep efficiency (SE; in %)	(TST/TIB) x 100
Wake time (in min)	Total time awake between sleep onset and final awakening.
Stage 1 sleep (S1; in %)	(Time spent in S1/TST) x 100
Stage 2 sleep (S2; in %)	(Time spent in S2/TST) x 100
Stage 3 sleep (S3; in %)	(Time spent in S3/TST) x 100
Stage 4 sleep (S4; in %)	(Time spent in S4/TST) x 100
Slow wave sleep (SWS; in %)	(Time spent in S3 and S4/TST) x 100
Rapid eye movement sleep (REM; in %)	(Time spent in REM/TST) x 100
REM latency (in min)	Time between S2 and the beginning of the first REM epoch.
Arousal index	Number of rapid changes (per hour of sleep) in the eletroencephalography (EEG) frequency of 3 seconds or greater in duration, and preceded by a minimum of 10 continuous seconds of sleep. These EEG frequency shifts could also lead to a change from sleep to wakefulness, or from a deeper sleep stage to a lighter stage.
Periodic limb movements (PLMS index)	Number of periodic limb movements per hour of sleep.

Procedure

After the recruitment of potentially eligible participants was finished, their parents were contacted and provided with all the information they requested about the investigation. First, the parents and children interested in taking part attended a session in the laboratory for the MFFT-20, although this had been already applied to some children in schools during the participant recruitment. This first session was also used to carry out the clinical interview for ADHD and the questionnaire on socio-demographic data, both with the parents. The other questionnaires to be completed during the research were also provided at this point, along with the questionnaires to be completed by the children's tutors. Written informed consent was required for parents and teachers prior to their self-completion of questionnaires. Either the parents' clinical interview or the data obtained from the parents and teachers' questionnaires were used to assess participants' inclusion criteria. Simultaneously, the impulsivity scores on the MFFT-20 obtained by the children without ADHD were used to carry out their classification into one of the other two participant conditions.

When the first procedure was completed, the sleep evaluation by PSG was scheduled and the parents were requested to complete a sleep diary during a week. We requested that medication be removed 48 hours before sleep evaluation in those children with ADHD who were using it, to prevent medication effects on sleep parameters. To avoid any potential impact on these children's school performance as a result of this medication withdrawal, sleep recordings were performed on Sunday. Researchers also came to the family's home and began with the electrode emplacement at least 2 hours before children's bedtime, in order to get that they became accustomed to the PSG equipment before sleeping.

Researchers provided parents with two reports reflecting their children's sleep results after their participation in the study was concluded.

Data Analysis

Differences between the three groups in terms of age and sex were analyzed by analysis of variance (ANOVA) and Pearson's chi-square, respectively. Their scores in the MFFT-20, and in the questionnaires completed by their parents and teachers, and their sleep parameters measured by PSG were compared by Kruskal-Wallis tests. Further comparisons between the groups were also conducted with Mann-Whitney U tests, when statistically significant differences were found between them in some variable. The IBM SPSS statistics version 23.0 software, and a 95% confidence interval, were used to conduct every data analysis.

Results

Participants' Demographic Profile and MFFT-20 scores

Age and sex of the participants were not found to be significantly different between the three groups, $F(2, 90) = 0.56$, $p = .574$, and $\chi^2(2) = 5.58$, $p = .275$, respectively. Most of participants with ADHD were taking medication and did not have any ADHD subtype specified and reported by a clinician (Table 1), so we did not perform any statistical analysis regarding these two variables.

Mean scores in the MFFT-20 in quantiles were significantly different between the group of children with cognitive impulsivity and the other two groups (Table 3). Impulsive children scored higher in the MFFT-20 than both children with ADHD and control children ($p < .001$). Children with ADHD also scored higher than controls (Table 3).

Symptomatology Reported by Parents and Teachers

Scores of impulsive children and control children were not found to be different in any of the questionnaires completed by their parents and teachers (Table 3), however the scores for both these groups differed significantly compared to those obtained by children with ADHD. Children with ADHD scored higher than impulsive and control children in all the subscales of the CPRS-48, except for Psychosomatic and Anxiety, and in the CTRS-10 (Table 3). Children with ADHD also obtained a higher total score than the other two groups in the HSQ-R and the SSQ-R ($p < .000$). With regards to the CBCL, children with ADHD scored higher than impulsive children and controls in all the subscales, except for the Somatic Problems. In the TRF, the scores of children with

ADHD were also higher than those obtained by impulsive and control children in most of the subscales. The unique exceptions were in Oppositional Problems, in which no differences appeared between children with ADHD and impulsive children, and in Conduct Problems, in which children with ADHD did not differ from the other two groups. Finally, regarding the SDQ, although differences were found between children with ADHD and the other groups in both versions, they were greater in the version for parents (Table 3).

Subjective Sleep Measures

Differences between children with ADHD and impulsive children were not found in any sleep variable assessed by the sleep questionnaires or the sleep diary. Neither did we find any difference between children with ADHD and controls, or between controls and children with cognitive impulsivity (Table 4).

Objective Sleep Measures

No significant differences were found between the groups in any of the sleep variables recorded by PSG (Table 5).

Table 3

Mean Scores (SD) Obtained by the Three Groups of Participants (N = 90) in the Questionnaires

	Group			Post hoc comparisons between groups (*p*)		
Questionnaire	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
MFFT-20	58.86 (31.58)	88.30 (6.28)	40.63 (21.56)	**.000**	**.038**	**.000**
CPRS-48						
Conduct Problem	7.53 (4.89)	3.35 (3.74)	3.15 (2.72)	**.000**	**.000**	.679
Learning Problem	7.90 (2.54)	3.27 (2.79)	2.10 (2.19)	**.000**	**.000**	.083
Psychosomatic	1.30 (1.44)	1.37 (1.45)	0.83 (1.23)	.866	.150	.087
Impulsive-Hyperactive	7.35 (3.21)	3.92 (2.83)	4.77 (3.01)	**.000**	**.002**	.211
Anxiety	2.48 (2.39)	1.50 (1.599	1.57 (1.78)	.072	.114	.963
ADHD Index	15.51 (6.1)	7.12 (5.80)	6.73 (4.96)	**.000**	**.000**	.952
CTRS-10	9.91 (6.83)	5.69 (7.25)	4.44 (4.84)	**.005**	**.001**	.943
HSQ-R total score	52.14 (28.18)	15.84 (16.72)	12.23 (14.27)	**.000**	**.000**	.493
SSQ-R total score	29.15 (18.22)	13.37 (17.34)	10.01 (16.48)	**.000**	**.000**	.327
CBCL/6-18						
Affective Problems	6.32 (4.01)	2.29 (2.23)	1.98 (2.04)	**.000**	**.000**	.616
Anxiety Problems	4.31 (2.29)	2.10 (1.67)	2.05 (2.48)	**.000**	**.000**	.466
Somatic Problems	1.53 (1.54)	1.71 (1.75)	1.15 (1.64)	.796	.197	.141
ADHD Problems	9.64 (3.20)	4.60 (4.72)	3.83 (3.02)	**.000**	**.000**	.789
Oppositional Problems	5.50 (3.18)	3.10 (2.67)	2.49 (2.29)	**.004**	**.000**	.443
Conduct Problems	5.28 (4.17)	2.55 (3.45)	1.77 (2.02)	**.003**	**.000**	.641
TRF/6-18						
Affective Problems	4.29 (3.60)	1.33 (1.77)	1.27 (1.49)	**.000**	**.000**	.954
Anxiety Problems	2.88 (1.81)	1.06 (1.47)	1.02 (1.17)	**.000**	**.000**	.742
Somatic Problems	0.95 (1.38)	0.52 (1.45)	0.39 (0.96)	**.042**	**.029**	.991

Table 3 (*Continued*)

Questionnaire	Group			Post hoc comparisons between groups (*p*)		
	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	ADHD vs. Impulsive	ADHD vs. Control	Impulsive vs. Control
TRF/6-18						
Innattention subscale	6.10 (2.86)	2.14 (2.37)	1.87 (2.31)	**.000**	**.000**	.733
ADHD subscale	4.16 (3.94)	2.36 (3.56)	1.63 (2.63)	**.027**	**.005**	.688
Oppositional Problems	2.72 (2.69)	1.87 (2.80)	1.36 (2.10)	.095	**.019**	.471
Conduct Problems	3.27 (4.71)	1.64 (2.96)	2.00 (3.54)	.051	.083	.903
SDQ parents						
Total scale	19.36 (6.49)	11.07 (7.26)	8.71 (6.38)	**.000**	**.000**	.282
Emotional Symptoms scale	4.08 (2.21)	2.47 (2.15)	1.85 (2.14)	**.005**	**.000**	.207
Behavioural Problems scale	3.67 (2.07)	2.53 (2.54)	1.94 (1.95)	**.027**	**.005**	.440
Hyperactivity scale	7.82 (1.96)	4.32 (2.77)	3.82 (2.55)	**.000**	**.000**	.584
Peer Problems scale	3.79 (2.20)	1.76 (1.76)	1.11 (1.26)	**.000**	**.000**	.199
Prosocial scale	6.73 (2.44)	8.00 (2.06)	7.96 (1.71)	**.044**	.057	.674
SDQ teachers						
Total scale	14.13 (6.51)	6.94 (6.54)	6.57 (5.77)	**.000**	**.000**	.930
Emotional Symptoms scale	2.68 (2.22)	0.99 (1.40)	0.98 (1.42)	**.002**	**.002**	.814
Behavioural Problems scale	2.19 (2.21)	1.13 (1.94)	1.23 (1.73)	**.032**	.091	.570
Hyperactivity scale	6.35 (2.75)	3.31 (3.17)	3.00 (2.78)	**.000**	**.000**	.822
Peer Problems scale	2.91 (2.14)	1.51 (1.81)	1.36 (1.83)	**.010**	**.002**	.724
Prosocial scale	6.50 (2.36)	7.37 (2.14)	7.44 (2.15)	.195	.164	.859

Note. Parents' questionnaires were not available for one control child, and teachers' questionnaires were not available for three children (one child of each group). SDQ scores were not available for two children with ADHD and one control child. ADHD = attention deficit hyperactivity disorder; MFFT-20 = Matching Familiar Figures Test-20; CPRS-48 = Conners' Parents Rating Scale-Revised; CTRS-10 = Conners' Teachers Rating Scale; HSQ-R = Home Situations Questionnaire-Revised; SSQ-R = School Situations Questionnaire-Revised; CBCL/6-18 = Child Behavior Checklist; TRF/6-18 = Teacher's Report Form; SDQ = Strength and Difficulties Questionnaire.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the MFFT-20 (Buela-Casal et al., 2002).

Table 4

Subjective Sleep Measures of the Three Groups of Participants (N = 90) Obtained Through the Pediatric Daytime Sleepiness Scale (PDSS), the Pediatric Sleep Questionnaire (PSQ), and the Sleep Diary, Completed by Their Parents

	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	$\chi2$	*p*
PDSS	9.43 (5.98)	7.45 (5.16)	6.36 (4.81)	4.33	.115
Total score PSQ (Part A)[b]	0.25 (0.17)	0.22 (0.18)	0.19 (0.20)	3.84	.147
Sleep diary					
Time in bed (min)	601.24 (33.78)	592.23 (28.28)	599.40 (32.23)	1.28	.528
Total sleep time (min)	563.85 (37.15)	564.71 (31.46)	565.87 (38.21)	0.05	.974
Sleep efficiency (%)	92.64 (8.48)	94.34 (3.43)	93.80 (6.50)	0.32	.853
No. of awakenings	0.32 (0.50)	0.23 (0.31)	0.19 (0.37)	1.44	.486

Note. The sleep diary of three impulsive children and one control child could not be collected. ADHD = attention deficit hyperactivity disorder.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal et al., 2002). [b] Part A collects information about the behavior displayed by the child during the night and while sleeping. The total score is computed by dividing the number of items answered positively by the total number of items answered (either positively or negatively). This total score can vary from 0 to 1. A higher total score reflects a higher number of sleep problems.

Table 5

Objective Sleep Measures of the Three Groups of Participants (N = 90) Obtained by Polysomnography

Sleep parameter	ADHD (*n* = 30)	Impulsive (*n* = 30)[a]	Control (*n* = 30)	χ2	*p*
Time in bed (min)	556.45 (77.03)	562.61 (48.32)	562.27 (52.26)	0.08	.962
Sleep period time (min)	519.47 (72.60)	539.60 (45.68)	545.92 (96.73)	0.78	.678
Total sleep time (min)	484.80 (69.24)	505.13 (44.71)	495.97 (57.33)	0.85	.652
Sleep latency (min)	25.39 (22.68)	18.27 (14.34)	21.65 (21.60)	1.10	.577
Sleep efficiency (%)	87.39 (6.91)	90.11 (5.91)	88.50 (7.42)	2.10	.350
Wake time (min)	11.10 (8.47)	9.07 (3.92)	9.83 (6.18)	0.23	.893
Stage 1 sleep (%)	5.34 (7.33)	3.08 (1.83)	4.42 (3.30)	2.54	.281
Stage 2 sleep (%)	34.93 (8.41)	34.61 (9.15)	33.96 (8.91)	0.49	.784
Stage 3 sleep (%)	14.04 (4.52)	15.22 (6.01)	13.23 (4.64)	0.33	.849
Stage 4 sleep (%)	29.42 (7.87)	29.91 (7.02)	31.02 (7.54)	0.80	.670
Slow wave sleep (%)	43.45 (8.56)	45.14 (8.96)	44.27 (10.10)	0.85	.654
REM sleep (%)	17.52 (4.84)	17.17 (5.03)	17.38 (5.07)	0.03	.986
REM latency (min)	147.82 (46.26)	179.97 (52.33)	182.03 (81.02)	5.96	.051
Arousal index	0.14 (0.22)	0.09 (0.17)	0.10 (0.17)	1.14	.567
PLMS index[b]	0.51 (0.97)	0.58 (1.00)	0.75 (1.38)	0.08	.962

Note. The exact PLMS index of three impulsive children could not be computed. ADHD = attention deficit hyperactivity disorder; REM = rapid eye movement; PLMS = periodic limb movements.

[a] The impulsive group comprised children whose scores in cognitive impulsivity were equal or higher than the 76th quantile in the Matching Familiar Figures Test-20 (Buela-Casal et al., 2002).

Discussion

The main goals of this study were to analyze the sleep characteristics of children with ADHD and children with cognitive impulsivity, and to compare them with children without ADHD or cognitive impulsivity. In relation to those goals, we did not find statistically significant differences between the three groups of children in any of the subjective and objective sleep variables taken into account.

Furthermore, we also wanted to examine the influence of other variables that could be potentially involved in the results of other studies conducted until now. Our attention was mainly focused on age, sex, medication, diagnostic criteria, and predominant ADHD symptoms. According to this, participants' information regarding age, sex, and medication were collected in order to perform further analyses in case differences were found between the groups. However, the lack of differences between them in age and sex made such analyses unjustifiable. Similarly, no analysis was done on the effects of medication , as most of children with ADHD were taking medication in our study (25 out of 30). The inequitable number of medicated and nonmedicated children did not enable to perform any comparative analysis with reliable results. The same was true in relation to predominant ADHD symptoms, as most of the children did not have any ADHD subtype appropriately specified. Nevertheless, the inclusion criteria established in this study allowed us to control the diagnostic criteria for ADHD, to a greater or lesser extent. This is because children with ADHD were required to have been diagnosed by a clinical specialist before taking part in the study, and that ADHD symptomatology was also corroborated later by parents' and teachers' reports. This procedure prevented us from including children with an ADHD diagnosis based only on subjective questionnaires, which has been a drawback in some previous studies.

Our findings in regard to differences between the groups in terms of sleep are not sufficiently consistent with other results of earlier studies. Unlike our findings, within the literature, sleep disturbances have largely been associated with ADHD in children, regardless of the sleep measures employed to assess their sleep characteristics. Numerous studies in which subjective sleep measures are employed indicate that children with ADHD show higher daytime sleepiness, sleep onset delay, sleep anxiety, night wakenings, and a lower sleep duration (Gruber et al., 2012; Owens, Maxim, Nobile, McGuinn, & Msall, 2000; Schneider et al., 2016). The fact that not all these variables were considered in our study may explain why we did not find more sleep difficulties in children with ADHD. However, the truth is that they were not found in those variables that we did evaluate. For instance, children with ADHD did not significantly differ from controls in sleep duration (or total sleep time), according to their sleep diaries, or in daytime sleepiness, according to their scores in the PDSS. Neither did they differ regarding their sleep quality in general, if we consider their total scores in the PSQ (Table 4).

There are some variables that could have contributed to these discrepancies between our results and the results of those studies. One of them is linked to the questionnaires used to collect sleep data. A large amount of studies in which sleep was assessed by some questionnaire focused on general sleep features over a determined period of time. On the contrary, studies in which sleep was assessed by sleep diaries, that enable the collection of more specific data, are more sparse. The use of a different sleep measure, even when all are subjective and completed by parents, might explain some differences in results. Another variable that might also explain those divergent results could be the presence of primary sleep disorders amongst participants with

ADHD in some studies. This might explain why children with ADHD displayed a greater number of sleep difficulties than controls, as subjective sleep data were not always supported by additional objective sleep assessments (e.g., Chiraphadhanakul, Jaimchariyatam, Pruksananonda, & Chonchaiya, 2016; Owens et al., 2000; Schneider et al., 2016), as they were in our study.

In other studies, sleep problems were also reported in children with ADHD when an objective sleep assessment was conducted. Regarding this, several studies seem to suggest that children with ADHD have a higher sleep latency, a lower sleep efficiency, and a greater amount of REM sleep (Lee et al., 2014; Prehn-Kristensen et al., 2011; Vigliano et al., 2016; Virring et al., 2016). Differences between children with ADHD and children without this disorder were also found in some NREM sleep stages. For instance, in the study of Vigliano et al. (2016), children with ADHD spent a higher amount of time in stage 1 sleep, and a lower amount of time in stages 2, 3 and 4. Conversely, in the study of Virring et al. (2016), lower amounts of sleep time were found regarding either stage 3 sleep or stage 1 sleep in children with ADHD. Sleep time corresponding to stage 1 sleep was also found to be shorter in children with ADHD in another study (Ringli et al., 2013). However, in a recent meta-analysis (Díaz-Román et al., 2016), the higher amount of time that children with ADHD spent in stage 1 sleep was pointed out as the unique difference between them and children not diagnosed with ADHD. In conclusion, although our findings are not consistent with the results of several previous studies, in regards to the absence of differences in sleep between children with ADHD and the other two groups, neither are the results provided by those studies consistent with each other. Furthermore, there are some studies in which no differences were found between children with ADHD and controls.

Several authors that compared children with ADHD and controls by means of PSG recordings, did not find significant differences between them in any sleep parameter (Cooper, Tyler, Wallace, & Burgess, 2004; Prehn-Kristensen, Munz, Molzow, Wilhelm, & Wiesner, 2013; Příhodová, Paclt, Kemlink, & Nevšímalová, 2012). Other authors, that obtained actigraphy measures, did not find differences either (Bergwerff, Luman, & Oosterlaan, 2016; Mullin, Harvey, & Hinshaw, 2011). Even though there are studies in which children with ADHD differed from controls in sleep measures obtained by questionnaires, they did not when their sleep characteristics were assessed objectively. For instance, in the study of Akinci et al. (2015), although children with ADHD showed a lower sleep quality and a higher daytime sleepiness than controls according to parents' reports, no differences were evident between them on the PSG recordings. Such discrepancies between subjective and objective sleep measures seem to suggest an impact of the type of sleep assessment on sleep findings. Even when sleep characteristics have been evaluated by different objective methods in studies, differences haveemerged in the results. For example, the study by Virring et al. (2016), in which children with ADHD differed from controls in PSG recordings, but no differences were found on the multiple sleep latency test (MSLT). However, Wiebe et al. (2013), who collected sleep data through three objective methods (PSG, actigraphy, and MSLT), as well as through questionnaires, did not find differences between children with ADHD and controls in any of the sleep methods employed.

As well as differences in results as a consequence of the sleep assessment method employed, there are still other variables that can affect results, increasing discrepancies between the studies conducted. One of the most important variables that may have lead us to different findings compared to previous investigations is the use of medication. A negative effect of medication on sleep in children with ADHD has been found in numerous studies over the years (Herman, 2015; Mick, Biederman, Jetton, & Faraone, 2000; Morash-Conway, Gendron, & Corkum, 2016; Stein, 1999). However, recent findings seem to suggest the opposite. For instance, Vélez-Galarraga, Guillén-Grima, Crespo-Eguílaz, and Sánchez-Carpintero (2016) found that those children without pharmacological treatment experienced more difficulties in getting to sleep than medicated children, and Chiraphadhanakul et al. (2016), also found fewer behavioral sleep problems in the medicated group. If one were to accept the conclusion that medication has a positive effect on sleep in children with ADHD, this might explain, to a greater or lesser extent, the results found in our study. Although we required medication to be removed 48 hours before sleep evaluation by PSG, a residual effect of a prolonged medication use of it could be admissible. And, in addition to that, parents were not required to complete the sleep questionnaires according to the time at which children were not under medication.

Nevertheless, whether medication impacts or not on sleep is still inconclusive. Particularly, because overall, the results of other studies support neither a positive effect, nor a negative one of medication on sleep in children with ADHD. Thus, no differences between medicated and nonmedicated children were observed in some studies (Cohen-Zion & Alcoli-Israel, 2004; Moreau, Rouleau, & Morin, 2014), and there were relatively few differences between them in other ones (Gau & Chiang, 2009; Schneider et al., 2016). In one study, sleep characteristics of the same group of participants with ADHD were assessed before and after medication use, but no significant changes were found in sleep architecture after medication intake (Vigliano et al., 2016). In this regard, the cross-sectional methodology followed in our study did not allow us to obtain participants' sleep measures prior to medication use. This lack of data to compare sleep parameters pre and post medication does not enable us to conclude if medication use may have prevented more differences between the groups being found. Although there are reasonable reasons to believe that this could be the case, according to somefindings within the research.

Another variable that could have created discrepancies between our study and other studies is related to the participants included. Or, more specifically, to the predominant ADHD symptomatology, or ADHD subtypes, amongst participants with this disorder. Although no differences in sleep were found regarding ADHD presentations in a recent study (Virring et al., 2016), the results of other studies seem to imply the opposite. some previous studies suggested that the children's predominant symptoms or ADHD subtypes may have an impact on their sleep disturbances, such as those children with the inattentive subtype showing fewer sleep problems and those with hyperactive-impulsive subtype showing more (Mayes et al., 2009; Wagner & Schlarb, 2012). The large number of children without any ADHD subtype appropriately specified in our study prevents us from determining the real effect of their ADHD subtypes on our results. Therefore, this question deserves a proper consideration when our results are discussed.

In general, some limitations are observed in this study; amongst them, the impossibility of providing data about subtype differences in sleepThis limitation does not enable an analysis of whether children with ADHD have more or fewer sleep problems than children with cognitive impulsivity depending on if they display more inattentive or hyperactive-impulsive symptoms. Another limitation is the cross-sectional methodology employed in this study. This makes it difficult to appropriately address the potential effect of medication on children's sleep characteristics, or how medication may mediate or reduce differences found between children with ADHD and the other two groups of children. There is also a noticeable limitation related to the discussion of our results regarding the group of children with cognitive impulsivity. Although cognitive impulsivity has been positively associated with some of the sleep problems suffered by children with ADHD (Lee et al., 2014), sleep problems in children with cognitive impulsivity but without ADHD were not evaluated. So, this is, to our knowledge, the first study that provides data on sleep characteristics in children with cognitive impulsivity. The lack of studies in regards to this aspect of our study restricts possibilities for comparison of our findings with existing evidence and, thus, for drawing any firm conclusion.

However, the novelty of analyzing sleep characteristics in children with cognitive impulsivity and comparing them to children with ADHD and a control group, represents one of the main strengths of this study. Another strength is related to the inclusion criteria required for participants. Particularly, the requirement for children with ADHD to have been diagnosed previously by a clinician rather than their participation being based only on cut-off scores on subjective questionnaires. Moreover, the collection of symptomatology data from two important environments -home and school-, through parents' and teachers' reports, also allowed us an appropriate classification of children into groups. The inclusion of this criteria permitted us to ensure the ADHD diagnosis of children in this condition, as well as that preventing the inclusion of children with subthreshold ADHD in the other two groups. Furthermore, the sleep assessment through both subjective and objective methods is another strength to be noted, given the discrepancy in results that are observed in the literature when different sleep measures are employed.

Conclusions

In summary, the results of this study suggest that children with ADHD do not differ from children with cognitive impulsivity in sleep characteristics. Neither do these groups of children differ significantly from children with a more reflexive cognitive style. Furthermore, the same results appear regardless of whether subjective or objective measures were employed to assess their sleep characteristics. According to these findings, the presence of sleep problems is not directly implied by either an ADHD diagnosis or an impulsive cognitive style. However, these results should be considered only as preliminary findings to be explored in further studies. It is possible that other variables could have led to the lack of significant differences found between the three groups of children, and this should be considered when coming to a conclusion regarding our findings. For example, the positive or negative effect of medication on sleep should be further addressed in future studies from a longitudinal approach. The impact of predominant ADHD symptoms or subtypes is also worthy of further research, in terms of their effect on the sleep patterns of children with ADHD, or on the greater sleep problems that they may cause in children without this disorder. Finally, more research on sleep in children with cognitive impulsivity, but without ADHD, is required to determine the degree to which sleep problems may affect children’s cognitive style.

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ESTUDIO 5

Children With Attention Deficit Hyperactivity Disorder and Children With Cognitive Impulsivity: Cognitive Performance and Relationship With Their Sleep Characteristics

Abstract

Objective: This study provides data on the cognitive performance of children with attention deficit hyperactivity disorder (ADHD) and children with cognitive impulsivity, in comparison to a control group. It also provides a further analysis of the relationship between sleep and the cognitive problems displayed by those children, or the ADHD symptoms and related problems suffered by children with ADHD. **Participants:** 30 children with ADHD, 30 children with cognitive impulsivity, and 30 control children. **Methods:** The children's cognitive performance in several tasks were compared. Correlations between subjective and objective sleep variables and cognitive variables in which children performed worse were computed within each group. Correlations between sleep variables, ADHD symptoms and related problems were also computed for children with ADHD. **Results:** Both children with ADHD and children with cognitive impulsivity showed cognitive deficits compared to controls, but these were higher in children with ADHD. A difference between them also emerged in relation to visual working memory. Some sleep variables correlated with the cognitive problems displayed by those children, as well as with the ADHD symptoms and related problems displayed by children with ADHD. **Conclusions:** The results of this study seem to suggest that sleep may have an impact on the cognitive problems seen in children with ADHD and children with cognitive impulsivity, as well as impacting on the ADHD symptoms and other problems suffered by children with ADHD. However, in order to support these findings, longitudinal studies that enable the establishment of a causal relationship between all these variables are required.

Keywords: sleep, cognitive performance, attention deficit hyperactivity disorder, ADHD, cognitive impulsivity, children.

Introduction

A high rate of school dropout has been estimated amongst students with attention deficit hyperactivity disorder (ADHD) (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2007; Barkley, Murphy, & Fischer, 2008), most likely due to the lower school performance associated with this disorder (Daley & Birchwood, 2010; Loe & Feldman, 2007). Inattention, hyperactivity and impulsivity symptoms, and cognitive impairments linked to ADHD seem to be the main causes for such school problems (Daley & Brichwood, 2010).

In particular, several problems related to working memory (WM), response inhibition, sustained attention, and processing speed (PS), amongst other executive functions, were suggested in children with ADHD in numerous studies (e.g., Moreno-García, Delgado-Pardo, & Roldán-Blasco, 2015; Schneider, Lam, & Mahone, 2016; Thaler, Bello, & Etcoff, 2013). Despite this, there is still insufficient agreement about their real cognitive impairments, due to some discrepancies between the results found across studies. As an example, even when WM deficits are one of the most commonly reported problems in children with ADHD, the WM performance of children with ADHD did not differ from normative children in some studies (Drechsler, Rizzo, & Steinhausen, 2008; Fosco, Hawk, Rosch, & Bubnik, 2015; Zinke et al., 2010). Concerning this, it has been pointed out that the possible involvement of other variables, besides ADHD, may be related to the cognitive deficits found in these children in research, and could explain the discrepancies between the studies. For instance, the results of a meta-analytic review suggested that some variables linked to the task employed for WM assessment itself (such as the number of trials, and the modality of stimuli presentation) could affect results (Kasper, Alderson, & Hudec, 2012).

Other variables that might have affected the results found about cognitive performance in children with ADHD are medication use, ADHD symptomatology, and sleep. Some studies have reported differences amongst children with ADHD, depending on medication use, suggesting a positive impact of this on their cognitive performance (Coghill et al., 2014; Pietrzak, Mollica, Maruff, & Snyder, 2006). ADHD subtypes have also been found to have an influence on their cognitive performance in other studies (Fenollar-Cortés, Navarro-Soria, González-Gómez, & García-Sevilla, 2015; Mayes, Calhoun, Chase, Mink, & Stagg, 2009). Other findings connect sleep with the cognitive performance of children with ADHD, even suggesting that sleep might moderate the possible effect of medication on it (Morash-Conway, Gendron, & Corkum, in press).

Regarding sleep, the relationship between this and ADHD has been widely addressed in research, with multiple studies aimed at analyzing the sleep patterns of children with ADHD. However, a lack of convincing results in relation to the actual sleep problems suffered by these children in comparison to children without ADHD is also observed (Díaz-Román, Hita-Yáñez, & Buela-Casal, 2016b). As a result, the nature of those problems, or whether they are the result of other variables unrelated to the ADHD itself, remains undetermined. Specifically, medication use, ADHD subtypes, and comorbid problems are amongst the factors thought to can be potential confounding variables for the results found on sleep and ADHD (Chiraphadhanakul, Jaimchariyatam, Pruksananonda, & Chonchaiya, 2016; Herman, 2015; Lycett, Mensah, Hiscock, & Sciberras, 2014; Wagner & Schlarb, 2012). The inconsistency of results between the studies conducted has prevented the obtainment of unquestionable conclusions regarding both sleep and cognitive impairments in children with ADHD. Consequently, the real extent of the impact of sleep on cognitive performance in these children is still unknown.

Another question that has not been appropriately addressed in research, and that also deserves special consideration, is the impulsive cognitive style or cognitive impulsivity. Although cognitive impulsivity has been associated with attention problems (Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2001), there is a need for further studies that analyze cognitive performance and sleep patterns in children with this cognitive style. There is also a need for studies that provide data regarding cognitive and sleep differences between these children and children with ADHD, when they are compared to children without ADHD and with a more reflexive cognitive style. Importantly, knowing whether both children display similar cognitive deficits, and understanding the repercussion of sleep on these deficits, could help to develop appropriate interventions to prevent or manage their school problems and subsequently reduce the risk for school failure or dropout.

Therefore, the goals of this study were: 1) to compare children with ADHD, children with cognitive impulsivity, and control children, in cognitive performance; 2) to assess the relationship between the cognitive impairments found in those children and their sleep characteristics; and 3) to analyze the relationship between symptomatology and sleep characteristics within children with ADHD.

Method

Participants

Thirty children with ADHD, 30 children with cognitive impulsivity, and 30 control children) took part in a previous study in which their sleep characteristics were compared (Díaz-Román, Hita-Yáñez, & Buela-Casal, 2016a). The present study comprised an assessment of the cognitive performance of those children (mean age = 8.81, *SD* = 1.38; 63.30% boys), and a further analysis of their sleep characteristics in relation to their cognitive performance and ADHD symptomatology.

Children with impulsivity scores in the Matching Familiar Figures Test-20 (MFFT-20; Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2002) equal or higher than the 76th quantile were included into the group of cognitive impulsivity or impulsive group. Full description of participants' inclusion criteria is available elsewhere (Díaz-Román et al., 2016a). In summary, impulsive children and controls could not have any psychiatric/psychological disorder or medical illness, or learning disability that could impact on results. Children with ADHD needed to have a diagnosis established by a clinician and not based only on school reports, and no comorbidities apart from comorbid oppositional defiant disorder or conduct disorder were allowed. The clinical diagnosis was also corroborated by the research team through a structured clinical interview for ADHD based on the fourth edition of the *Diagnostic and Statiscal Manual of Mental Disorders* (DSM-IV; American Psychiatric Association, 1995), administered to their parents, and symptomatology data collected by parents' and teachers' questionnaires.

This investigation was approved by the Human Research Ethics Committee of the University of Granada (Spain), and written informed consent was provided by parents and teachers.

Screening and Sleep Measures

Personal data on age, sex, medical history and medication use, along with other variables, were collected. The MFFT-20 (Buela-Casal et al., 2002), and the following questionnaires for parents and teachers were employed as screening tools: the Conners'

Parents and Teachers Rating Scales (CPRS-48 and CTRS-10; Conners, 1973; Goyette, Conners, & Ulrich, 1978; Werry, Sprague, & Cohen, 1975), the Home and School Situations Questionnaires-Revised (HSQ-R and SSQ-R; DuPaul & Barkley, 1992), the Child Behavior Checklist and Teacher's Report Form (CBCL/6-18 and TRF; Achenbach & Rescorla, 2001), and the Strength and Difficulties Questionnaires (SDQ; Goodman, 1997).

Subjective sleep data were obtained from parents through: a) The Pediatric Daytime Sleepiness Scale (PDSS; Drake et al., 2003); b) Part A of the Pediatric Sleep Questionnaire (PSQ; Tomás, Miralles, & Beseler, 2007); and c) a sleep diary completed during a week.

Objective sleep data were obtained by home polysomnography (PSG) recordings. The Rechtschaffen and Kales criteria (1968) were followed to score sleep. The objective variables considered for this study were: time in bed (TIB), sleep period time (SPT), total sleep time (TST), sleep efficiency (SE), sleep latency (SL), wake time (WT), sleep stages 1, 2, 3, and 4 (S1, S2, S3, and S4), slow wave sleep (SWS), rapid eye movement (REM) sleep, and REM latency.

Further description of the screening instruments, the sleep evaluation, and the sleep parameters assessed were reported elsewhere (Díaz-Román et al., 2016a).

Cognitive Performance Assessment

Three laboratory sessions were arranged for the cognitive evaluation which comprised the following tasks:

Integrated Visual and Auditory Continuous Performance Test (IVA CPT; Sandford & Turner, 2000). An adaptation of the original version (Sandford & Turner, 2000), was employed to assess response control and sustained attention. This comprised a practice block (16 trials), and four experimental blocks (60 trials per block; 30 with auditory stimuli and 30 with visual stimuli). The version used did not allow the transformation of children's scores into standardized scores, so the total scores of the Response Control, Attention and Attribute scales were not computed. However, the scores corresponding to each subscale were calculated for auditory and visual modalities.

Computer reversal test. This was employed to assess children's discrimination learning/ability, and included a practice block (14 trials) and four experimental blocks (two learning blocks and two reversal blocks; 30 trials per block). Pairs of animals were used as stimuli, and children had to select one animal of each pair pressing the correct button of the mouse corresponding to its placement on the screen. They received immediate feedback on their performance. Mean response times for correct responses, and percentages of correct responses, mistakes, and non-responses, were computed for acquisition and reversal conditions.

N-Back. Two conditions (1-back and 2-back) were used to evaluate WM. Children had to press the right or left mouse button when the number shown on the screen was or was not the same as the number presented *n* trials before. Each condition included 20 practical and 30 experimental trials. Mean response times for correct responses, and percentages of correct responses (hits and correct rejections), mistakes (false alarms and misses) and non-responses, were computed for each condition.

Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV; Wechsler, 2010b). The Full Scale Intelligence Quotient (FSIQ) and the composite scores on the four indices of verbal comprehension (VC), perceptual reasoning (PR), WM, and PS, were computed.

Statistical Analyses

Children's scores on cognitive performance were compared by Kruskal-Wallis or Mann-Whitney U tests, depending on if significant differences appeared between the groups. Spearman correlation coefficients were computed for sleep with the cognitive deficits found in each group, and for sleep with ADHD symptomatology within children with ADHD. The IBM SPSS statistics version 23.0 software, and a 95% confidence interval, were used for analyses.

Results

Data on participants' characteristics, parents' and teachers' questionnaires, cognitive impulsivity, and sleep measures, were reported elsewhere (Díaz-Román et al., 2016a). The groups did not differ in age, sex, and sleep parameters, whilst they did in cognitive impulsivity and questionnaires, as expected.

Cognitive Performance

IVA CPT. Response control of children with ADHD was worse than the other two groups, with higher scores in auditory and visual prudence (Table 1). They showed a lower influence of presentation modality (visual or auditory) in performance than impulsive children, according to their scores in balance. No differences were observed in the attention subscales.

Table 1

Mean Scores (SD) of the Three Groups of Children (N = 90) in an Adapted Version of the Integrate Visual and Auditory Continuous Performance Test

	Group			Post hoc comparisons between groups (*p*)		
Scale	ADHD (1)	Impulsivity (2)	Control (3)	1 vs. 2	1 vs. 3	2 vs. 3
Response Control						
Auditory						
Prudence	7.97 (12.07)	3.50 (4.85)	4.43 (11.10)	**.025**	**.008**	.624
Consistency	218.41 (83.29)	198.44 (58.68)	202.69 (60.23)	.391	.565	.791
Stamina[a]	-68.24 (131.90)	-69.71 (101.02)	-55.52 (136.54)	.813	.779	.889
Visual						
Prudence	6.90 (14.74)	1.30 (1.88)	3.32 (10.40)	**.010**	.086	.274
Consistency	227.13 (83.22)	190.72 (54.92)	200.81 (67.14)	.058	.290	.652
Stamina[a]	-49.82 (116.74)	-9.48 (78.19)	-8.66 (111.88)	.152	.064	.446
Attention						
Auditory						
Vigilance	0.90 (2.92)	0.07 (0.25)	1.39 (7.37)	.203	.122	.627
Focus	200.27 (70.26)	195.26 (57.98)	200.14 (58.79)	.790	.963	.744
Speed	804.24 (164.41)	845.01 (114.91)	840.09 (105.31)	.367	.269	.852
Visual						
Vigilance	2.47 (10.32)	0.07 (0.25)	0.21 (0.79)	.185	.444	.565
Focus	217.95 (84.16)	187.50 (54.33)	201.12 (71.15)	.156	.534	.619
Speed	752.94 (161.46)	737.57 (106.50)	746.96 (111.36)	.595	.840	.709
Attribute						
Balance[b]	47.95 (101.15)	100.33 (59.75)	103.70 (97.03)	**.017**	.050	.767
Balance_CR[b]	51.29 (99.46)	107.44 (55.67)	93.13 (73.22)	**.011**	.074	.597
Readiness[c]	-52.42 (65.65)	-65.00 (55.56)	-33.26 (83.16)	.657	.269	.120
Readiness_CR[c]	-46.59 (67.35)	-66.14 (56.47)	-39.66 (94.27)	.322	.608	.116

Note. The means and standard deviations shown in the table were directly obtained from the children's data, with no transformation into standardized scores. The execution scores of two control children were not available. ADHD = attention deficit hyperactivity disorder; CR = correct responses.

[a] A negative value means that the children's processing speed was affected by the length of time elapsed. [b] A positive value means that children processed visual information quicker than auditory information. [c] A negative value means that children processed information quicker when the demand was higher than when it was lower.

Computer Reversal Test. Children did not differ in the learning blocks, but children with ADHD and impulsive children committed more mistakes than controls in the reversal ones (Table 2). Impulsive children also obtained a lower percentage of correct responses than controls in those blocks. Performance of impulsive children was significantly affected by the type of block, according to their correct responses in learning and reversal blocks (*d*_correct responses), and in comparison to control children (Table 2).

Table 2

Mean Scores (SD) Obtained by the Three Groups of Children (N = 90) in the Computer Reversal Test

	Group			Post hoc comparisons between groups (*p*)		
Variable	ADHD (1)	Impulsivity (2)	Control (3)	1 vs. 2	1 vs. 3	2 vs. 3
Learning						
CR (%)	66.38 (12.40)	66.22 (10.57)	65.69 (10.71)	.814	.618	.820
M (%)	32.59 (11.67)	32.72 (10.45)	32.47 (9.71)	.843	.864	.927
NR (%)	1.03 (1.44)	1.06 (1.55)	1.84 (3.00)	.952	.579	.535
RT	627.15 (211.62)	634.36 (187.48)	642.68 (157.88)	.660	.414	.744
Reversal						
CR (%)	54.31 (10.36)	50.17 (14.02)	58.51 (10.21)	.245	.075	**.019**
M (%)	44.14 (9.42)	48.33 (14.21)	39.43 (10.19)	.227	**.049**	**.013**
NR (%)	1.55 (2.59)	1.50 (2.67)	2.07 (4.12)	.925	.866	.903
RT	663.05 (192.31)	670.11 (206.48)	722.52 (179.73)	.988	.164	.197
Difference (*d*) between blocks						
*d*_CR [a]	12.07 (13.68)	16.06 (18.20)	7.18 (8.74)	.399	.266	**.045**
*d*_M [b]	-11.55 (13.05)	-15.61 (17.93)	-6.95 (9.35)	.457	.255	.085
*d*_RT [c]	-35.89 (123.59)	-35.5 (98.00)	-79.83 (124.70)	.976	.184	.095

Note. Mean response times (RT) were obtained only for correct responses (CR). The execution scores of one child with ADHD and one control child were not available. ADHD = attention deficit hyperactivity disorder; M = mistakes; NR = non-responses.

[a] A positive value in this variable means that children obtained a higher number of CR (accuracy) in the learning blocks. [b] A negative value in this variable means that children committed a higher number of M in the reversal blocks. [c] A negative value in this variable means that mean RT were higher in the reversal blocks.

N-back. Children with ADHD committed a higher number of false alarms, and a higher total number of mistakes than impulsive children in the 1-back (Table 3). Similar scores were found in the 2-back condition.

Table 3

Mean Scores (SD) of the Three Groups of Children (N = 90) in the N-Back

Variables	Group			Post hoc comparisons between groups (*p*)		
	ADHD (1)	Impulsivity (2)	Control (3)	1 vs. 2	1 vs. 3	2 vs. 3
			1-back			
CR (%)	62.78 (19.54)	67.00 (24.72)	63.78 (20.91)	.170	.695	.317
H	20.22 (7.97)	20.78 (9.29)	17.00 (10.18)	.590	.242	.138
CRJ	42.56 (14.92)	46.22 (18.08)	46.8 (15.15)	.197	.204	.864
M (%)	25.00 (17.59)	16.33 (17.88)	22.44 (17.96)	**.019**	.509	.086
FA	14.11 (13.80)	7.11 (11.74)	9.67 (11.29)	**.007**	.118	.137
MS	10.89 (7.63)	9.22 (8.10)	12.78 (10.14)	.288	.633	.167
NR (%)	12.22 (12.85)	16.67 (22.42)	13.78 (19.39)	.893	.517	.428
Mean RT	725.10 (202.41)	764.93 (238.99)	723.94 (193.57)	.628	.988	.617
TG	685.65 (208.05)	735.64 (258.57)	700.74 (230.46)	.785	.929	.519
NGT	764.54 (231.03)	794.22 (234.17)	747.14 (203.80)	.617	.802	.505
			2-back			
CR (%)	48.22 (21.91)	52.22 (18.54)	52.67 (17.12)	.374	.584	.841
H	11.78 (9.46)	15.00 (7.87)	13.33 (7.88)	.132	.413	.412
CRJ	36.44 (17.06)	37.22 (15.54)	39.33 (14.68)	.982	.435	.651
M (%)	23.56 (13.13)	21.89 (12.62)	22.11 (14.05)	.614	.784	.964
FA	10.56 (9.27)	10.00 (9.26)	9.00 (7.89)	.940	.470	.675
MS	13.00 (10.30)	11.89 (8.70)	13.11 (9.82)	.783	.899	.760
NR (%)	28.22 (27.48)	25.89 (25.56)	25.22 (23.27)	.777	.715	.727
Mean RT	910.85 (347.81)	941.91 (330.61)	839.60 (258.03)	.649	.544	.303
TG	922.32 (451.14)	954.37 (364.50)	847.28 (290.35)	.476	.790	.324
NGT	899.37 (292.77)	929.45 (326.71)	831.92 (263.22)	.727	.433	.310

Note. Mean response times (RT) were obtained only for correct responses, and RT of one impulsive child were not available. ADHD = attention deficit hyperactivity disorder; CR = correct responses; H = hits; CRJ = correct rejections; M = mistakes; FA = false alarms; MS = misses; NR = non-responses; TG = targets; NTG = non-tagets.

WISC-IV. Children with ADHD and impulsive children showed a poorer performance than controls in WM and PS, although children with ADHD obtained the lowest scores, and they also scored lower in VC and FSIQ (Table 4).

Table 4

Composite Mean Scores (SD) of the Three Groups of Children (N = 90) in the Fourth Edition of the Wechsler Intelligence Scale for Children (WISC-IV)

	Group			Post hoc comparisons between groups (*p*)		
Scores	ADHD (1)	Impulsivity (2)	Control (3)	1 vs. 2	1 vs. 3	2 vs. 3
VC	101.67 (17.58)	111.03 (13.67)	113.53 (15.16)	**.032**	**.014**	.564
PR	95.67 (17.28)	92.90 (13.19)	99.63 (16.46)	.673	.283	.137
WM	84.73 (15.27)	95.80 (17.37)	105.10 (15.28)	**.015**	**.000**	**.037**
PS	90.33 (15.18)	98.20 (14.52)	106.50 (14.96)	**.017**	**.000**	**.034**
FSIQ	91.33 (16.54)	99.20 (15.03)	107.33 (16.10)	**.048**	**.001**	.077

Note. ADHD = attention-deficit/hyperactivity disorder; VC = Verbal Comprehension; PR = Perceptual Reasoning; WM = Working Memory; PS = Processing Speed; FSIQ = Full Scale Intelligence Quotient.

Sleep and Cognitive Performance

Subjective Sleep Variables. Within the ADHD group, bidirectional correlations were found for TST with auditory prudence, and daytime sleepiness with WM. Also the PSQ total score correlated with VC, WM, and FSIQ (Table 5). For impulsive children, the unique significant correlation found was between the number of awakenings (NA) and mistakes in reversal blocks (Table 6).

Objective Sleep Variables. Bidirectional correlations were found for TIB and SPT with auditory prudence, mistakes and false alarms in 1-back, within the ADHD group. Mistakes also correlated with S4 (Table 5). For impulsive children, TIB correlated with WM, and S2 correlated with mistakes and correct responses in reversal blocks. Correct responses also correlated with S3 and SWS (Table 6).

Table 5

Spearman's Correlation Coefficients (n) Between Sleep Variables and Cognitive Performance Within the Group of Children With ADHD

	IVA CPT		Reversal block	1-back		WISC-IV			
Sleep variables	AP	VP	M (%)	M (%)	FA (%)	VC	WM	PS	FSIQ
Sleep diary									
TIB (min)	.31 (28)	.06 (28)	.00 (27)	-.01 (28)	.09 (28)	.24 (28)	.24 (28)	.25 (28)	.31 (28)
TST (min)	**.54**** (30)	.29 (30)	.12 (29)	.11 (30)	.18 (30)	-.01 (30)	.09 (30)	.04 (30)	-.01 (30)
SE (%)	.31 (28)	.25 (28)	.27 (27)	.05 (28)	.05 (28)	-.25 (28)	-.07 (28)	-.15 (28)	-.33 (28)
NA	.07 (29)	.34 (29)	-.14 (29)	.14 (29)	.10 (29)	.28 (29)	.02 (29)	-.25 (29)	.14 (29)
PDSS	-.28 (30)	-.16 (30)	-.07 (29)	-.16 (30)	-.17 (30)	.25 (30)	**.38*** (30)	.13 (30)	.33 (30)
Total PSQ_A[a]	-.27 (30)	.22 (30)	-.01 (29)	-.30 (30)	-.28 (30)	**.56**** (30)	**.49**** (30)	.09 (30)	**.49**** (30)
Polysomnography									
TIB (min)	**.45*** (30)	.12 (30)	.12 (29)	**.47**** (30)	**.50**** (30)	-.09 (30)	-.06 (30)	.05 (30)	-.01 (30)
SPT (min)	**.48**** (30)	.24 (30)	.21 (29)	**.38*** (30)	**.39*** (30)	.02 (30)	.09 (30)	.05 (30)	.06 (30)
TST (min)	.32 (30)	.29 (30)	.12 (29)	.27 (30)	.33 (30)	.06 (30)	.02 (30)	-.15 (30)	.04 (30)
SL (min)	-.10 (30)	-.22 (30)	-.07 (29)	.04 (30)	.08 (30)	.06 (30)	-.08 (30)	-.00 (30)	.07 (30)
SE (%)	-.13 (30)	.22 (30)	.12 (29)	-.17 (30)	-.20 (30)	.15 (30)	.07 (30)	-.26 (30)	.05 (30)
WT (min)	.13 (30)	.01 (30)	-.20 (29)	-.09 (30)	.01 (30)	.09 (30)	.16 (30)	.13 (30)	.21 (30)

Table 5 (*Continued*)

	IVA CPT		Reversal block	1-back		WISC-IV			
Sleep variables	AP	VP	M (%)	M (%)	FA (%)	VC	WM	PS	FSIQ
Polysomnography									
S1 (%)	-.15 (30)	-.15 (30)	.14 (29)	.17 (30)	.18 (30)	-.19 (30)	-.08 (30)	.15 (30)	-.19 (30)
S2 (%)	-.01 (30)	-.21 (30)	.15 (29)	.14 (30)	.12 (30)	-.17 (30)	-.12 (30)	.32 (30)	.00 (30)
S3 (%)	.32 (30)	.18 (30)	-.11 (29)	.29 (30)	.24 (30)	.14 (30)	.26 (30)	-.01 (30)	.09 (30)
S4 (%)	-.18 (30)	-.06 (30)	-.19 (29)	**-.38*** (30)	-.36 (30)	.10 (30)	.02 (30)	-.27 (30)	.02 (30)
SWS (%)	.00 (30)	.10 (30)	-.25 (29)	-.19 (30)	-.18 (30)	.10 (30)	.05 (30)	-.30 (30)	-.02 (30)
REM (%)	-.04 (30)	.25 (30)	.20 (29)	-.06 (30)	-.05 (30)	.28 (30)	.16 (30)	-.22 (30)	.19 (30)
LREM (min)	-.36 (30)	-.29 (30)	-.22 (29)	-.10 (30)	-.18 (30)	.12 (30)	-.06 (30)	.22 (30)	.01 (30)

Note. ADHD = attention deficit hyperactivity disorder; IVA CPT = Intermediate Visual and Auditory Computer Performance Test; WISC-IV = Wechsler Intelligence Scale for Children, fourth edition; AP = auditory prudence; VP = visual prudence; M = mistakes; FA = false alarms; VC = Verbal Comprehension; WM = Working Memory; PS = Processing Speed; FSIQ = Full Scale Intelligence Quotient; TIB = time in bed; SPT = sleep period time; TST = total sleep time; SE = sleep efficiency; NA = number of awakenings; PDSS = Pediatric Daytime Sleepiness Scale; PSQ_A = Pediatric Sleep Questionnaire, Part A; SL = sleep latency; WT = wake time; S1 = stage 1 sleep; S2 = stage 2 sleep; S3 = stage 3 sleep; S4 = stage 4 sleep; SWS = slow wave sleep; REM = rapid eye movement; LREM = REM latency.

[a] The total score was computed by dividing the number of items answered positively by the total number of items answered (either positively or negatively). This score can vary from 0 to 1. A higher total score reflects a higher number of sleep problems.

* $p < .05$. ** $p < .01$.

Table 6

Spearman's Correlation Coefficients (n) Between Sleep Variables and Cognitive Performance Within the Group of Children With Cognitive Impulsivity

	Reversal block		
Sleep variables	Correct responses (%)	Mistakes (%)	WMI_WISC-IV
Sleep diary			
TIB (min)	.10 (27)	-.14 (27)	-.26 (27)
TST (min)	.33 (27)	-.36 (27)	-.11 (27)
SE (%)	.26 (27)	-.23 (27)	.02 (27)
NA	-.37 (27)	**.39*** (27)	.03 (27)
PDSS	-.14 (30)	.11 (30)	.00 (30)
Total PSQ_A[a]	-.01 (30)	.03 (30)	-.30 (30)
Polysomnography			
TIB (min)	-.01 (30)	-.09 (30)	**-.38*** (30)
SPT (min)	-.01 (30)	-.08 (30)	-.28 (30)
TST (min)	-.01 (30)	-.02 (30)	-.29 (30)
SL (min)	-.11 (30)	.14 (30)	-.20 (30)
SE (%)	.08 (30)	.01 (30)	.21 (30)
WT (min)	-.04 (30)	.01 (30)	-.00 (30)
S1 (%)	.01 (30)	-.04 (30)	.16 (30)
S2 (%)	**.41*** (30)	**-.37*** (30)	.12 (30)
S3 (%)	**-.40*** (30)	.34 (30)	-.06 (30)
S4 (%)	-.15 (30)	.12 (30)	-.05 (30)
SWS (%)	**-.40*** (30)	.33 (30)	-.02 (30)
REM (%)	-.06 (30)	.12 (30)	-.03 (30)
LREM (min)	.23 (30)	-.33 (30)	-.25 (30)

Note. WMI = Working Memory index; WISC-IV = Wechsler Intelligence Scale for Children, fourth edition; TIB = time in bed; SPT = sleep period time; TST = total sleep time; SE = sleep efficiency; NA = number of awakenings; PDSS = Pediatric Daytime Sleepiness Scale; PSQ_A = Pediatric Sleep Questionnaire, Part A; SL = sleep latency; WT = wake time; S1 = stage 1 sleep; S2 = stage 2 sleep; S3 = stage 3 sleep; S4 = stage 4 sleep; SWS = slow wave sleep; REM = rapid eye movement; LREM = REM latency.

[a] The total score was computed by dividing the number of items answered positively by the total number of items answered (either positively or negatively). This score can vary from 0 to 1. A higher total score reflects a higher number of sleep problems.

* $p < .05$.

Sleep and ADHD Symptomatology

Subjective Sleep Variables. The sleep variables that most correlated with children's problems were PSQ total score (with parents' reports), and NA (with teachers' reports) (Table 7). Another correlation appeared between SE and peer problems (SDQ-teachers).

Objective Sleep Variables. Several correlations appeared between children's symptomatology and WT and SL, while SE only correlated with affective problems (TRF) (Table 8). Fewer correlations were found regarding sleep architecture (Table 9).

Table 7

Spearman's Correlation Coefficients Between Subjective Sleep Variables, ADHD Symptoms and Related Problems Reported by Parents and Teachers in Questionnaires, Within the Group of Children With ADHD

Questionnaire	TIB (min)	TST (min)	SE (%)	NA	PDSS	PSQ_A[a]
CPRS-48						
Conduct Problem	-.14 (28)	-.21 (30)	-.06 (28)	.26 (29)	.19 (30)	**.42*** (30)
Learning Problem	-.10 (28)	.22 (30)	.00 (28)	.13 (29)	-.21 (30)	.12 (30)
Psychosomatic	-.03 (28)	.05 (30)	.21 (28)	-.16 (29)	.21 (30)	.05 (30)
Impulsive-Hyperactive	-.10 (28)	-.31 (30)	-.26 (28)	.21 (29)	.29 (30)	.36 (30)
Anxiety	-.24 (28)	.07 (30)	.25 (28)	-.01 (29)	-.21 (30)	-.18 (30)
ADHD Index	-.14 (28)	-.12 (30)	-.10 (28)	.35 (29)	.18 (30)	**.37*** (30)
CTRS-10	.09 (27)	.01 (29)	.26 (27)	.34 (28)	.09 (29)	.19 (29)
HSQ-R total score	.18 (28)	.14 (30)	-.07 (28)	**.38*** (29)	.04 (30)	**.52**** (30)
SSQ-R total score	-.07 (27)	-.00 (29)	.26 (27)	**.38*** (28)	-.05 (29)	-.00 (29)
CBCL/6-18						
Affective Problems	-.03 (28)	-.05 (30)	-.04 (28)	**.40*** (29)	.24 (30)	.34 (30)
Anxiety Problems	.16 (28)	.11 (30)	-.03 (28)	.05 (29)	.18 (30)	**.44*** (30)
Somatic Problems	.00 (28)	.05 (30)	.15 (28)	.03 (29)	.33 (30)	.07 (30)
ADHD Problems	.19 (28)	.11 (30)	-.09 (28)	.27 (29)	.36 (30)	**.46**** (30)
Oppositional Problems	-.08 (28)	-.11 (30)	.17 (28)	.12 (29)	.31 (30)	**.45*** (30)
Conduct Problems	-.03 (28)	-.13 (30)	.03 (28)	.10 (29)	.24 (30)	.35 (30)
TRF/6-18						
Affective Problems	-.16 (27)	-.15 (29)	.12 (27)	.29 (28)	-.06 (29)	.01 (29)
Anxiety Problems	-.04 (27)	.14 (29)	.32 (27)	.17 (28)	-.27 (29)	-.17 (29)
Somatic Problems	.14 (27)	.14 (29)	.02 (27)	.11 (28)	.13 (29)	-.15 (29)
Innattention	-.17 (27)	-.22 (29)	.05 (27)	**.43*** (28)	-.07 (29)	.05 (29)

Table 7 (*Continued*)

Questionnaire	TIB (min)	TST (min)	SE (%)	NA	PDSS	PSQ_A[a]
TRF/6-18						
Hyperactivity	.17 (27)	.06 (29)	.30 (27)	.27 (28)	.23 (29)	.23 (29)
Oppositional Problems	.16 (27)	.02 (29)	.21 (27)	.24 (28)	.22 (29)	.24 (29)
Conduct Problems	-.03 (27)	-.11 (29)	.15 (27)	.32 (28)	.06 (29)	.14 (29)
SDQ parents						
Total scale	.11 (27)	.05 (28)	-.16 (27)	**.42*** (27)	.33 (28)	**.50**** (28)
Emotional Symptoms	.16 (27)	.27 (28)	.05 (27)	.30 (27)	.23 (28)	.21 (28)
Behavioural Problems	-.02 (27)	-.04 (28)	-.10 (27)	.34 (27)	.24 (28)	**.42*** (28)
Hyperactivity	.18 (27)	.06 (28)	-.07 (27)	.25 (27)	.36 (28)	**.67**** (28)
Peer Problems	.09 (27)	-.04 (28)	-.36 (27)	**.42*** (27)	.22 (28)	**.38*** (28)
Prosocial	-.02 (27)	-.03 (28)	.05 (27)	-.23 (27)	.04 (28)	-.22 (28)
SDQ teachers						
Total scale	.08 (26)	-.00 (27)	.03 (26)	**.58**** (26)	.07 (27)	.15 (27)
Emotional Symptoms	.07 (26)	.29 (27)	.09 (26)	**.49*** (26)	-.22 (27)	-.15 (27)
Behavioural Problems	.06 (26)	.07 (27)	.09 (26)	**.45*** (26)	.17 (27)	.11 (27)
Hyperactivity	.10 (26)	.02 (27)	.20 (26)	**.40*** (26)	.17 (27)	.17 (27)
Peer Problems	.10 (26)	-.29 (27)	**-.47*** (26)	.39 (26)	.05 (27)	.26 (27)
Prosocial	-.15 (26)	.11 (27)	.19 (26)	-.10 (26)	-.29 (27)	**-.44*** (27)

Note. ADHD = attention deficit hyperactivity disorder; CPRS-48 = Conners' Parents Rating Scale-Revised; CTRS-10 = Conners' Teachers Rating Scale; HSQ-R = Home Situations Questionnaire-Revised; SSQ-R = School Situations Questionnaire-Revised; CBCL/6-18 = Child Behavior Checklist; TRF/6-18 = Teacher's Report Form; SDQ = Strength and Difficulties Questionnaire. TIB = time in bed; TST = total sleep time; SE = sleep efficiency; NA = number of awakenings; PDSS = Pediatric Daytime Sleepiness Scale; PSQ_A = Pediatric Sleep Questionnaire, Part A.

[a] The total score was computed by dividing the number of items answered positively by the total number of items answered (either positively or negatively). This score can vary from 0 to 1. A higher total score reflects a higher number of sleep problems.

* $p < .05$. ** $p < .01$.

Table 8

Spearman's Correlation Coefficients Between Objective Sleep Latency and Continuity Variables, ADHD Symptoms and Related Problems Reported by Parents and Teachers in Questionnaires, Within the Group of Children With ADHD

Questionnaire	TIB (min)	SPT (min)	TST (min)	SE (%)	WT (min)	SL (min)	LREM (min)
CPRS-48 (*n* = 30)							
Conduct Problem	.01	.09	.08	.24	**-.43***	-.20	.04
Learning Problem	.14	.19	.02	-.06	-.11	-.21	-.11
Psychosomatic	.09	.22	.20	.08	-.01	.01	.10
Impulsive-Hyperactive	.24	.18	.19	.06	-.18	.17	-.15
Anxiety	.05	.04	-.02	-.02	**-.38***	-.07	.05
ADHD Index	.19	.23	.23	.18	-.34	-.10	-.14
CTRS-10 (*n* = 29)	-.04	.00	-.10	.05	-.27	-.21	-.17
HSQ-R total score (*n* = 30)	-.01	-.03	-.07	-.07	.12	-.08	-.26
SSQ-R total score (*n* = 29)	-.07	-.01	-.06	.10	-.23	-.25	-.14
CBCL/6-18 (*n* = 30)							
Affective Problems	.05	.16	.21	.31	**-.45***	**-.36***	-.14
Anxiety Problems	.03	.18	.06	.07	-.24	-.25	.10
Somatic Problems	-.06	.08	.18	.19	.03	-.00	-.10
ADHD Problems	.15	.23	.07	.01	-.13	-.09	-.16
Oppositional Problems	-.02	.15	.09	.25	-.22	-.34	.15
Conduct Problems	-.09	.02	.02	.29	-.33	-.28	-.20
TRF/6-18 (*n* = 29)							
Affective Problems	-.13	.09	.15	**.44***	**-.38***	**-.50****	-.07
Anxiety Problems	.05	.21	.15	.10	-.11	**-.44***	-.04
Somatic Problems	.05	.11	.34	.31	-.14	-.19	-.17
Innattention	.01	.03	.06	.23	**-.54****	-.17	.14

Table 8 (*Continued*)

Questionnaire	TIB (min)	SPT (min)	TST (min)	SE (%)	WT (min)	SL (min)	LREM (min)
TRF/6-18 (*n* = 29)							
Hyperactivity	-.02	.07	.00	.08	-.20	-.27	-.15
Oppositional Problems	-.07	-.01	-.10	.06	-.24	-.30	-.06
Conduct Problems	-.25	-.25	-.20	.11	**-.41***	-.32	-.23
SDQ parents (*n* = 28)							
Total scale	-.26	-.13	-.14	.21	**-.50****	**-.49****	-.04
Emotional Symptoms	.02	.11	.14	.12	-.34	**-.43***	.00
Behavioural Problems	-.13	-.08	-.19	.02	**-.54****	-.24	.03
Hyperactivity	-.28	-.16	-.19	.17	-.19	-.28	-.04
Peer Problems	-.28	-.11	-.08	.28	-.34	**-.55****	.03
Prosocial	.08	-.01	.01	-.24	**.45***	.34	-.05
SDQ teachers (*n* = 27)							
Total scale	-.02	.07	.08	.22	**-.38***	**-.53****	-.13
Emotional Symptoms	.33	.26	.25	-.10	-.13	-.27	-.32
Behavioural Problems	.04	.09	.12	.23	**-.38***	**-.49****	-.12
Hyperactivity	-.10	-.02	-.07	.13	-.33	-.35	-.07
Peer Problems	-.25	-.13	-.12	.22	-.22	-.35	.01
Prosocial	.26	.16	.22	-.19	.01	.22	-.07

Note. ADHD = attention deficit hyperactivity disorder; CPRS-48 = Conners' Parents Rating Scale-Revised; CTRS-10 = Conners' Teachers Rating Scale; HSQ-R = Home Situations Questionnaire-Revised; SSQ-R = School Situations Questionnaire-Revised; CBCL/6-18 = Child Behavior Checklist; TRF/6-18 = Teacher's Report Form; SDQ = Strength and Difficulties Questionnaire; TIB = time in bed; SPT = sleep period time; TST = total sleep time; SE = sleep efficiency; WT = wake time; SL = sleep latency; LREM = latency to rapid eye movement sleep.

* $p < .05$. ** $p < .01$.

Table 9

Spearman's Correlation Coefficients Between Objective Sleep Architecture Variables, ADHD Symptoms and Related Problems Reported by Parents and Teachers in Questionnaires, Within the Group of Children With ADHD

Questionnaire	S1 (%)	S2 (%)	S3 (%)	S4 (%)	SWS (%)	REM (%)
CPRS-48 (*n* = 30)						
Conduct Problem	-.08	-.06	.11	-.11	.02	.22
Learning Problem	-.20	-.15	.14	-.11	.04	.17
Psychosomatic	.28	.08	.07	-.18	-.10	-.06
Impulsive-Hyperactive	-.07	-.06	.08	-.06	.04	.11
Anxiety	-.13	-.09	.10	-.04	.13	-.01
ADHD Index	-.11	-.11	.21	-.18	.03	.21
CTRS-10 (*n* = 29)	.05	.13	-.08	-.14	-.19	.02
HSQ-R total score (*n* = 30)	**-.45***	-.15	-.30	.16	.04	.40
SSQ-R total score (*n* = 29)	.13	.16	.04	-.18	-.16	-.24
CBCL/6-18 (*n* = 30)						
Affective Problems	.01	-.09	-.03	-.08	-.03	.31
Anxiety Problems	.16	.05	.08	-.28	-.17	.22
Somatic Problems	**.37***	-.12	.22	.09	.17	-.16
ADHD Problems	.03	.01	.18	-.23	-.19	.27
Oppositional Problems	.08	-.05	.06	.02	.06	.10
Conduct Problems	-.19	-.16	.14	.08	.13	.24
TRF/6-18 (*n* = 29)						
Affective Problems	.30	.32	-.12	-.31	-.35	-.08
Anxiety Problems	.20	.15	-.10	-.25	-.27	.11
Somatic Problems	.18	-.09	.27	-.03	.07	-.04
Innattention	.20	.23	-.04	-.28	-.22	-.14

Table 9 (*Continued*)

Questionnaire	S1 (%)	S2 (%)	S3 (%)	S4 (%)	SWS (%)	REM (%)
TRF/6-18 (*n* = 29)						
Hyperactivity	.10	.06	-.03	-.12	-.16	.11
Oppositional Problems	.15	.21	-.06	-.31	-.36	.10
Conduct Problems	-.09	-.06	-.20	.02	-.07	.17
SDQ parents (*n* = 28)						
Total scale	.05	-.02	.19	-.25	-.12	.20
Emotional Symptoms	.12	-.10	.31	-.19	.02	.03
Behavioural Problems	.07	.13	.25	**-.41***	-.25	.03
Hyperactivity	.01	.03	.04	-.23	-.20	.33
Peer Problems	-.09	-.16	.06	-.00	.06	.26
Prosocial	.20	.06	-.12	.18	.03	**-.39***
SDQ teachers (*n* = 27)						
Total scale	-.06	.10	-.06	-.26	-.25	.15
Emotional Symptoms	-.17	-.01	.06	-.16	-.08	.11
Behavioural Problems	-.06	-.02	.16	-.28	-.16	.20
Hyperactivity	.12	.09	.03	-.18	-.18	-.09
Peer Problems	-.13	.26	-.33	-.24	**-.38***	.22
Prosocial	.01	-.22	.13	.23	.28	-.28

Note. ADHD = attention deficit hyperactivity disorder; CPRS-48 = Conners' Parents Rating Scale-Revised; CTRS-10 = Conners' Teachers Rating Scale; HSQ-R = Home Situations Questionnaire-Revised; SSQ-R = School Situations Questionnaire-Revised; CBCL/6-18 = Child Behavior Checklist; TRF/6-18 = Teacher's Report Form; SDQ = Strength and Difficulties Questionnaire; S1 = stage 1 sleep; S2 = stage 2 sleep; S3 = stage 3 sleep; S4 = stage 4 sleep; SWS = slow wave sleep; REM = rapid eye movement sleep.

* $p < .05$.

Discussion

Children with ADHD showed a significantly lower performance in relation to response control (IVA CPT), discrimination learning (computer reversal test), phonological WM, VC, PS, and FSIQ (WISC-IV), than control children. Children with cognitive impulsivity also differed from controls in discrimination learning, phonological WM, and PS. However, regarding WM, although children with ADHD and impulsive children performed worse than controls with auditory stimuli (WISC-IV), they did not when visual stimuli were also employed to assess WM (n-back). the unique significant differences found in the n-back were between children with ADHD and impulsive children. Therefore, the results of comparing these children in cognitive performance, the first goal of our study, suggest that both groups present cognitive problems compared to controls. However, these problems are greater for children with ADHD, with the main difference between them and impulsive children residing in WM. Although both children had problems with phonological WM, children with cognitive impulsivity presented a higher ability for visual WM than either children with ADHD or controls (Table 3). Another interesting finding was the absence of significant differences between the groups in sustained attention (attention subscales in the IVA CPT).

Lower attention scores have been displayed by children with ADHD in several studies (Kim et al., 2015; Moreno-García et al., 2015), suggesting sustained attention problems in these children compared to controls. However, despite our results contradicting those of earlier studies, ours is not the first study in which no differences in attention have been found between children with ADHD and controls in CPT tasks. For instance, in the study of Corbett, Constantine, Hendren, Rocke, and Ozonoff (2009), children with ADHD differed from controls in the response control quotients, but not in the attention quotients. Furthermore, our results in the rest of the tasks employed are more consistent with previous findings. Thus, the crucial role attributed to the prefrontal cortex for reversal task performance (Evers et al., 2005; Hampshire et al., 2012), would justify the worse performance of children with ADHD and impulsive children in reversal blocks in our study. Mainly, because both ADHD and cognitive impulsivity are linked to impairments in that brain region (See Arce & Santisteban, 2006, for a review). Furthermore, WM and PS have been pointed out as the main domains in which children with ADHD display deficits (Mayes & Calhoun, 2006; Wechsler, 2010a). A lower intelligence quotient was also found in other studies in children with this disorder (Barry, Lyman, & Klinger, 2002; Loe & Feldman, 2007). While it is true that the lower VC scores obtained by children with ADHD in our study disagree with other findings that suggest good VC in these children (Wechsler, 2010a), the lack of more studies comparing them to controls in this domain makes drawing conclusions difficult. The same is true for the n-back. No significant differences were found between children with ADHD and controls in other studies (Drechsler et al., 2008; Fosco et al., 2015; Zinke et al., 2010), but there is not any previous data available that explains why they were found regarding impulsive children.

With regards to the relationship between sleep and cognitive performance, the analysis of which was the second goal of our study, different results appeared in children with ADHD and impulsive children. For instance, whereas phonological WM correlated with two subjective sleep measures (PDSS and PSQ) within children with ADHD, no correlation was found between that variable and sleep within impulsive children. In fact, the unique subjective variable that correlated with impulsive children's cognitive performance was NA, one variable that did not show any relation to cognitive performance within children with ADHD. Furthermore, objective TIB correlated with the worse performance of children with ADHD in the IVA CPT and the 1-back. However it did not correlate with their lower scores in the WM, whereas a correlation was found within the impulsive group. Additionally, although some sleep architecture variables correlated with the cognitive performance of children with ADHD and impulsive children, these variables were not the same for both groups. Neither were the cognitive variables involved. Particularly, sleep correlated with the poor execution of children with ADHD in response control and WM, and with the poor execution of impulsive children in discrimination learning and phonological WM. So, according to our results, sleep might have an impact on the worse cognitive performance of both groups of children in comparison to controls. However, either the sleep variables or the cognitive functions involved would be different for both of them.

In other studies in which the relationship between sleep and cognitive performance was examined, some similar results were reported. Specifically, though few studies have analyzed such relationship in children with ADHD, these studies and others with normative children seem to corroborate the impact of sleep duration on cognitive performance (Cho et al., 2015; Moreau, Rouleau, & Morin, 2013). Interestingly, sleep duration was found to affect cognitive functioning even when changes in this variable were small (Gruber et al., 2011; Vriend et al., 2013). Other sleep variables that showed a relationship with cognitive performance in past research were SE, SL, and severity of sleep problems (Hansen, Skirbekk, Oerbeck, Wentzel-Larsen, & Kristensen, 2014; Sciberras, DePetro, Mensah, & Hiscock, 2015; Steenari et al., 2003). As yet, little agreement has been reached in regards to these variables, as some existing studies suggest they do not impact on cognitive performance (Cho et al., 2015; Moreau et al., 2013). Nevertheless, the lack of cohesion of results between the studies conducted, including our own, might be due to differences related to the type of sleep assessment performed. For example, there is a remarkable lack of studies where sleep data were obtained through objective measures. There are also major differences between studies regarding the questionnaires employed to collect subjective sleep data, and the number and kind of sleep problems covered in them. In conclusion, although our results seem to support the results of previous studies, the unavailability of more data on the relationship between sleep and cognitive functioning in children with ADHD restricts further comparison. The same limitation is observed in relation to our results in impulsive children, being this the first study in which a correlation analysis of sleep and cognitive performance in these children was conducted. While some authors provided data on sleep and cognitive impulsivity (Lee et at., 2014; Um et al., 2016), no analysis of this cognitive style was carried out in normative children without any disorder.

In relation to our third goal, symptomatology reported by parents and teachers correlated with several subjective and objective sleep parameters within children with ADHD. Specifically, the highest number of significant correlations with sleep were found for affective problems (CBCL and TRF), problems at home (HSQ-R), total difficulties (SDQ-parents and teachers), peer problems (SDQ-parents), and behaviour problems (SDQ-teachers). According to such correlations, those would be the problems presented by children with ADHD that could be affected by their sleep characteristics to a greater extent. The sleep parameters that might have a greater negative impact on the severity of the problems displayed by children with ADHD are number of awakenings (sleep diary), total sleep difficulties (PSQ), and WT and SL (PSG recordings).

Comparing our results with the results of other studies, some important similarities emerge. On the one hand, some studies explored the relationship between sleep and internalizing or externalizing problems in children with ADHD, by means of some of the questionnaires or subscales that we also employed in our study. This relationship was analyzed through the children's scores in the CBCL and the TRF (as internalizing behavior measures) in one study (Bergwerff, Luman, & Oosterlaan, 2016), where some interaction effects were found between these scores, and ADHD symptoms, and sleep. More specifically, they were found for TIB, TST, and sleep bout duration; this last one directly linked to NA. The children's scores on the emotional and conduct subscales of the SDQ were also the measures employed in another study, in which emotional, but not conduct problems, appeared to be related to sleep disturbances (Mulraney, Giallo, Lycett, Mensah, & Sciberras, 2016). Higher total scores in the SDQ were also associated with more sleep disturbances in the study of Chiraphadhanakul et al. (2016). On the other hand, a relationship between severity of ADHD symptoms and sleep disorders appeared in the study of Vélez-Galarraga, Guillén-Grima, Crespo-Eguílaz, and Sánchez-Carpintero (2016). Hysing, Lundervold, Posserud, and Sivertsen (2016), also found a higher severity of ADHD symptoms to be associated with shorter sleep duration, including later bedtime, longer sleep latency and more wake time in the night. In conclusion, all those findings seem to support our results regarding an association between sleep and ADHD symptoms or related problems in children with this disorder.

Nevertheless, some limitations should be considered when our results are discussed. The most important one is the cross-sectional approach of this study. This means that only bidirectional relationships between sleep and cognitive performance, or between sleep and symptomatology within children with ADHD, could be analyzed and no causal relationships between those variables could be explored. This approach also made it difficult to control any possible effect of ADHD medication on cognitive performance, or on the correlations found between this and sleep. Another limitation is that the lack of more studies about cognitive performance and sleep in children with cognitive impulsivity means we cannot compare our findings with earlier ones in order to draw further conclusions. However, the novelty of some analyses conducted is also one of the main strengths of our study. Therefore, this is one of the first studies in which the cognitive performance of children with ADHD, children with cognitive impulsivity, and normative children with a more reflexive cognitive style, was compared. This is also the first study in which the relationship between sleep and cognitive problems was analyzed in both children with ADHD and children with cognitive impulsivity. Furthermore, this is one of the few studies in which the relationship between cognitive performance and sleep characteristics in children with ADHD was explored employing both subjective and objective sleep parameters.

The results obtained suggest that both children with ADHD and impulsive children have cognitive problems compared to controls, althoughthese are more pronounced in WM. The main cognitive differences between children with ADHD and impulsive children would reside in the larger cognitive difficulties showed by children with ADHD, and in their problems regarding visual WM. The cognitive deficits found in both groups of children in comparison to controls might be also associated with their sleep characteristics, although differences between them would appear in relation to the cognitive and sleep variables affected. Finally, sleep seems to have a bidirectional relationship with ADHD symptoms and related problems in children with ADHD, but this relationship should be analyzed further with a longitudinal approach in order to establish any causality. All these results have clinical implications for the management of sleep problems and cognitive deficits in children with ADHD and children with cognitive impulsivity without any underlying psychiatric disorder. However, the novelty of some data reported here requires further exploration in future studies with a longitudinal methodology. Especially, in order to obtain more reliable conclusions that would be crucial for the prevention of cognitive and sleep problems in these children.

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DISCUSIÓN

Discusión

Esta tesis doctoral tenía como objetivo general evaluar los problemas de sueño y de rendimiento cognitivo en niños con TDAH, niños con impulsividad cognitiva, y niños sin TDAH y sin impulsividad cognitiva. Para conseguir ese objetivo general se propusieron cuatro objetivos específicos. El primero de ellos era examinar el estado de la cuestión sobre el sueño en niños con TDAH. Es decir, conocer el punto exacto en el que se encontraba la investigación sobre el sueño en estos niños, resumir los hallazgos más relevantes, y aportar nuevos resultados desde otro punto de vista. El segundo era analizar las diferencias entre los tres grupos respecto al rendimiento cognitivo. El tercero, analizar las diferencias entre ellos respecto a sus características del sueño. Finalmente, el cuarto y último objetivo específico propuesto era determinar la relación entre el sueño y los problemas cognitivos encontrados en cada grupo.

En cuanto al análisis de las investigaciones previas sobre las características del sueño en niños con TDAH, se han revisado los estudios empíricos disponibles desde 1983 hasta marzo de 2014, que cumplían con unos criterios específicos, diseñados atendiendo a una idea principal: conocer los problemas de sueño que estos niños pueden presentar, pero los cuales podrían atribuirse realmente al TDAH y no a otros trastornos del sueño de carácter primario. Esto supone abordar el estudio del sueño en el TDAH desde un enfoque diferente al adoptado por la mayoría de los estudios realizados hasta ahora, pero cuyos resultados pueden servir como punto de partida para el desarrollo del resto de la investigación contemplada en esta tesis.

Por un lado, la novedad del enfoque, junto a otros criterios requeridos (como el contar con un grupo control), han supuesto que, de todos los estudios realizados sobre el sueño en niños con TDAH durante las últimas décadas, se haya podido considerar solo un número limitado de los mismos en la revisión sistemática y los dos metaanálisis. Por otro lado, los resultados obtenidos con los metaanálisis sugieren pocas diferencias entre las características del sueño de los niños con TDAH y los controles, al tiempo que indican la posible intervención de otras variables en los hallazgos encontrados hasta ahora. En efecto, la única diferencia encontrada entre ambos grupos de niños es con respecto a la fase 1 del sueño NREM (*non-rapid eye movement*), en la que los niños con TDAH pasaron una mayor cantidad de tiempo que los controles. Unos resultados que no encajan con los encontrados en dos de los estudios incluidos en la revisión sistemática pero no en los metaaálisis. Pues en uno de ellos la cantidad de tiempo que pasaron los niños con TDAH en la fase 1 del sueño NREM fue menor que la de los controles (Ringli et al., 2013). Y, en el otro estudio, los niños con TDAH y los controles no se diferenciaron en el tiempo de sueño NREM, sino en el mayor de tiempo de sueño REM que mostraron los niños con TDAH (Prehn-Kristensen et al., 2011). Lo que sugeriría un sueño más profundo en estos niños, al contrario de lo parecen indicar nuestros resultados.

En cuanto a otras variables que podrían haber intervenido en tales resultados, existe cierta similitud entre los estudios incluidos en los metaanálisis respecto a algunas variable importantes. Como la edad de los participantes y la distribución del sexo entre ambos grupos, la retirada de la medicación para el TDAH antes de la evaluación del sueño, la objetividad de esta evaluación (mediante polisomnografía o actigrafía), y las comorbilidades de los niños con TDAH. Cabe destacar que las variables mencionadas, junto a la sintomatología predominante o subtipos de esos niños, constituían otro foco de interés en nuestro análisis de la literatura, además de las diferencias entre los grupos. Por lo que el hecho de no haber encontrado diferencias notables entre los estudios respecto a ellas, y solo respecto a los subtipos, hace posible una influencia de estos últimos en los resultados obtenidos.

En este sentido, estudios previos han sugerido que los niños con TDAH que más problemas de sueño pueden presentar son los del subtipo hiperactivo-impulsivo, siendo menores estos problemas en los del subtipo inatento (Mayes, Calhoun, Bixler, et al., 2009; Wagner y Schlarb, 2012). Y en los dos metaanálisis realizados, el número de niños con el subtipo inatento es considerablemente superior al número de niños con el subtipo hiperactivo-impulsivo, correspondiendo a estos últimos la menor participación. Lo que, atendiendo a los resultados de esos estudios previos, podría haber contribuido a no encontrar más diferencias en el sueño entre los niños con TDAH y los niños sin este trastorno. Sin embargo, el reducido número de estudios incluidos en la revisión sistemática impidió llevar a cabo otro tipo de análisis que ayudaría a determinar esta cuestión.

Se observan también otros factores que podrían haber intervenido en los resultados encontrados. Por ejemplo, el reducido tamaño de la muestra en algunos de los estudios (Mullin, Harvey y Hinshaw, 2011; Prehn-Kristensen et al., 2013; Příhodová, Paclt, Kemlink y Nevšímalová, 2012), o la falta de más estudios incluidos que aportaran medidas subjetivas sobre el sueño. Esto último impidió realizar un metaanálisis con esas medidas que hubiera permitido analizar las diferencias entre niños con TDAH y controles en otras variables como la somnolencia diurna, uno de los problemas señalados en niños con esta patología (Gruber et al., 2012; Owens, Maxim, Nobile, McGuinn y Msall, 2000). También existe la posibilidad de que la manera de diagnosticar a los niños con TDAH pueda haber intervenido en los resultados. Sobre todo a raíz del debate surgido en torno a la existencia del trastorno (García, González y

Pérez, 2014), o a su sobrediagnóstico (Bruchmüller, Margraf y Schneider, 2012; Thomas, Mitchell y Batstra, 2013). Ya que los falsos positivos en los niños con TDAH contribuirían a la desaparición de las diferencias en el sueño entre los grupos.

En cualquier caso, más allá de la posible intervención de otras variables, estos resultados vienen a respaldar aún más la necesidad ya detectada de más investigaciones sobre el sueño en niños con TDAH y, por consiguiente, también la que se ha llevado a cabo a posteriori en esta tesis doctoral. Una investigación de la que se discuten a continuación los hallazgos encontrados en relación a cada uno de los otros tres objetivos específicos mencionados anteriormente.

Diferencias entre los tres grupos respecto al rendimiento cognitivo

Se han comparado los tres grupos de niños en algunas de las funciones cognitivas en las que los niños con TDAH mostraron problemas en estudios previos, empleando para ello pruebas o tareas de evaluación comúnmente utilizadas en la literatura. Así, se ha evaluado su capacidad de atención sostenida y de inhibición o control de la respuesta, y su capacidad de aprendizaje discriminatorio, mediante una versión adaptada del *Integrated Visual and Auditory Computer Performance Test* (IVA CPT; Sandford y Turner, 2000), y una prueba de ordenador de reversal (*computer reversal test*). Y se ha evaluado su capacidad de memoria de trabajo y otras funciones cognitivas, como su velocidad de procesamiento y su cociente intelectual o perfil cognitivo general, mediante el n-back y la cuarta edición del *Wechsler Intelligence Scale for Children* (WISC-IV; Wechsler, 2010b).

La falta de diferencias estadísticamente significativas entre los grupos en el IVA CPT indica que ni los niños con TDAH ni los niños con impulsividad cognitiva presentan problemas de atención sostenida o de inhibición o control de la respuesta, en comparación con su grupo de iguales. Al contrario de lo que sugirieron diversos estudios anteriores, en los que el IVA CPT mostró buena utilidad para discriminar entre niños con TDAH y niños sin esta patología (ej., Epstein et al., 2003; Kim et al., 2015; Losier et al., 1996; Moreno-García et al., 2015). No obstante, las diferencias entre los estudios llevados a cabo en relación a algunas variables importantes, podrían explicar las cotradicciones entre nuestros resultados y los de otros estudios previos. Por ejemplo, la diversidad existente entre las versiones del CPT empleadas por los estudios (véase revisión de Meneres-Sancho et al., 2015), y las diferencias en cuanto a las puntuaciones de los participantes analizadas en cada estudio o proporcionadas por los autores (Corbett et al., 2009; Corbett y Constantine, 2006). U otras diferencias relativas a los propios participantes, como el uso o no de tratamiento farmacológico (Epstein et al., 2003; Kim et al., 2015).

En relación al computer revesal test, aunque no se observan diferencias entre los grupos durante la fase de acquisición, sí que aparecen diferencias entre los grupos en la fase de reversal, pues en esta los niños con impulsividad cognitiva cometieron más errores y obtuvieron menos respuestas correctas que los controles. Esto sugiere problemas en cuanto a la capacidad de aprendizaje discriminatorio en los niños con impulsividad cognitiva. Mientras que los niños con TDAH no muestran dificultades en esta función cognitiva en comparación con los niños sin este trastorno. Tales hallazgos no se corresponden con lo esperado para los niños con TDAH, teniendo en cuenta la implicación del córtex prefrontal en las pruebas de reversal (Cools et al., 2002; Rogers et al., 2000), y la disfunción en esta área cerebral asociada tanto al TDAH como a la impulsividad cognitiva (Arce y Santisteban, 2006). Aunque esto último sí explica el peor rendimiento en la prueba de los niños con impulsividad cognitiva.

Por otro lado, los resultados de los análisis realizados en cuanto al n-back no muestran diferencias entre los grupos en esta prueba, e independientemente de la carga de memoria de trabajo (1-back o 2-back). Sin embargo, tanto los niños con TDAH como los niños con impulsividad cognitiva obtuvieron una menor puntuación que los controles en el índice de memoria de trabajo del WISC-IV. Estos resultados parecen sugerir, analizados de forma conjunta, que los problemas de memoria de trabajo que ambos grupos de niños presentan son solo en relación a su memoria de trabajo fonológica pero no a la visual. De manera que tales problemas aparecen cuando la memoria de trabajo es evaluada mediante estímulos auditivos solamente (WISC-IV), pero no sobresalen cuando se incluyen tanto estímulos auditivos como visuales en la evaluación (n-back). Una cuestión que no queda clara teniendo en cuenta los resultados de otros estudios disponibles en la literatura. Ya que, aunque en algunos estudios tampoco se encontraron diferencias entre los niños con TDAH y los controles en el n-back (Drechsler et al., 2008; Fosco et al., 2015; Zinke et al., 2010), en otros estudios sí que se encontró un peor rendimiento de los niños con TDAH en esta prueba (Marx et al., 2010; Strand et al., 2012). Además, en cuanto al WISC-IV, los resultados de otros estudios fueron similares a los nuestros, señalando déficits de memoria de trabajo a nivel fonológico en los niños con TDAH (O'Brien et al., 2010; Styck y Watkins, 2014).

Respecto al resto de funciones cognitivas evaluadas mediante el WISC-IV, más allá de las diferencias entre los grupos observadas en la ejecución de cada uno de los subpruebas que componen el test, conviene destacar las diferencias entre ellos en los tres índices restantes y en la escala total o cociente intelectual. En este sentido, además de las diferencias ya comentadas en la capacidad de memoria de trabajo, tanto los niños con TDAH como los niños con impulsividad cognitiva obtuvieron peores puntuaciones que los controles en velocidad de procesamiento. También los niños con TDAH puntuaron peor que los controles en comprensión verbal, al tiempo que los niños con impulsividad cognitiva lo hicieron en razonamiento perceptivo. Y, por último, ambos grupos de niños obtuvieron también un menor cociente intelectual que los controles. Algunos de estos resultados encajan con los de estudios previos, puesto que tanto la memoria de trabajo como la velocidad de procesamiento se han señalado como los dominios en los que los niños con TDAH tienen mayores déficits (Mayes y Calhoun, 2006; Wechsler, 2010a). Si bien algunos hallazgos sugirieron una buena capacidad de comprensión verbal en los niños con TDAH (Wechsler, 2010a), y tampoco queda claro hasta qué punto estos niños presentaban un menor cociente intelectual, o este podía ser responsable del deterioro en otras capacidades. No obstante, en la mayoría de estudios en los que los niños con TDAH fueron evaluados mediante el WISC-IV, no fueron comparados con un grupo control sin TDAH. Esta cuestión, junto a otras, no permite una comparación exhaustiva de los resultados y la extracción de conclusiones que explicarían las discrepancias.

En conclusión, estos resultados confirman, en mayor o menor medida, la existencia de problemas cognitivos en los niños con TDAH en comparación con su grupo de iguales, al tiempo que señalan la también existencia de estos problemas en los niños con impulsividad cognitiva. Sin embargo, tanto estos resultados como las discrepancias entre estos y los de algunos estudios previos, apuntan a una posible influencia de otras variables en el peor rendimiento cognitivo de ambos grupos de niños. En particular, más allá de las diferencias entre las versiones de las pruebas utilizadas en cada estudio, y los grupos de participantes incluidos, es de destacar, sobre todo, un posible impacto de los subtipos de TDAH y del uso de tratamiento farmacológico sobre los distintos hallazgos.

Por un lado, porque hay estudios que sugieren la influencia de los subtipos sobre el rendimiento cognitivo de los niños con TDAH (Fenollar-Cortés et al., 2015; Mayes, Calhoun, Chase, Mink y Stagg, 2009), y no pudimos distinguir entre subtipos a la hora de evaluar a estos niños. Por otro lado, porque diversos estudios han indicado un efecto positivo de la medicación sobre el rendimiento cognitivo (Coghill et al., 2014; Pietrzak et al., 2006), y un alto porcentaje de niños con TDAH estaban usándola en el momento de nuestra evaluación (83,33%). De hecho, el CPT y el n-back son algunas de las pruebas en las que se ha observado ese efecto (Bédard et al., 2015, Kobel et al., 2009; Losier et al., 1996), y en ninguna de las dos hemos observado diferencias entre los niños con TDAH y los controles. Además, sería admisible que la medicación hubiera contribuido también a la ausencia de diferencias entre ambos niños en el computer reversal test, dado el papel del córtex prefrontal en la ejecución en tareas de reversal (Cools et al., 2002; Rogers et al., 2000), y el efecto de los estimulantes sobre esta área cerebral (Rubio-Morell et al., 2008).

En definitiva, la no determinación de la posible influencia de esas variables sobre el rendimiento cognitivo de los niños evaluados impulsa a seguir investigando sobre esta temática, y a realizar más estudios en los que niños con TDAH y niños con impulsividad cognitiva sean comparados entre ellos y con un grupo control.

Diferencias entre los tres grupos respecto a sus características del sueño

En la evaluación del sueño se incluyeron tanto medidas objetivas, con los registros polisomnográficos realizados en el domicilio familiar (previa retirada de la medicación 48 horas antes), como subjetivas, mediante los dos cuestionarios y el diario de sueño cumplimentados por los padres. A pesar de ello, no se observan diferencias significativas entre los grupos en ninguna de las variables de sueño evaluadas. Es decir, de acuerdo a nuestros resultados, ni los niños con TDAH ni los niños con impulsividad cognitiva presentan características del sueño diferentes a las de los niños sin TDAH y con un estilo cognitivo más reflexivo.

Estos resultados, aunque similares a los que obtuvimos previamente con el análisis sistemático de la literatura, son contradictorios a muchos de los estudios realizados hasta ahora, en los que sí se han resaltado diferencias en el sueño entre los niños con TDAH y los niños sin esta patología (Gruber et al., 2012; Lee et al., 2014; Owens et al., 2000; Prehn-Kristensen et al., 2011; Schneider et al., 2016; Vigliano et al., 2016; Virring, Lambek, Thomsen, Moller y Jennum, 2016). Sin embargo, existen investigaciones sobre el sueño en niños con TDAH, en las que estos tampoco difirieron de los controles en ningún parámetro objetivo. Como en varios estudios polisomnográficos (Cooper, Tyler, Wallace y Burgess, 2004; Prehn-Kristensen et al., 2013; Příhodová et al., 2012), o en otros donde fueron evaluados mediante actigrafía (Bergwerff, Luman y Oosterlaan, 2016; Mullin et al., 2011). Además, particularmente relevante es el hecho de que, en algunos estudios, las diferencias en el sueño entre los niños con y sin TDAH han variado dependiendo del tipo de evaluación del mismo. Sobre todo, se aprecian discrepancias entre medidas subjetivas y objetivas, encontrándose diferencias entre los grupos en las primeras y no en las segundas (Akinci et al., 2015). Aunque también se han observado contradicciones en los resultados incluso entre medidas objetivas (Virring et al., 2016).

Si bien esas discrepancias entre los estudios dependiendo de la evaluación del sueño no llegan a explicar el motivo por el que no aparecen tampoco diferencias entre los grupos en ninguno de los dos cuestionarios cumplimentados por los padres ni en el diario de sueño. A este respecto, conviene prestar atención a dos variables fundamentales, que podrían también explicar la ausencia de diferencias entre los grupos y las contradicciones existentes en la literatura sobre el sueño en el TDAH. En concreto, las mismas variables mencionadas que podrían haber repercutido en nuestros resultados sobre el rendimiento cognitivo, lo podrían haber hecho también sobre las características del sueño: la medicación y los subtipos de TDAH.

La medicación porque, contrariamente a lo que se ha venido pensando hasta ahora, que esta afectaba negativamente al sueño de los niños con TDAH (Herman, 2015; Mick, Biederman, Jetton y Faraone, 2000; Morash-Conway et al., 2016; Stein, 1999), recientes hallazgos sugieren un efecto positivo de la misma, habiéndose observado más dificultades en el sueño en niños con TDAH sin medicación que en los medicados en algunos estudios (Chiraphadhanakul, Jaimchariyatam, Pruksananonda y Chonchaiya, 2016; Vélez-Galarraga, Guillén-Grima, Crespo-Eguílaz y Sánchez-Carpintero, 2016). Aunque el impacto de la medicación no está todavía claro, puesto que hay otros estudios en los que no se observó ningún efecto (ni positivo ni negativo) de esta (Cohen-Zion y Alcoli-Israel, 2004; Moreau, Rouleau y Morin, 2014), pero es una cuestión a tener en cuenta a la hora de interpretar y discutir nuestros resultados. Principalmente, porque la mayoría de los niños con TDAH que evaluamos estaban siendo tratados con medicación. Esa medicación fue retirada 48 horas antes de la evaluación polisomnográfica, pero aún así sería aceptable un efecto residual derivado del prolongado uso de esta. Además, la medicación seguía utilizándose cuando los padres completaron los cuestionarios y el diario de sueño. Junto a la medicación, la otra variable a considerar es la sintomatología predominante de los niños con TDAH o sus subtipos porque su influencia sobre el sueño fue observada en otros estudios (Mayes, Calhoun, Bixler, et al., 2009; Wagner y Schlarb, 2012).

En definitiva, aunque los niños con TDAH han presentado diferencias en el sueño con respecto a los niños sin este trastorno en numerosos estudios, pero también van apareciendo cada vez más estudios en los que, como en esta tesis doctoral, no se observan diferencias entre los dos grupos. Esto, junto a otros hallazgos encontrados, parece indicar que hay otras variables, más allá del propio diagnóstico de TDAH, implicadas en la aparición de los problemas de sueño en estos niños. Lo que explicaría el que tales problemas se observaran en algunos estudios y en otros no.

Relación entre el sueño y los problemas cognitivos encontrados en cada grupo

Para analizar la relación entre las características del sueño de los niños evaluados anteriormente y los problemas cognitivos presentados por estos, se ha comparado, en primer lugar, su rendimiento cognitivo en el IVA CPT, el computer reversal test, el n-back y el WISC-IV. En segundo lugar, se han llevado a cabo distintos análisis correlacionales entre todas las variables de sueño tenidas en cuenta y las variables cognitivas en las que cada grupo presentaba problemas. Y, en tercer lugar, debido a la relación encontrada en la literatura entre los síntomas del TDAH y otros problemas asociados, y el sueño (Mulraney, Giallo, Lycett, Mensah y Sciberras, 2016; Vélez-Galarraga et al., 2016), se han correlacionado también, dentro del grupo de niños con TDAH, las variables de sueño con las puntuaciones obtenidas por estos niños en cada uno de los cuestionarios completados por los padres y profesores. Pues estas últimas correlaciones podrían ayudar a obtener una visión mucho más amplia de la ausencia de diferencias en el sueño entre los niños con TDAH y los otros dos grupos en la investigación desarrollada en esta tesis doctoral.

Los resultados de los análisis realizados respecto al rendimiento cognitivo son similares a los encontrados antes, salvo porque esta vez sí se observan diferencias entre los grupos en el IVA CPT y en el n-back. En concreto, los niños con TDAH cometieron más errores de comisión que los niños con impulsividad cognitiva y los controles en el IVA CPT, lo que sugiere que una peor capacidad de control o de inhibición de la respuesta. Y también comerieron más errores que los niños con impulsividad cognitiva en el 1-back, sugiriendo, en resumen, una diferencia entre los niños con TDAH y los niños con impulsividad cognitiva en cuanto a su memoria de trabajo a nivel visual.

Por otro lado, los distintos análisis correlacionales realizados muestran una relación entre algunas de las variables del sueño y el peor rendimiento observado en los niños con TDAH y en los niños con impulsividad cognitiva en algunas de las pruebas. Por ejemplo, algunas de las variables de sueño que correlacionan significativamente con el rendimiento cognitivo son, de las subjetivas, el número de problemas de sueño y el número de despertares durante la noche, y de las objetivas, el tiempo en la cama, el período de sueño, y otras variables relativas a la arquitectura del sueño. No obstante, se observa que, aunque estos resultados apuntan a una relación entre las características del sueño y el peor rendimiento cognitivo tanto de los niños con TDAH como de los niños con impulsividad cognitiva, las variables de sueño y las funciones cognitivas implicadas en esta relación no son las mismas para ambos grupos. Sin embargo, la falta de estudios sobre el sueño y su relación con el rendimiento en niños con impulsividad cognitiva sin ningún trastorno no permite profundizar en esta cuestión. Además, tampoco hay disponible un gran número de estudios que hayan explorado esa relación en niños con TDAH, si bien la variable sobre la que parece haber un mayor consenso hasta ahora es la duración del sueño (Gruber et al., 2011; Moreau et al., 2013).

Por otra parte, respecto a los análisis correlacionales realizados entre las características del sueño y la sintomatología de los niños con TDAH, se encuentran diversas corelaciones entre varias variables de sueño subjetivas y objetivas, y los síntomas de TDAH u otros problemas asociados indicados por sus padres y profesores. Concretamente, los problemas afectivos (subescala del *Child Behavior Checklist* y del *Teacher's Report Form*, CBCL y TRF; Achenbach y Rescorla, 2001), los problemas en el hogar (*Home Situations Questionnaire-Revised*, HSQ-R; DuPaul y Barkley, 1992), el total de dificultades (versión para padres y profesores del *Strengths and Difficulties Questionnaire*, SDQ; Goodman, 1997), los problemas con los compañeros (subescala del SDQ de padres), y los problemas de conducta (subescala del SDQ de profesores), son los que muestran el mayor número de correlaciones con el sueño. Por tanto, a juzgar por los resultados obtenidos, estos serían los problemas presentados por los niños con TDAH que más relación guardarían con sus características del sueño. Al tiempo que, en relación a estas características, y teniendo en cuenta el número de correlaciones asociadas, las más implicadas en la gravedad de los problemas de estos niños serían los despertares durante la noche, el número o gravedad de los problemas de sueño que tuvieran, la latencia de sueño y el tiempo despiertos durante la noche.

Los hallazgos de algunos estudios señalaron una relación entre la gravedad de los síntomas de TDAH y los problemas de sueño (Vélez-Galarraga et al., 2016), o la duración del sueño (Hysing, Lundervold, Posserud y Sivertsen, 2016). También en otros estudios se encontraron correlaciones entre las puntuaciones de los niños con TDAH en algunos de los cuestionarios utilizados en esta tesis doctoral, y algunos parámetros del sueño. Por ejemplo, entre las puntuaciones en el CBCL y en el TRF, y el tiempo en la cama, el tiempo total de sueño y el período de sueño (ligado a los despertares durante la noche) (Bergwerff et al., 2016). Así como, entre las alteraciones del sueño y los problemas emocionales (Mulraney et al., 2016), o el total de problemas presentados (Chiraphadhanakul et al., 2016), ambos medidos con el SDQ. Por tanto, los resultados de esta tesis doctoral concuerdan con los de estudios previos, apoyando la existencia de una relación entre la gravedad de los síntomas de TDAH u otros problemas presentados por los niños con este trastorno, y sus características del sueño.

Aportaciones de esta tesis doctoral y aspectos clave a tener en cuenta en futuras investigaciones

La principal finalidad de esta tesis doctoral era proporcionar resultados que contribuyeran al avance del conocimiento sobre el rendimiento cognitivo y el sueño en niños con TDAH y en niños con impulsividad cognitiva. En este sentido, a lo largo de la tesis se han abordado diversas cuestiones con una implicación directa para la práctica clínica y la investigación en niños con TDAH, en relación a sus problemas cognitivos y de sueño. Además de aportar datos comparativos sobre las características del sueño y el rendimiento cognitivo en estos niños, en niños con impulsividad cognitiva, y en niños sin TDAH más reflexivos, también se han puesto en entredicho algunos de los hallazgos encontrados hasta ahora. Señalándose y discutiéndose algunas de las variables más relevantes que han podido venir repercutiendo sobre los resultados de muchos estudios, contribuyendo al aumento de las discrepancias entre ellos.

Respecto a los niños con impulsividad cognitiva, se han señalado cuáles podrían ser las principales dificultades que estos niños podrían presentar en comparación con otros niños con un estilo cognitivo más reflexivo, y que podrían afectar a su rendimiento académico. Así como también se han indicado algunas de las características del sueño de estos niños que más podrían intervenir en sus problemas a nivel cognitivo. Los resultados de esta tesis en cuanto a este grupo de niños sirven de precedente para investigaciones futuras. Especialmente relevante es destacar que, aunque algunos autores habían sugerido una relación entre el sueño y la impulsividad cognitiva (Lee et al., 2014; Um et al., 2016), ningún estudio había analizado hasta ahora esta relación en niños normativos sin ninguna patología. Ni tampoco se había comparado a estos niños con niños con TDAH, ni respecto a sus características del sueño ni a su rendimiento cognitivo.

Otro de los aspectos a destacar en relación a esta tesis doctoral es el protocolo seguido para la inclusión, clasificación y evaluación de los participantes. Por ejemplo, se requirió, entre otros citerios de inclusión, que los niños con TDAH hubieran sido diagnosticados previamente por un especialista, y que este diagnóstico fuera confirmado posteriormente por la información proporcionada por sus padres y profesores tutores mediante diversos cuestionarios. Esto permitió reducir el riesgo de falsos positivos en los niños con TDAH, al tiempo que también permitió comprobar que ni los niños con impulsividad cognitiva ni los controles presentaban síntomas de TDAH que pudieran interferir en los resultados. Además, la clasificación de los niños dentro del grupo con impulsividad cognitiva se realizó a partir de sus puntuaciones en el *Matching Familiar Figures Test*-20 (MFFT-20; Buela-Casal, Carretero-Dios y De los Santos-Roig, 2002), una prueba que cuenta con buenos indicadores de calidad (Buela-Casal, Carretero-Dios, De los Santos-Roig y Bermúdez, 2003). Y, en cuanto a la evaluación de los participantes, destacar las pruebas utilizadas para evaluar su rendimiento cogitivo, así como la consideración tanto de medidas subjetivas como objetivas para evaluar sus características del sueño.

Pese a los criterios metodológicos empleados y a la relevancia de algunos resultados presentados en esta tesis, son necesarios más estudios que confirmen estos hallazgos. Para empezar, porque la falta de mayores estudios previos sobre las variables estudiadas en esta tesis y la impulsividad cognitiva limita la contrastación de los resultados para la obtención de conclusiones en cuanto a este estilo cognitivo. Pero, sobre todo, porque el carácter transversal de la metodología seguida en esta tesis no permite determinar el impacto sobre el rendimiento cognitivo y el sueño del tratamiento farmacológico de los niños con TDAH, constituyendo este una de las variables potenciales de influencia más relevantes. Es decir, sería pausible tanto que la medicación de los niños con TDAH evaluados hubiera influido positivamente para que estos no presentaran más diferencias respecto a los otros dos grupos de niños en sueño y rendimiento cognitivo, como que no las hubiera habido independientemente de la medicación. Especialmente teniendo en cuenta el permisible efecto de la medicación a corto plazo pero su debatible eficacia a largo plazo (Timimi, 2004), y el hecho de que el tiempo que llevaban tomando medicación los niños evaluados ni se registró ni fue controlado en esta tesis. Por último, tampoco la distribución de los subtipos de TDAH entre los niños con este trastorno en los distintos análisis de la tesis posibilita examinar la influencia real de estos subtipos sobre el rendimiento cognitivo y las características del sueño mostradas por estos niños, ni corroborar que la existencia de estos subtipos se ve reflejada realmente en diferencias entre ellos en las variables evaluadas. Algo a lo que sí parecen apuntar los resultados de algunos autores (González-Castro et al., 2010; González-Castro, Rodríguez, Cueli, García y Alvarez-García, 2015).

En conjunto, la falta de un mayor análisis sobre la influencia de la medicación y los subtipos limita en parte cualquier tipo de aportación de esta tesis doctoral al debate o la polémica actual sobre la existencia del trastorno. Pues, por un lado, no se encuentran diferencias significativas entre los niños con TDAH y los controles a nivel fisiológico en cuanto a sus características del sueño, más allá de la mayor cantidad de sueño ligero observada en el análisis de las investigaciones previas pero que no se corresponde con lo observado a posteriori en esta tesis. Por consiguiente, no hemos encontrado resultados que, sin valorar la medicación y los subtipos, indiquen una diferencia sustancial entre ambos grupos de niños que podría ser inherente al TDAH, a favor de la existencia de esta entidad clínica. Pero en cambio, por otro lado, las diferencias que sí hemos encontrado entre ambos grupos a nivel cognitivo sugieren que los niños con un diagnóstico de TDAH presentan problemas cognitivos, respecto a otros niños sin este diagnóstico, sobre los que es preciso intervenir para evitar consecuencias indeseables a largo plazo. Esto aún cuando la propia etiqueta diagnóstica de TDAH pueda ser debatible o su uso obedecer a otras razones de índole cuestionable, o el tratamiento farmacológico pueda no ser el medio más favorable para lograr los cambios deseados (García et al., 2014; Pérez, 2014; Timimi, 2004, 2014). Es decir, más allá de los argumentos existentes a favor (Barkley, 2002) o en contra del TDAH o del manejo clínico que se está llevando a cabo (García et al., 2014; Pérez, 2014; Timimi, 2004, 2014), se encuentran niños con problemas cognitivos frente a su grupo de iguales.

En pocas palabras, lo que esta tesis doctoral viene a resaltar es la importancia de futuras investigaciones que, desde un enfoque longitudinal, analicen en profundidad cada una de esas cuestiones. De forma que proporcionen más datos sobre los problemas cognitivos y de sueño que tanto los niños con un diagnóstico de TDAH (más allá de que exista o no el trastorno como tal) como los niños con impulsividad cognitiva pueden presentar con respecto a su grupo de iguales. O, sobre la relación del sueño con esos problemas cognitivos desde un punto de vista causal. En definitiva, investigaciones cuyas aportaciones permitan abordar tales problemas desde otra perspectiva, dejando de lado la intervención farmacológica en pos de otro tipo de intervenciones que podrían llegar a ser más útiles o beneficiosas a largo plazo.

CONCLUSIONES

Conclusiones

De esta tesis doctoral se derivan las siguientes conclusiones principales:

- Los niños con TDAH y los niños con impulsividad cognitiva presentan un peor rendimiento cognitivo que los niños sin TDAH y con un estilo cognitivo más reflexivo, que se manifiesta en distintas capacidades.
- Los niños con TDAH tienen una menor capacidad de control o inhibición de la respuesta que los niños sin TDAH.
- Los niños con TDAH y los niños con impulsividad cognitiva tienen problemas de aprendizaje discriminativo comparados con su grupo de iguales, pero estos problemas son mayores en los niños con impulsividad cognitiva.
- Tanto los niños con TDAH como los niños con impulsividad cognitiva tienen una menor capacidad de memoria de trabajo a nivel fonológico que los niños sin TDAH y sin impulsividad cognitiva. Los niños con TDAH presentan también una menor capacidad de memoria de trabajo a nivel visual en comparación con los niños con impulsividad cognitiva.
- Los niños con TDAH manifiestan una peor comprensión verbal que los niños con impulsividad cognitiva y que los niños sin este trastorno y sin problemas de impulsividad cognitiva asociados.
- La capacidad de velocidad de procesamiento es peor en los niños con TDAH y en los niños con impulsividad cognitiva, en comparación con su grupo de pares.
- La capacidad de razonamiento perceptivo y la capacidad de atención sostenida no están afectadas ni en los niños con TDAH ni en los niños con impulsividad cognitiva en comparación con su grupo de iguales.

- Se observan características del sueño similares en los niños con TDAH, en los niños con impulsividad cognitiva, y en los niños sin ninguno de estos problemas. Por tanto, el diagnóstico de TDAH no implica directamente la presencia de problemas de sueño en los niños con esta patología, como tampoco lo hace el tener un estilo cognitivo más impulsivo. La medicación y los subtipos de TDAH pueden intervenir en los problemas que presentan los primeros.
- Existe una relación entre algunas características del sueño de los niños con TDAH y de los niños con impulsividad cognitiva, y los problemas cognitivos que estos niños presentan comparados con su grupo de iguales, aunque las variables de sueño y las funciones cognitivas implicadas en esa relación no son las mismas para ambos.
- La gravedad de los síntomas y otros problemas asociados que los niños con TDAH pueden presentar guardan una relación con sus características del sueño, aunque falta por determinar la dirección de esta relación.

CONCLUSIONS

Conclusions

The main conclusions arising from this doctoral thesis are as follows:

- Children with ADHD and children with cognitive impulsivity have a lower performance compared to children without ADHD who also had a more reflexive cognitive style, which is revealed in different abilities.
- Children with ADHD have a lower response control or inhibition compared to children without ADHD.
- Children with ADHD and children with cognitive impulsivity have discrimination learning problems compared to their peers, but these problems are greater in children with cognitive impulsivity.
- Both children with ADHD and children with cognitive impulsivity have a lower working memory on the phonological level compared to children without ADHD or cognitive impulsivity. Children with ADHD also show a lower working memory on the visual level in comparison with children with cognitive impulsivity.
- The verbal comprehension of children with ADHD is worse compared to children with cognitive impulsivity, and also compared to children without this disorder and without associated impulsivity cognitive problems.
- Processing speed is lower in children with ADHD and children with cognitive impulsivity, in comparison with their peers.
- Perceptual reasoning and sustained attention are not affected in children with ADHD or in children with cognitive impulsivity in comparison with their peers.
- Similar sleep characteristics are observed in children with ADHD, children with cognitive impulsivity, and children without any of these problems. Therefore, an

ADHD diagnosis does not directly imply the presence of sleep problems in children with this pathology; again, neither does having a more impulsive cognitive style imply it. Medication and ADHD subtypes can be involved in the problems showed by children with ADHD.

- A relationship exists between some sleep characteristics of children with ADHD and children with cognitive impulsivity, and the cognitive problems that these children have in comparison with their peers. This occurs even though the sleep variables and the cognitive functions involved in that relationship are not the same for both types of children.
- Severity of symptoms and other related problems that children with ADHD can have are connected to their sleep characteristics, although the direction of this relationship is still undetermined.

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