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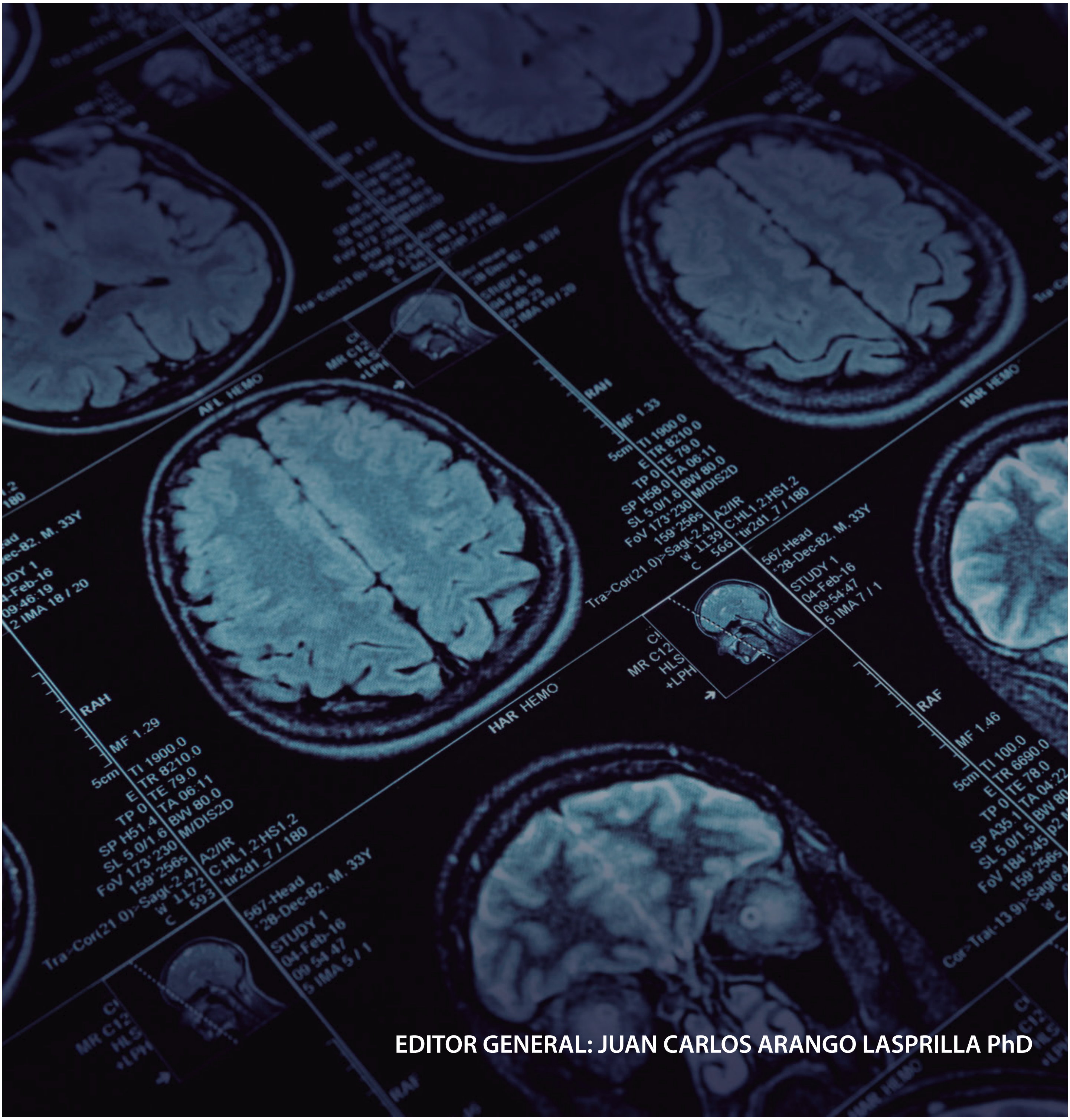

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Neuropsicología de la epilepsia rolándica. Una revisión

David Garnica Agudelo[1,2,3], Álvaro Izquierdo Bello[4,5], Jairo Zuluaga Gómez[2,6,1]

RESUMEN

Introducción: *la epilepsia rolándica (ER) o epilepsia con puntas centro-temporales (ECTS) es una de las epilepsias de la niñez más frecuentes. A lo largo de los últimos años se ha controvertido su categorización como epilepsia "benigna". Objetivo: presentar una revisión teórica de las investigaciones publicadas sobre las consecuencias cognitivas y comportamentales de esta epilepsia y que tienen implicaciones en la comprensión del desarrollo neurocognitivo de los pacientes.* ***Método:*** *revisión de artículos de investigación originales, de revisión y metaanálisis publicados entre 2008 y 2018 en las bases de datos PudMed, Medline, ScienceDirect, SpringerLink, Scopus, PsycINFO, Ovid Journals, Wiley Online Library, Hindawi, Scielo, Nature y John Libbey Eurotext. Las palabras de búsqueda fueron* ***rolandic epilepsy, benign epilepsy of childhood with centrotemporal spikes, cognition, neuropsychology, deficit, impairment, language, attention, memory, executive functions, electroencephalography, neuroimaging.*** ***Resultados:*** *recuperación de un total de 120 artículos e inclusión de 111 publicaciones en la revisión.* ***Conclusión:*** *la evidencia de estudios de neuropsicología y neurociencia cognitiva sobre las dificultades cognitivas y comportamentales, así como los metaanálisis realizados a la fecha, indican que la ER no debe considerarse como benigna ni autolimitada. También la evidencia indica que presenta un desarrollo cognitivo caracterizado por una función intelectual normal y déficits de variable durabilidad en el lenguaje y adquisición de la lecto-escritura, conciencia fonológica, atención, memoria y funciones ejecutivas.*

Palabras clave:

Epilepsia rolándica, Epilepsia con puntas centrotemporales, Neuropsicología, Desarrollo cognitivo, Cognición.

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ABSTRACT

Introduction: rolandic epilepsy or epilepsy of childhood with centro-temporal spikes (ECTS) is one of the most common forms of pediatric epilepsies. During the last years controversy has grown about its categorization as “benign” epilepsy. **Objective:** to present a theoretical review of the published research about the cognitive and behavioral consequences of this epilepsy and that have implications in the comprehension of the neurocognitive development of the patients. **Method:** review of original research, review, and meta-analysis articles published between 2008 and 2018 in the PudMed, Medline, ScienceDirect, SpringerLink, Scopus, PsycINFO, Ovid Journals, Wiley Online Library, Hindawi, Scielo, Nature, and John Libbey Eurotext databases. The search terms were *rolandic epilepsy, benign epilepsy of childhood with centrotemporal spikes, cognition, neuropsychology, deficit, impairment, language, attention, memory, executive functions, electroencephalography, neuroimaging*. **Results:** a total of 120 articles were found and 111 were included in the review. **Conclusion:** the evidence from neuropsychology and cognitive neuroscience studies about the cognitive and behavioral difficulties, as well as the meta-analyses published to the date, indicate that ECTS should not be considered as benign or auto-limited. In addition, the evidence points to a cognitive development characterized by a normal intellectual function and deficits with variable durability in language, reading and writing acquisition, phonological awareness, attention, memory, and executive functions.

Keywords:

Rolandic epilepsy, Epilepsy of childhood with centro-temporal spikes, Neuropsychology, Cognitive development, Cognition.

Introducción

Epilepsia rolándica: definición y características clínicas

La epilepsia rolándica (ER) (también epilepsia benigna de la niñez con puntas centrotemporales) es un síndrome electroclínico de la niñez (1), de etiología idiopática y con crisis focales, incluyéndose dentro del espectro de “síndromes benignos de susceptibilidad a crisis focales” (2). De acuerdo a la última clasificación de las epilepsias y crisis de la Liga Internacional Contra la Epilepsia (ILAE) (1,3,4), el término “idiopático” se remplaza por “genético”, cambiando la etiología de la ER a genética, y el término “benigno” se remplaza por “autolimitado” o “farmacorrespondedor” y, por tanto, sobre la ER continúa el debate sobre su clasificación como epilepsia autolimitada y su naturaleza con compromisos cognitivo-comportamentales.

La ER es una de las epilepsias infantiles más frecuentes, con edad de inicio entre los 4 y 10 años en 90% de los pacientes, edad media de inicio de 7 años y una mayor frecuencia en el género masculino con una relación respecto al femenino de 3:2. La remisión de la actividad epiléptica y de las crisis ocurre entre 2 y 4 años luego del inicio y antes de los 16 años. La ER presenta crisis relacionadas con el sueño en 80% a 90% de los pacientes y aproximadamente 15% de los pacientes tienen las crisis en sueño y en vigilia, pero para cerca del 10% ocurren al despertar. La frecuencia de crisis usualmente es baja y alrededor del 10% de los casos presentan solo una crisis. Sin embargo, aproximadamente 20% de los niños tienen crisis frecuentes y pueden ocurrir varias veces por día. Solo 20 a 25% de los niños presenta más de un tipo de crisis, las cuales pueden durar entre 30 segundos y 3 minutos. Las crisis pueden presentarse con signos orofaciales motores (contracciones de un lado de la cara con predilección por alguna comisura labial, de lengua o mandíbula, sonidos guturales), hipersalivacion (sialorrea), detención del habla (por contracción de músculos orofaríngeos) y síntomas somatosensoriales (entumecimiento unilateral o parestesia de lengua, labios, mejillas). Las descargas epileptiformes interictales (IED) de la ER se caracterizan por puntas u ondas agudas localizadas en el área centrotemporal o rolándica. Estas son puntas amplias, difásicas, de alto voltaje (100-300 μV), con un dipolo transverso, frecuentemente seguidas por una onda lenta. Es frecuente una actividad lenta y rítmica en las regiones de las puntas. Éstas pueden ocurrir aisladas o en grupos, en un hemisferio o de forma bilateral y sincrónica. Por último, pueden ocurrir en vigilia o en el sueño, y pueden difundirse a regiones cerebrales adyacentes(5,6).

La evidencia epidemiológica de la ER es limitada, pero se ha calculado una prevalencia del 15% entre 1 y 14 años con convulsiones no febriles y una incidencia de 10-20 por cada 100.000 entre 1 y 15 años(3,9).

En cuanto a la etiología de la ER, se considera que está determinada genéticamente según estudios con familiares que sugieren una herencia multifactorial, presumiblemente autosómica dominante, con penetrancia alta pero incompleta y por estudios que la relacionan con una mutación en cromosoma 15q14 y al gen precursor de la subunidad α7 del receptor para acetilcolina (α7-AChR) (5-8,10). Evidencia más reciente indica que existen mutaciones heterocigóticas en el gen *GRIN2A* (del cromosoma 16) en individuos con ER, epilepsia focal atípica de la niñez (AFEC), síndrome de Landau-Kleffner (LKS) y estatus epiléptico de punta onda durante sueño lento (CSWS)(11). En un estudio de asociación del genoma completo (GWA) se encontró una relación entre discapacidad de la lectura (dislexia) y variaciones en el cromosoma 7q21 y 1q42 en familias con probandos con ER(12). Las evaluaciones cognitivas a probandos con ER, sus hermanos y controles, indican déficits de lectura en 42% de los probandos y en 22% de los hermanos, sumado a un riesgo objetivo mayor de los últimos para presentar discapacidad de lectura(13-15). Por último, se reportaron dos casos de co-ocurrencia de epilepsia de ausencia infantil y ER, sugiriendo probables asociaciones genéticas que posibiliten una patofisiología común(16).

Metodología

En esta revisión los criterios de inclusión fueron: 1) artículos de investigación original, series de casos, capítulos de libro, revisiones narrativas, revisiones sistemáticas y meta-análisis; 2) investigaciones estrictamente enfocadas en la neuropsicología de la ER; 3) estudios con metodologías de evaluación neuropsicológica, neuroimagen y EEG/ERP; y 4) investigaciones relevantes para el debate del estatus benigno de la ER, sus efectos sobre la cognición y comportamiento, sus morbilidades a largo plazo y estudios posteriores a la remisión de la actividad epiléptica. Por otra parte, se excluyeron artículos correspondientes a estudios de caso y todos los publicados previamente a 2008. En consecuencia, la búsqueda bibliográfica tuvo en cuenta un rango de tiempo de 10 años, el comprendido entre 2008 y 2018. Las bases de datos consultadas fueron PudMed, Medline, ScienceDirect, SpringerLink, Scopus, PsycINFO, Ovid Journals, Wiley Online Library, Hindawi, Scielo, Nature y John Libbey Eurotext. Las palabras claves de búsqueda fueron *rolandic epilepsy, benign epilepsy of childhood with centrotemporal spikes, cognition, neuropsychology, deficit, impairment, language, attention, memory, executive functions, electroencephalography, neuroimaging*. El inglés fue el único idioma de búsqueda. El número total de documentos encontrados fue 120 y el número total de publicaciones analizadas e incluidas en la revisión es 111. Se descartaron 9 publicaciones al tratarse de una carta editorial, emplear metodologías de modelamiento (neurociencia computacional), limitarse a la localización de puntas-ondas en MEG y EEG, analizar la eficacia de fármacos antiepilépticos (FAE) y la frecuencia de actividad epileptiforme generalizada en el EEG.

Estudios de electroencefalografía en epilepsia rolándica

Con electroencefalografía (EEG) se han investigado los efectos de las IED y crisis nocturnas en niños con ER, encontrando que es probable que causen un desarrollo atípico de las redes cerebrales del lenguaje, contribuyendo a un funcionamiento menos eficiente de los procesos psicolingüísticos y a la aparición de compromisos lingüísticos (en lectura, deletreo, aprendizaje auditivo verbal, discriminación auditiva con ruido de fondo y expresión gramática)(17,18).[2] Xiao *et al.*(19) y Systad *et al.*(20) presentan evidencia de una correlación significativa entre la presencia de IED nocturnas y puntas centrotemporales en regiones rolándicas, giro frontal inferior izquierdo (broca) y derecho, lóbulo parietal inferior izquierdo giro supramarginal y núcleo caudado izquierdo con un retraso en las habilidades del lenguaje (vocabulario, sintaxis, morfosintaxis, fonología, memoria de corto plazo, habilidades ortográficas y decodificación fonológica).

Los estudios con potenciales relacionados con eventos (ERPs) indican amplitudes significativamente mayores en tareas de memoria de trabajo visual en regiones fronto-centrales, probablemente requiriendo mayor esfuerzo para lograr la discriminación frente a controles(21). Tomé *et al.*(22) encontraron mayores amplitudes y leves latencias prolongadas en tareas de discriminación auditiva en electrodos fronto-centrales. Casali *et al.*(23) hallaron pacientes con latencias prolongadas y amplitudes reducidas en ERPs auditivos (P300) respecto a controles, pero sin ser diferencias significativas. Monjauze *et al.*(24) evidenciaron patrones atípicos de lateralización del lenguaje en regiones frontales de pacientes en remisión, sugiriendo que estos compromisos pueden persistir luego de la fase activa del desorden. Boatman *et al.*(25) no encontraron diferencias en la latencia o amplitud de las respuestas corticales N100 para estímulos del habla o tonos, pero el potencial de disparidad (mismatch negativity) fue elicitado pasivamente, estuvo ausente o fue prolongado para el habla y no para tonos en niños con ER. Por último, Elkholy *et al.*(26) hallaron una desincronización alfa relacionada a evento (ERD) significativamente inferior con respecto a controles como indicador de una activación cerebral disruptiva para estímulos que requieren atención auditiva.

Con magnetoencefalografía (MEG) se han evidenciado dipolos tangenciales generados en el surco central o precentral que no se localizan y, o detectan con EEG. En consecuencia, se ha propuesto la MEG como herramienta diagnóstica para la ER(27,28). Al mismo tiempo, hay evidencia de que las puntas en localizaciones posteriores se relacionan a cuadros atípicos de la ER con pronóstico más pobre para el funcionamiento cognitivo y con una mayor frecuencia de crisis(29). También se han hallado dipolos de localización ventrolateral alrededor del nivel orofacial que pueden ser característicos de la ER y dipolos dorsomediales alrededor del nivel de las manos probablemente propios de las variantes atípicas(30).

Estudios de neuroimagen en epilepsia rolándica

Son múltiples los hallazgos de anormalidades estructurales en resonancia magnética (MR). Primero, un aumento del volumen de la corteza frontal inferior y media bilateral, ínsula izquierda, del giro supramarginal bilateral(31), de la corteza frontal superior derecha, temporal superior y medial derecha, y del *pars triangularis* izquierdo(32). Segundo, hay un aumento del volumen de la materia gris cortical en el giro frontal superior bilateralmente, ínsula bilateral, giro frontal inferior derecho(31), *precuneus* derecho, giro orbitofrontal izquierdo, *pars orbitalis* izquierdo, giro precentral izquierdo, putamen bilateral y amígdala(32). Al mismo tiempo, hay evidencia de un adelgazamiento del volumen cortical en giro frontal medial rostral bilateral, giro frontal inferior derecho, giro temporal inferior izquierdo y *cuneus* derecho(33). Sobre este aspecto, Overvliet *et al.*(34) encontraron un grosor cortical reducido en la corteza rolándica y en los giros temporal superior y supramarginal del hemisferio izquierdo, pero con un adelgazamiento cortical gradual en regiones frontales, centroparietales, temporales y mediales del hemisferio izquierdo en función de la edad, sugiriendo una trayectoria de desarrollo cerebral atípica. Otro hallazgo importante es una hipertrofia del putamen, la cual se presenta con elongación dorsoventral del núcleo caudado izquierdo y del putamen bilateral, sugiriendo cambios adaptativos porque se encontró una correlación entre un mayor volumen del putamen y un mejor desempeño en pruebas específicas de funciones ejecutivas(33,35).

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[2] Se ha propuesto que las anormalidades epileptiformes nocturnas en EEG caracterizan a un espectro de compromisos del lenguaje, desde el trastorno específico del lenguaje (SLI), ER, epilepsia nocturna del lóbulo frontal, estado epiléptico del sueño, hasta el LKS, con menores déficits para el primero y mayores para el último(17).

Una diferencia entre la ER y ER con trastorno por déficit de atención e hiperactividad (TDAH) es la presencia de giros caudal y cingulado posterior izquierdos más gruesos, junto a un mayor volumen de los giros del *pars opercularis* izquierdo(32). Los niños con ER atípica y dificultades comportamentales presentan una menor relación entre el volumen del lóbulo frontal y prefrontal a diferencia de niños con ER típica y controles, incluso posterior a la remisión de la epilepsia, sugiriendo una disfunción frontal para la ER atípica(36,37). Con tractografía se han encontrado anormalidades en la microestructura de la materia blanca: 1) mayores valores de difusividad axial y promedio para el fascículo longitudinal superior izquierdo, parte retrolenticular de la cápsula interna, radiación talámica posterior, cuerpo calloso y núcleo estriado sagital(38); y 2) una menor anisotropía fraccional de los giros precentrales y del giro poscentral izquierdo, siendo una variable correlacionada negativamente con la duración de la epilepsia(39).

Por otra parte, se han encontrado diferentes alteraciones y cambios significativos en las redes cerebrales de procesamiento lingüístico por medio de resonancia magnética funcional (fMRI). En primer lugar, hay evidencia de una mayor representación bilateral del procesamiento del lenguaje (un menor índice de lateralización izquierda en comparación a controles) y de una disminución en la conectividad entre áreas sensoriomotoras izquierdas (giro frontal superior, giro supramarginal, lóbulo parietal inferior) y el giro frontal inferior (área de Broca)(40,41). Esto implica una menor conectividad e integración entre redes motoras y del lenguaje, correspondiendo con las áreas de actividad epileptiforme y constituyendo un probable correlato neural de la disfunción lingüística y de lecto-escritura(40,42,43). Segundo, empleando fMRI en estado de reposo (rs-fMRI), se encontró mayor conectividad funcional entre el área rolándica, áreas del lenguaje (núcleo lentiforme izquierdo, giro frontal medial izquierdo, giro frontal inferior derecho) y el giro temporal inferior izquierdo en pacientes que en controles(44). Esto sugiere que las alteraciones en conectividad funcional en redes relacionadas con la zona de inicio de las crisis y las áreas de procesamiento del lenguaje pueden relacionarse con plasticidad adaptativa ante la disfunción cognitiva(44). Tercero, se observó una red más amplia para la comprensión del lenguaje, pues en tareas de lectura los pacientes y controles activan la región frontal inferior izquierda y las áreas temporales bilaterales, pero solo los pacientes muestran activación en el hipocampo izquierdo, precuneus, núcleo caudado izquierdo y putamen izquierdo(45). Por último, existe una red atípica para el procesamiento semántico pero más amplia con respecto a controles y en correlación a un desempeño más bajo en evaluación neuropsicológica del lenguaje, sugiriendo una reorganización funcional de la arquitectura neuronal para el lenguaje(46,47).[3]

Similarmente, otros estudios de neuroimagen son relevantes. Por ejemplo, Chen *et al.*(48) reportaron que los niños con inicio reciente de ER presentan un aumento de la amplitud de fluctuación de baja frecuencia (ALFF) en el área de Broca derecha, una disminución de la ALFF en el giro fusiforme bilateral y una conectividad funcional menor entre el área de Broca con el lóbulo prefrontal derecho y redes parietales del lenguaje. Estos cambios corresponden posiblemente a un mecanismo compensatorio en un estadio temprano de la ER. En cuanto a los niños con ER más TDAH, Xiao *et al.*(49) reportaron una conectividad funcional disminuida en la red atencional dorsal (surco intraparietal y campo ocular frontal que permiten el control de la atención espacial y atención selectiva) a comparación de niños con ER sin TDAH, quienes presentan una conectividad funcional mayor en la red atencional ventral (unión temporoparietal y corteza frontal ventral que permiten reorientar la atención a estímulos salientes) en comparación a controles. Este último estudio sugiere que los niños con ER y TDAH pueden

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[3] Vannest et al.(46) hallaron cambios en la localización cerebral del procesamiento lingüístico. Con tareas de decisión semántica hay un aumento significativo en la activación del giro fusiforme y del giro temporal medial derecho, pero menor activación en la región frontal izquierda, supramarginal izquierda y del cíngulo. En tareas de procesamiento de historias se observa mayor activación del giro supramarginal izquierdo, mientras que en tarea de discriminación de la prosodia hay mayor activación de la corteza dorsolateral prefrontal bilateral y del giro temporal superior derecho. Esto sugiere que los pacientes pueden requerir más recursos cerebrales para procesar estímulos lingüísticos: reclutan cortezas visuales asociadas con la imaginería visual (porque las tareas de decisión requieren propiedades visuales de los nombres) y el cuerpo estriado para el procesamiento de los significados.

presentar esta diferencia neurobiológica como correlato de un compromiso en la reorientación atencional a diferencia de los que no tienen TDAH y de niños con desarrollo típico. Comprendiendo esta reorganización en redes cerebrales, Oser *et al.*(50) y Ofer *et al.*(51) estudiaron los cambios en la activación de la red por defecto (*default mode network* - DMN). Hallaron una activación significativamente menor de la DMN en condición de reposo, menor desactivación del precuneus con tarea de generación de oraciones, mayor duración de la enfermedad correlacionada con disminución significativa de la eficiencia y centralidad de nodos de la red parietal (incluyendo el lóbulo parietal inferior izquierdo) y una centralidad reducida de ésta área correlacionada con un desarrollo cognitivo favorable determinado por puntuaciones mayores en prueba de inteligencia(50,51).

Neuropsicología de la epilepsia rolándica

La revisión de Vannest *et al.*(52) sostiene que la ER presenta déficits en múltiples dominios cognitivos, siendo la función intelectual general la menos afectada, pero con las variantes y crisis epilépticas atípicas presentando los resultados más pobres. A pesar de esto, un estudio presenta evidencia de niños con ER de diagnóstico reciente con un perfil neuropsicológico e intelectual normal(53). Este hallazgo es contradictorio con el de otros estudios, pues se han encontrado y anormalidades en la sincronización local en EEG (tomografía electromagnética de baja resolución - LORETA) al inicio de la enfermedad(54) y déficits en procesos lingüísticos previos al diagnóstico (55,56). De hecho, solamente Kwon, Seo y Hwang(53) presentan un perfil cognitivo normal. El resto de investigaciones revisadas indica un desempeño más bajo o déficits significativos en múltiples procesos cognitivos.

Atención, memoria de trabajo y velocidad de procesamiento

La revisión de Kavros *et al.*(57), sobre los compromisos atencionales de la ER, argumenta déficits en los tres sistemas atencionales del modelo de Michael Posner: red de alerta, red de orientación y red de ejecución. Estos compromisos se presentan con puntas centrotemporales activas y se resuelven en la remisión EEG. Coherentemente, Cerminara *et al.*(58) encontraron un menor desempeño respecto a controles en tareas de vigilancia (tónica y fásica), atención selectiva (tiempo de reacción, impulsividad en tarea *go/no go*, incompatibilidad y escaneo visual). En cuanto a la prevalencia del TDAH en pacientes con ER, dos estudios encontraron que entre 65% y 70% han sido diagnosticados con este trastorno(59,60). Estas investigaciones indican que pacientes con un índice alto de puntas centrotemporales (≥40/min) en el EEG de sueño tienen un desempeño más bajo en atención selectiva visual y que hay un riesgo mayor de dificultades atencionales para niños con crisis refractarias y más de un FAE(59,60). En relación a esto, Danhofer *et al.*(61) hallaron una correlación significativa entre un mayor número de puntas centrotemporales nocturnas y un menor desempeño en pruebas de atención selectiva y dividida. Por otra parte, Lima *et al.*(62) evaluaron niños con ER con y sin TDAH para compararlos con controles y niños con TDAH sin epilepsia. Encontraron que niños con ER más TDAH tienen un desempeño atencional y ejecutivo significativamente menor que niños con ER y niños con TDAH, particularmente en Conners' Continuous Performance Test II y Trail Making Test B. Finalmente, existe evidencia de un compromiso significativo en atención selectiva visual y auditiva en pacientes de ER y sus hermanos, sugiriendo una relación genética(14).

La ER también presenta dificultades en memoria de trabajo. El desempeño es significativamente inferior en retención de dígitos en orden directo e inverso(63-65), cubos de Corsi en orden directo e inverso (memoria de trabajo visual)(64) y tareas experimentales de recobro espacio-temporal de objetos presentados visualmente(66). En experimentos de ERPs, los pacientes presentan mayores amplitudes en regiones frontales y centrales entre 300 y 500 ms posteriores a los estímulos objetivo en tarea de memoria de trabajo viso-espacial(67,68). También, los niños con epilepsia controlada muestran un patrón de activación cortical diferente, sugiriendo que requieren mayor procesamiento cerebral para lograr el mismo desempeño que los controles en estas tareas.

Finalmente, la velocidad de procesamiento presenta menor rendimiento con respecto a los controles, pero sin una diferencia estadísticamente significativa(33,63,65).

Memoria

Se ha planteado que las IED en sueño no REM (NREM) pueden interferir en la retroalimentación de la corteza temporal y frontal, causando déficits en la consolidación de la memoria declarativa. Por ejemplo, se han encontrado compromisos en memoria debido a diferencias significativas con respecto a controles en pruebas de aprendizaje de palabras u oraciones(14,69-74), recobro inmediato y diferido de lista de palabras(14,70,72,74), aprendizaje de números y su recobro inmediato(75), aprendizaje de figuras o matrices visuales y recobro diferido de figuras(71). En consecuencia, estas dificultades probablemente interfieren con la consolidación de huellas de memoria correspondientes a información lingüística y se correlacionan con los hallazgos de los estudios de neuroimagen arriba reseñados(69).

Lenguaje, conciencia fonológica y audición

La literatura es consistente al indicar compromisos en procesos de expresión y comprensión verbal. El metaanálisis de Smith, Bajomo y Pal(76) indica tamaños del efecto (*d* de Cohen) entre 0,71 a 0,75 (efecto medio) para evaluaciones de lenguaje receptivo y expresivo, indicando una diferencia de 1 desviación estándar respecto a controles. Múltiples investigaciones reportan desempeños significativamente inferiores frente a controles en pruebas de comprensión verbal (definición de conceptos, seguimiento de instrucciones), recobro de oraciones, fluidez verbal, conocimiento del vocabulario y de categorías, denominación con estímulo visual, producción de oraciones y articulación(28,40,41,69,77-80). De acuerdo a la revisión de Teixeira y Santos(81), los déficits más consistentes entre la literatura están en las habilidades semánticas, morfosintácticas y fonológicas. A estas evidencias se suman que los hermanos de niños con ER tienen mayor riesgo de presentar compromisos lingüísticos similares(14); el compromiso del lenguaje antecede al diagnóstico en algunos pacientes(55); existe una lateralización EEG atípica para el lenguaje(24) junto a una reorganización hemisférica y funcional para el lenguaje(44,47); y que hay una correlación entre la presencia de actividad epileptiforme nocturna y las dificultades en el lenguaje(17,19,20,73,75,82,85).

Se han realizado investigaciones específicas sobre la conciencia fonológica y audición en la ER. En experimentos de audición dicótica los pacientes no muestran la ventaja del oído derecho/hemisferio izquierdo en la discriminación de estímulos fonológicos y competitivos (combinaciones de consonantes y una vocal). En su lugar, se observa un índice de lateralización menor para el hemisferio izquierdo en niños con localización multifocal de IED, sugiriendo que la actividad interictal puede inducir una reorganización de la lateralización de la percepción del habla, con una representación bilateral para el procesamiento de estímulos verbales y auditivos(18). Otro estudio de audición dicótica encontró que los niños con actividad epileptiforme del hemisferio izquierdo no presentan dominancia en este hemisferio para el procesamiento del lugar de la articulación y expresión sonora de consonantes específicas, por lo que los autores proponen que la actividad epileptiforme interfiere con el desarrollo de la dominancia izquierda de mecanismos fonológicos(81,82). Boatman *et al.*(25) encontraron un reconocimiento del habla normal pero un desempeño significativamente más bajo que los controles en el reconocimiento del habla con ruido de fondo. En cuanto a estudios que emplearon pruebas estandarizadas, se observa un desempeño significativamente inferior en memoria auditiva (aprendizaje y recobro de oraciones)(71), cancelación de sonidos, deletreo y escritura de no palabras, síntesis de sílabas y fonemas, segmentación de sílabas y fonemas, manipulación de sílabas y fonemas, transposición de sílabas y fonemas, repetición de rimas y aliteración(64,83,84).

Habilidades escolares, desempeño escolar y dificultades educativas

Conociendo que los niños con ER presentan una red cerebral atípica para la comprensión del lenguaje(40,42-44) y que requieren un reclutamiento mayor de áreas cerebrales para realizar una tarea de comprensión de lectura(44,45), se han propuesto éstas diferencias como correlato neurobiológico de las dificultades en lecto-escritura(40-42). Otro factor que puede contribuir al déficit de lectura es la cantidad de actividad epileptiforme nocturna, pues se encontró una correlación significativa entre una mayor actividad epileptiforme nocturna y un menor desempeño en lectura de palabras y coeficiente intelectual (CI) verbal evaluado con Escala de Wechsler de Inteligencia para Niños III (WISC-III)(83). Asimismo, el meta-análisis de Smith, Bajomo y Pal(76) muestra valores de tamaño del efecto significativos (≥0,8) correspondientes a un resultado significativamente menor de niños con ER en tareas de lectura. Al respecto, los estudios de evaluación neuropsicológica demuestran puntuaciones significativamente inferiores en pruebas de comprensión de lectura(86), velocidad (lectura de párrafos, tiempo de respuesta para lectura de pseudo-palabras)(57,87) y precisión (lectura de palabras, pseudo-palabras, oraciones)(55,84-89). En cuanto a escritura, Fonseca *et al.*(88) reportan que aproximadamente el 54.8% de los pacientes presenta un desempeño inferior en tareas de escritura (precisión en dictados de palabras) respecto a controles, pero ésta diferencia no es estadísticamente significativa. Völkl-Kernstock *et al.*(90) no encontraron diferencias significativas entre pacientes y controles en pruebas de habilidades de lectura y ortográficas. Finalmente, Oliveira *et al.*(91) reportaron que alrededor del 19.4% de los pacientes tiene un diagnóstico previo de dislexia, con diferencias significativas entre pacientes y controles en pruebas de lectura y escritura.

Las investigaciones sobre habilidades matemáticas en la ER indican resultados limitados. Canavese *et al.*(92) y Perkins et al.(28), dos estudios sin grupo control, reportaron que 2 niños de muestras de 10 y 9 pacientes, respectivamente, cumplían con el diagnóstico de discalculia, con resultados por debajo de lo normal en pruebas de conteo, multiplicación, sustracción y cálculo escrito. Otros estudios reportan que 29% a 100% de las muestras evaluadas presentan un desempeño inferior a controles en habilidades matemáticas, pero sin una diferencia estadísticamente significativa(77,91,93).

En cuanto al desempeño escolar de los niños con ER, varios estudios evaluaron las habilidades escolares con el Academic Performance Test (APT) y el School Performance Test (SPT)(85,91,94). Los resultados indican puntajes en pruebas de lectura y escritura significativamente más bajos que los controles y la población general. Tedrus *et al.*(94) encontraron este déficit en el 18.4% de su muestra, pero en correlación a amplitudes alfa relativas inferiores en electrodos centro-parietales (EEG) en comparación a pacientes sin dificultades escolares y a controles. Piccinelli *et al.*(95) encontraron que 45% de sus pacientes presentó dificultades significativas en lectura, escritura y cálculo en comparación a controles, también en correlación a un mayor número de IED nocturnas y a un inicio más temprano de la epilepsia. Finalmente, otros estudios que han aplicado cuestionarios semi-estructurados a padres y profesores de los pacientes evidencian una disminución significativa del desempeño en áreas de idiomas y matemáticas, menores hábitos de estudio(90) y pérdida de un año académico en escuela primaria en el 35% de los pacientes(55).

Funciones ejecutivas

Kanemura y Aihara(36) y Vago *et al.*(96) sugieren una disfunción frontal y un desarrollo tardío de las capacidades ejecutivas de organizar y aplicar estrategias. El primer estudio encontró síntomas de impulsividad e hiperactividad posteriores a la remisión de crisis y una reducción de la relación del volumen de la corteza frontal/corteza prefrontal posterior a la remisión de crisis y al EEG anormal (estudiando volumetría con MR). El segundo estudio halló un déficit en aprendizaje verbal y una eficiencia significativamente menor en el empleo de una estrategia de aprendizaje por agrupamiento semántico en el California Verbal Learning Test (CVLT), sin que esto se presentara en pacientes menores de 10 años.

Otras investigaciones muestran que los niños con ER tienen un desempeño significativamente más bajo frente a controles en pruebas de impulsividad (Matching Familiar Figures Test y Go/No Go Test), caracterizado por un mayor número de errores y mayor tiempo en la toma de decisión(58,63). Se han observado resultados deficientes en pruebas de atención dividida y cambio de tarea (Trail Making Test B)(63,97), flexibilidad cognitiva (Wisconsin Card Sorting Test, Modified Card Sorting Test, Stroop Test 1)(63,97), fluidez verbal (FAS)(63,97,98) y fluidez gráfica-semántica (Five Point Test)(56). Los anteriores estudios reportaron un CI normal, excepto el de Hwang *et al.*(99), en el que los pacientes con un mayor número de IED presentaron puntajes bajos en Stroop test y resultado limítrofe a normal-bajo en CI de ejecución y total del WISC-III.

Habilidades visoconstruccionales y visomotoras

Múltiples estudios sobre el desarrollo motor de niños con ER, en los que los comparan con controles pareados, presentan evidencia de dificultades significativas en motricidad fina, habilidad viso-construccional y coordinación visomotora al evaluar con Bender Visual Motor Gestalt Test, Figura Compleja de Rey, Grooved Pegboard Test y Purdue Pegboard Test(28,87,100). También se han reportado déficits significativos en destrezas manuales de apuntar y atrapar, evaluando con la Movement Assessment Battery for Children (MACB-2)(101,102). Kirby *et al.*(102) también aplicaron la entrevista para padres Developmental Coordination Disorder Questionnaire (DCDQ) y Detailed Assessment of Speed Handwriting, encontrando que el 33.3% de la muestra presentó sospecha de dispraxia y que el 37.5% tuvo un puntaje de velocidad de escritura inferior al percentil 15. Similarmente, Overvliet *et al.*(89) aplicaron una entrevista a padres sobre hitos del desarrollo, encontrando que el 22.9% de la muestra presentó dificultades motoras significativas en correlación a un retraso en habilidades de lectura de palabras y de oraciones. Finalmente, Brindley *et al.*(101) encontraron un desempeño significativamente inferior en destreza manual correlacionado significativamente con una alteración en la dinámica oscilatoria de banda beta relacionada al movimiento en la corteza motora ipsilateral en un paradigma de MEG de abducción de los dedos. Estos autores afirman que en la ER puede existir una disrupción de la comunicación interhemisférica involucrada en la coordinación del control motor.

Coeficiente intelectual y cambios comportamentales

La función intelectual fue evaluada en la mayoría de los artículos revisados con la Escala Wechsler de Inteligencia para Niños: versión revisada (WISC-R), tercera versión (WISC-III), cuarta versión (WISC-IV), versión abreviada (WASI) y para preescolar y primaria (WPPSI). Otros instrumentos empleados fueron Raven's Progressive Matrices (RPM)(64,66), Kaufman Assessment Battery for Children (KABC)(73) y Kaufmann Brief Intelligence Test (KBIT)(101,102). Múltiples estudios demuestran un CI normal de los niños con ER sin diferencias significativas con respecto a grupos control pareados(13,14,16,18,26,33,35,36,43,46-49,55,56,57,63,66,71,73,80,82,83,92,94,95,100,101). Sin embargo, otras investigaciones apuntan a que, aunque los niños con ER generalmente tienen CI normal, sí presentan puntuaciones significativamente inferiores respecto a controles en las mediciones de CI total, verbal, de ejecución, memoria de trabajo y velocidad de procesamiento(38,44,86,90,96,98,104). Debe resaltarse que la mayoría de los estudios sostienen como criterio de exclusión un CI mayor o igual a 70, para descartar discapacidad intelectual, pero es discutible que se han estudiado pacientes con desempeño limítrofe y que la mayor parte de las publicaciones no indique el porcentaje de pacientes con CI limítrofe (rango 70 a 79). Solamente estos estudios reportan el porcentaje de pacientes con CI limítrofe: Perkins *et al.* (22.2% - 2 pacientes)(28), Lopes *et al.* (13% - 4 pacientes)(65) y Ebus *et al.* (21% - 39 pacientes)(73).

Por otra parte, se ha reportado que los pacientes con ER no cumplen criterios de depresión o ansiedad significativa, pero sus puntajes en instrumentos específicos son significativamente más altos en comparación a controles. Estos puntajes se correlacionan positivamente con una edad menor, mayor frecuencia de crisis, mayor índice de puntas-ondas y mayor duración de la enfermedad(103). Otros cambios comportamentales son mayor frecuencia de síntomas de agresión, dificultades atencionales y aislamiento(90,103). Estos aspectos se han evidenciado con instrumentos semi-estructurados para padres como el Child Behavior Checklist (CBCL) y de tamizaje como Depression Self-Rating Scale for Children (DSRSC) y Screen for Child Anxiety-Related Emotional Disorders (SCARED).

Discusión: desarrollo cognitivo en epilepsia rolándica y remisión en la adolescencia

En general, el desarrollo cognitivo en la epilepsia pediátrica se caracteriza más por un rezago en comparación a los niños con desarrollo típico que por un deterioro progresivo o la carencia de un desarrollo esperado para la edad, presentando compromisos cognitivos que pueden observarse antes o después del diagnóstico, siendo estables hasta por 6 años(105,106). Siguiendo estos planteamientos, la ER presenta rezagos en el desarrollo del lenguaje y la adquisición de la lectura y escritura, además de déficits en conciencia fonológica, atención (selectiva y dividida), memoria (aprendizaje verbal y gráfico) y funciones ejecutivas (estrategias de aprendizaje, monitoreo, fluidez y flexibilidad). Esto implica también un desempeño académico disminuido y resultados normales aunque más bajos que los controles en pruebas de inteligencia. De esta forma, no se argumenta la existencia de un desarrollo cognitivo atípico en la ER (variante típica) pero sí un rezago en distintos dominios cognitivos respecto a niños con desarrollo típico. Similarmente, los estudios del desarrollo cerebral han encontrado una correlación significativa entre dificultades lingüísticas y la presencia de IED nocturnas(17,19,20,73,75,82,83); cambios en el grosor y volumen de materia gris(31-37); cambios en conectividad de materia blanca(38,39); compensaciones funcionales definidas como una red cerebral más amplia para el procesamiento lingüístico-motor y de la lectura(40-48); y diferencias en la red de control atencional y la DMN(44,49-51). Estos argumentos encuentran sustento en el meta-análisis de Wickens *et al.*(107) que reporta desviaciones estándar combinadas entre 0.42 y 0.81, con el mayor efecto para el almacenamiento y recuperación de largo-plazo y el menor efecto para el procesamiento visual, argumentando así una primera evidencia clara de las dificultades cognitivas pervasivas de la ER. En consecuencia, y siguiendo la postura de múltiples publicaciones(19,28,33,34,52,75,76,87,98,107,108), se sugiere que la ER no debe considerarse como benigna ni autolimitada. En particular, Lee, Hwang y Kwong(108) sugieren que debe considerarse así solamente cuando no existen déficits neuropsicológicos o son leves antes del tratamiento médico. Adicionalmente, se ha discutido sobre la pertinencia de realizar tratamiento o no para la ER(52,108,109). Por ejemplo, Hughes(109) revisa las recomendaciones de 96 publicaciones e indica que dos-tercios de éstas favorecen el tratamiento con FAE, teniendo el ácido valproico los resultados más favorables. También se sugiere el tratamiento ante la presencia de IED, con el objetivo de suprimir sus efectos deletéreos y heterogéneos sobre la cognición y el comportamiento(19).

La discusión sobre la naturaleza de la ER también ha incluido los posibles déficits cognitivos posteriores a la remisión de crisis y actividad epileptiforme en EEG, comúnmente observada en la adolescencia. Los estudios transversales que realizan seguimiento y las investigaciones longitudinales ofrecen resultados contradictorios. Callenbach *et al.*(110) no encontraron déficits cognitivos significativos en pacientes con ER variante típica y atípica luego de un seguimiento de cinco años posteriores a remisión total. No obstante, existe evidencia de déficits posteriores a la remisión: Clemens *et al.*(54) encontraron anormalidades en la conectividad funcional cerebral estudiada con EEG; Kanemura y Aihara(36) hallaron una relación reducida entre volumen de corteza prefrontal y lóbulo frontal junto a dificultades por impulsividad e hiperactividad; Monjauze *et al.*(24) encontraron diferencias significativas con respecto a controles en CI (ejecución, verbal y total), vocabulario receptivo, formulación de oraciones y lectura básica, también con menores índices de lateralización del lenguaje estudiados con ERP; Ay *et al.*(87) evidenciaron déficits en pruebas de lectura; y Hommet *et al.*(111) reportaron un patrón diferente de organización cerebral para el lenguaje con el paradigma de tarea-dual (interferencia). Las limitaciones de estos estudios incluyen muestras pequeñas y no haber analizado los efectos de las IED en la cognición, el desempeño académico, las dificultades comportamentales y la evolución de forma típica a atípica.(82,112,113)

Finalmente, son varias las implicaciones clínicas de esta revisión. En primer lugar, que la ER no debe considerarse benigna ni autolimitada, indicando la necesidad de un diagnóstico temprano, control farmacológico y reporte de la actividad epileptiforme y de las crisis. Al mismo tiempo, se hace necesario realizar una evaluación neuropsicológica infantil completa coordinada con una intervención terapéutica de acuerdo con los déficits encontrados, involucrando distintos profesionales (médicos, terapeutas ocupacionales y del lenguaje, pedagogos y psicólogos). En cuanto a implicaciones científicas, se sugiere que las investigaciones futuras aborden los efectos a largo plazo de la ER y las relaciones de las variables genéticas con el desarrollo cognitivo de los pacientes, con otras epilepsias y desórdenes del aprendizaje. Los estudios longitudinales pueden comparar muestras y subgrupos más amplios según: variante típica o atípica, presencia de IED, número de fármacos, distinta edad de inicio y duración, diferente magnitud de compromisos neuropsicológicos y su presencia posterior a la remisión.

CONCLUSIÓN

La evidencia sugiere que la ER no es una epilepsia pediátrica benigna ni autolimitada debido a déficits significativos en procesamiento del lenguaje, adquisición de la lectura y la escritura, conciencia fonológica, memoria-aprendizaje verbal, atención y funciones ejecutivas. A pesar de que los pacientes presentan una función intelectual normal, el desempeño escolar puede disminuir considerablemente y los déficits neurocognitivos pueden presentarse con durabilidad variable, en algunos casos prolongándose posteriormente a la remisión de la actividad epiléptica. De acuerdo con ello, se sugiere realizar una intervención interdisciplinaria y evaluaciones neuropsicológicas cuando se realiza el diagnóstico, a lo largo de la evolución de la enfermedad y luego de la remisión.

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Relación entre la salud mental y la calidad de vida en cuidadores de personas con trauma de cráneo en Barranquilla, Colombia

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RESUMEN

El objetivo del estudio fue determinar la relación entre la salud mental y la calidad de vida de cuidadores de personas con TCE de Barranquilla, Colombia. Se entrevistó a 50 cuidadores de individuos con TCE, utilizando la escala de satisfacción con la vida, el Patient Health Questionary-9, la escala de sobrecarga de Zarit, la escala de autoestima de Rosenberg, el inventario de ansiedad estado-rasgo y el Short Form-36. Análisis de correlación canónica revelaron que a mejor salud mental, mejor calidad de vida. Específicamente se encontró que los participantes con mayor sobrecarga tuvieron peor funcionamiento social y menor vitalidad. Los resultados sugieren la necesidad de desarrollar e implementar políticas sociosanitarias dirigidas al tratamiento de la salud mental de los cuidadores de pacientes con TCE. Además, deben diseñarse estrategias orientadas a reducir la sobrecarga, a través del mejoramiento del funcionamiento social y del incremento de su nivel de vitalidad.

Palabras clave:

depresión, sobrecarga, ansiedad, autoestima, calidad de vida.

ABSTRACT

The aim of this study was to determine the system of connections between mental health and quality of life of caregivers of individuals with TBI in Barranquilla, Colombia. 50 caregivers of individuals with TBI completed the Satisfaction with Life Scale, Patient Health Questionary-9, Zarit Burden Interview, Rosenberg Self-Esteem Scale, State-Trait Anxiety Inventory, and the Short Form-36. Canonical correlation analyses showed that the better the caregivers' mental health, the better their life quality. Specifically, individuals with a greater burden had worse social functioning and less vitality. These results suggest the need to develop and implement sociosanitary policies and specific measures to treat the mental health of the caregivers of

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patients with TBI. Furthermore, new interventions strategies should be designed in order to reduce caregiver burden through the betterment of their social functioning and the increase of their vitality levels.

Keywords:

depression, burden, anxiety, self-esteem, quality of life

Introducción

Los traumatismos craneoencefálicos (TCE) se pueden definir como una alteración neurológica adquirida y no degenerativa originada por una fuerza externa que causa un daño extendido en el cerebro, afectando tanto a zonas corticales como subcorticales(1, 2). El TCE es una de las primeras causas de muerte y discapacidad en personas menores de 35 años(3) y se calcula que para el 2020, será una de las primeras causas de mortalidad y morbilidad a nivel mundial (4).

Dentro de las personas que sobreviven a un TCE, es común encontrar una amplia variedad de secuelas cognitivas (atención, memoria, funciones ejecutivas, etc.), conductuales (tanto por exceso como por defecto, como puede ser la apatía, agresividad, impulsividad, etc.), emocionales (ansiedad, depresión, etc.), de personalidad (cambios de humor, labilidad emocional, etc.), físicas (problemas de sueño, cefalea, espasticidad, incontinencia, etc.), sociales (aislamiento social, menor contacto social, etc.) y familiares (problemas maritales, de comunicación, etc.) (2-9). Todas estas secuelas, perduran tras el incidente e impactan no solo en el paciente, sino también en la familia y el cuidador.

La mayoría de problemas que presentan las personas con TCE perduran a lo largo del tiempo y crean discapacidad. Por tal motivo, es común que requieran cuidados y supervisión constante, generalmente realizadas por miembros de la familia que desempeñan un rol de cuidador informal. Dada la intensidad y la duración de los problemas y que los familiares no suelen estar preparados para asumir el papel de cuidador, es común encontrar que éstos se vuelvan más vulnerables a presentar problemas de salud mental tales como sobrecarga, estrés, fatiga, trastornos somáticos, menor tiempo para uno mismo, irritabilidad, aumento en la toma de medicamentos legales, ilegales y alcohol, problemas económicos, cambios de roles, menor satisfacción familiar, pobre ajuste social, aislamiento social, sentimientos de culpa, enojo, depresión y ansiedad (2, 6-16).

A consecuencia de esta gran variedad de alteraciones psicológicas que pueden presentar los cuidadores, la calidad de vida de los mismos suele verse afectada, influyendo esto a su vez en el cuidado del paciente (17). Varios estudios como el de Hickey, O´Boyle (3) o el de Jackson, Turner-Stokes (18) han demostrado que los cuidadores de pacientes con TCE tienen peor calidad de vida, incluso comparándolos con cuidadores de otras poblaciones clínicas tales como demencia (18), enfermedades crónicas y cáncer (3).

El concepto de calidad de vida hace referencia a un constructo multidimensional que refleja la percepción que tiene un individuo acerca de su bienestar físico, emocional o social (2, 4). Hay pocos estudios que hayan investigado la calidad de vida en cuidadores de personas con TCE. La mayoría de ellos se han realizado en Europa y varían en el tamaño de la muestra (desde 22 a 222 cuidadores) y en los instrumentos que han utilizado para medir la calidad de vida como por ejemplo el SF-36, World Health Organization Quality of Life, Schedule of Evaluation of Individual Quality of Life-Direct Weightin. En general todos ellos coinciden en reportar que los cuidadores presentan una peor calidad de vida tanto a corto como a largo plazo (4, 19) en áreas como la salud mental (17, 18), y física (3, 19). Más específicamente, en estudios que han utilizado la escala del SF36 se ha encontrado que el rendimiento de estos cuidadores es peor en las subescalas de rol físico, rol emocional, vitalidad, dolor corporal, funcionamiento social, salud mental y salud general en comparación con un grupo control de no cuidadores (4, 19).

Según lo anterior, se puede observar que los problemas de salud mental en cuidadores de personas con TCE son muy frecuentes, e investigaciones recientes han demostrado que estas personas también presentan una peor calidad de vida. Pese a esto, tanto los problemas de salud mental como la calidad de vida de estos cuidadores han sido investigados de forma independiente, y no existen prácticamente estudios en el mundo que establezcan la relación entre estos dos componentes en esta población. Además, hay todavía menos estudios que se hayan realizado en Latinoamérica, donde existen altas tasas de incidencia en TCE y una falta de recursos y servicios tanto para pacientes como para sus cuidadores, siendo esta población idónea para investigar este tipo de problemas y su posible relación (4). Es por ello que el objetivo de este estudio es determinar la relación entre la salud mental y la calidad de vida en un grupo de cuidadores de personas con TCE de la ciudad de Barranquilla, Colombia.

Método

Participantes

Los participantes fueron reclutados a través del servicio de urgencias de la Clínica Cervantes Barragán en Barranquilla, Colombia, entre los familiares de pacientes con TCE leve, moderado o severo, sufrido entre enero de 2007 y diciembre de 2009. Los criterios de inclusión para participar en el estudio fueron (1) ser el cuidador principal de la persona con TCE, 2) llevar más de seis meses cuidando al paciente y (3) no tener historia personal de alteraciones físicas, psicológicas o neurológicas antes de asumir el rol de cuidador. De los 69 sujetos que cumplieron con los criterios de inclusión, 13 no aceptaron la invitación a participar y 6 no pudieron asistir a las citas por la imposibilidad de transportarse hasta el lugar de evaluación. Los participantes tenían una edad media de 39.68 años (*DE*= 14.09). La mayoría de sujetos eran mujeres (88%) y estaban casados (36%). El 34% eran solteros, el 16% vivían en unión libre, el 10% estaba separado y el 4%, viudos. La mayoría de los cuidadores eran los padres del paciente (26%). El promedio de tiempo semanal que dedicaban a cuidar al paciente fue de 33.52 horas (*DE*= 27.09) (M_e = 27.50). El promedio de años de educación de la muestra fue de 11 años (*DE*= 3.33).

Instrumentos

Para la recolección de los datos sociodemográficos se utilizó un cuestionario diseñado por los investigadores. Posteriormente se administró una serie de cuestionarios para medir la calidad de vida y la salud mental de los cuidadores. Los cuestionarios se describen a acontinuacion:

Short form-36 (SF-36) (20). La calidad de vida (CV) de los participantes fue evaluada por el SF-36, una escala de autorreporte que evalúa ocho dominios principales: (1) función física, (2) funcionamiento social, (3) rol físico, (4) dolor corporal, (5) salud mental, (6) rol emocional, (7) vitalidad, y (8) salud general. Sin embargo, en este estudio sólo se examinaron seis dominios especialmente asociados a alteraciones de la salud física. De esta manera se disminuye la posibilidad de sesgo, ya que los dominios rol emocional y salud mental del SF-36, exclusivamente destinados a estimar variables de salud mental, podrían eclipsar la relación existente entre las variables del SF-36 que evalúan salud física y las otras medidas de salud mental del estudio. Las subescalas del SF-36 tienen un rango de 0 a 100 puntos, siendo los puntajes más altos, indicadores de mejor CV (21).

El SF-36 ha sido ampliamente utilizado en diferentes poblaciones con y sin discapacidad(21), incluyendo a cuidadores de pacientes con TCE (4, 22). Además ha sido traducida a diferentes idiomas, entre ellos el español. Diversos estudios han demostrado la validez de su traducción y adaptación para su uso en diversos países (21, 23).

Escala de Satisfacción Con la Vida (SWLS) (24). Los participantes contestaron la SWLS, que es un instrumento que evalúa el nivel de satisfacción global con la vida a través de 5 preguntas de autorreporte. Cada pregunta debe ser respondida en una escala que va de 1 (totalmente en desacuerdo) a 7 (totalmente de acuerdo). Una puntuación alta representa un alto nivel de satisfacción con la vida (25). La versión en español de la SWLS ha demostrado tener buenas propiedades psicométricas (26).

Patient Health Questionary-9 (PHQ-9) (27). El PHQ-9 es un cuestionario de autorreporte del *Patient Health Questionary* y fue utilizado en este estudio para evaluar la depresión de los cuidadores. El PHQ-9 está compuesto por ocho preguntas que describen los síntomas de la depresión. Se debe responder a cada ítem indicando la frecuencia del síntoma (desde 0 = nunca, hasta 3 = casi todos los días). Las puntuaciones oscilan de 0 a 27, siendo los puntajes más altos indicadores de mayor depresión (28). La versión en español del PHQ-9 (27) ha demostrado tener buenos niveles de validez y fiabilidad en la evaluación de la depresión en hispanohablantes (29, 30).

Zarit Burden Interview (ZBI) (31). El ZBI fue utilizado en el presente estudio como medida de sobrecarga. Consta de 22 ítems de autorreporte a los que el evaluado debe responder teniendo en cuenta la frecuencia en que ocurren las situaciones allí planteadas (desde 0 = nunca, hasta 4 = Casi siempre). Las puntuaciones totales oscilan entre 0 y 88, siendo las puntuaciones más altas indicadores de mayor sobrecarga (32). El ZBI ha sido utilizado en diversas investigaciones con cuidadores de pacientes con TCE (33-35). Asimismo, su versión en español ha mostrado buenos niveles de consistencia/validez interna (36).

Escala de Autoestima de Rosenberg (EAR) (37). La EAR es una escala de evaluación del autoestima en la que se presentan 10 afirmaciones acerca del evaluado, quien debe responder el nivel de acuerdo o desacuerdo en cada una (desde 1 = muy de acuerdo, hasta 4 = muy en desacuerdo). Las puntuaciones oscilan entre 10 y 40, siendo los puntajes más altos indicadores de mayor autoestima. La versión en español (38) ha demostrado niveles adecuados de validez y confiabilidad (39).

Cuestionario de Ansiedad Estado-Rasgo (STAI) (40). El STAI es un autoinforme que consta de 40 ítems que evalúan la ansiedad estado (20 ítems) y la ansiedad rasgo (20 ítems). Para cada ítem del STAI, los sujetos deben responder si su estado actual (ansiedad estado) o su estado general (ansiedad rasgo) se asemejan o no con los planteados por la escala, debiendo responder desde 1 (nada) hasta 3 (mucho). La variable incluida en el estudio fue la puntuación global (rango posible entre 0 y 120 puntos) siendo los puntajes más altos indicadores de mayor ansiedad. La consistencia interna y la validez del STAI en español han demostrado ser adecuadas (41, 42). Asimismo, el STAI ha demostrado estar relacionado con variables clínicas y de personalidad (42, 43).

Procedimiento

Los participantes fueron contactados telefónicamente a través de la Clínica Cervantes Barragán de la ciudad de Barranquilla y fueron invitados a participar en el estudio. A todos aquellos cuidadores de pacientes con TCE que aceptaron participar se les asignó una cita con los evaluadores. En la cita los participantes leyeron y firmaron el consentimiento informado que formó parte del protocolo de investigación aprobado por el Comité de Ética de la Universidad del Norte (Barranquilla). Durante la cita, todos los participantes fueron entrevistados por los evaluadores para recoger los datos sociodemográficos y les fueron administrados los cuestionarios SF-36, la SWLS, el PHQ-9, el ZBI, la EAR y el STAI.

Análisis estadísticos

En este estudio, la salud mental fue evaluada a través de las escalas de satisfacción con la vida, depresión, sobrecarga, autoestima y ansiedad. Por su parte, la CV fue evaluada por medio de seis de los dominios del SF-36: (1) función física, (2) funcionamiento social, (3) rol físico, (4) dolor corporal, (5) vitalidad, y (6) salud general. Con el objetivo de comprobar la hipótesis de que la CV de los cuidadores de pacientes con TCE se relacionaría con su salud mental, se realizó una correlación canónica para estimar la cantidad de varianza compartida entre estos dos constructos. Posteriormente se analizaron las cargas canónicas de cada una de las variables, para identificar patrones específicos de relación entre los constructos. De igual forma, se realizó una matriz de correlación de todas las variables. Todos los análisis fueron realizados utilizando el SPSS 20.

Resultados

Supuestos de normalidad

Fueron evaluados los supuestos de normalidad, con el fin de verificar la idoneidad de los análisis propuestos. Todos los criterios se cumplieron. La curtosis y la asimetría de todas las variables fue < |2|. Los gráficos de dispersión mostraron una distribución apropiada y normal de los residuos.

Matriz de correlación

La matriz de correlación (tabla 2-1) muestra las correlaciones y el nivel de significación de cada una de las variables del estudio. En su mayoría las medidas de salud mental mostraron entre ellas relaciones significativas con valores absolutos de al menos, .346, solamente las relaciones entre sobrecarga y autoestima y entre sobrecarga y ansiedad no fueron significativas (p > ,10). La satisfacción con la vida correlacionó positivamente con autoestima (.373), y negativamente con el resto de medidas (Tabla 2-1). La depresión correlacionó positivamente con la sobrecarga (.346) y la ansiedad (.508) y negativamente con el resto de medidas. Por último, la autoestima y ansiedad mostraron una correlación negativa (-.549).

Tabla 2-1. Matriz de correlaciones

	1	2	3	4	5	6	7	8	9	10
1 Sat. con vida	-									
2 Autoestima	.377**	-								
3 Sobrecarga	-.505**	-.091	-							
4 Depresión	-.447**	-.347*	.346*	-						
5 Ansiedad	-.424**	-.549**	.232	.508**	-					
6 Función física	.331*	.417**	-.266	-.201	-.458**	-				
7 Rol físico	.177	.344*	-.470**	-.435**	-.389**	.392**	-			
8 Energía	.555**	.220	-.687**	-.480**	-.284*	.260	.662**	-		
9 Función social	.479**	.199	-.626**	-.619**	-.393**	.188	.557**	.652**	-	
10 Dolor corporal	.325*	.286*	-.411**	-.394**	-.231	.246	.634**	.625**	.619**	-
11 Salud general	.346*	.202	-.594**	-.148	-.261	.377**	.449**	.565**	.510**	.468**

* = p < .05; ** = p < .01

Por su parte, casi todos los dominios la CV correlacionaron positivamente entre ellos, con una magnitud de la relación de entre .377 hasta .665. Sólo la función física correlacionó única y positivamente con rol físico (.392) y salud general (.377).

Por último, las magnitudes absolutas de las relaciones significativas entre las variables de salud mental y los dominios de la CV variaron de .284 a .687. La satisfacción con la vida correlacionó positivamente todos los dominios de la CV (rango de r = .331 a .555), excepto con rol físico (p = .22). De igual forma, sobrecarga se asoció a cinco de los dominios de CV incluyendo rol físico (-.470), vitalidad (-.687), funcionamiento social (-.626), Dolor corporal (-.411) y salud general (-.594). La ansiedad correlacionó negativamente con 4 de los dominios de CV (rango de r = -.284 a -.458). No se asoció con dolor corporal y salud general (p > .07). La depresión correlacionó negativamente con cuatro dominios de CV (rangos de r = -.394 a -.619), pero no con función física y salud general (p > .16). Por último, autoestima correlacionó positivamente con rol físico (.417), rol físico (.344) y dolor corporal (.286).

Correlaciones canónicas

La primera correlación canónica fue de .85 (varianza compartida 72.2%), λ = ,11; X^2= 94.92; p<0,001 (figura 2-1). De acuerdo con lo planteado por Cohen (1988), se muestra un tamaño del efecto grande. Fueron calculados los coeficientes canónicos estandarizados para establecer la contribución de las variables para cada una de las correlaciones canónicas (tabla 2-2). En la primera correlación canónica, los coeficientes canónicos estandarizados de salud mental mostraron que la sobrecarga es el factor con mayor carga (.607) y el único significativo, ya que el resto de variables obtuvieron coeficientes menores a .40, punto de corte convencional para la interpretación del mismo. Por otra parte, los coeficientes canónicos estandarizados para las variables de CV mostraron una mayor carga de la variable de funcionamiento social (-.613), seguida de vitalidad (-.598). Los coeficientes del resto de variables estuvieron por debajo de .40. Este patrón de varianza compartida sugiere que los cuidadores de pacientes con TCE con mayor sobrecarga tuvieron peor funcionamiento social y menor vitalidad.

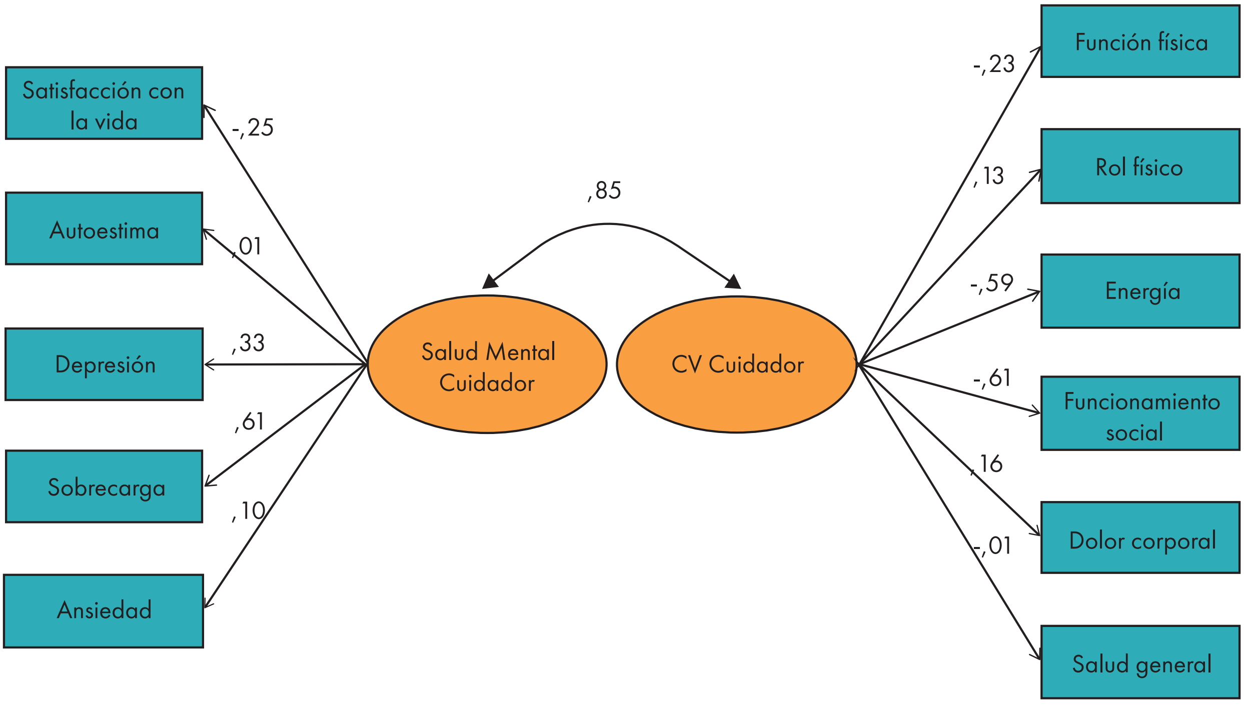

Figura 2-1. Modelo conceptual de correlación canónica y coeficientes de la primera correlación.

La segunda correlación canónica fue de .59 (varianza compartida 34.8%), λ= .39; X^2= 40.89; p< .01; la tercera de .50 (varianza compartida 25%), λ= .59; X^2= 22.66; p< .05; la cuarta de .39 (varianza compartida 15.2%), λ= .79; X^2= 10.07; p= .122; y la quinta de .25 (varianza compartida 6.2%), λ= .94; X^2= 2.84; p= .241. Ninguna de ellas es significativa. Sin embargo, los coeficientes canónicos estandarizados se muestran para referencia en la tabla 2.

Discusión

El objetivo de este estudio fue determinar la relación entre la salud mental, operativizada como satisfacción con la vida, estado de ánimo, sobrecarga, autoestima y ansiedad, y la calidad de vida (función física, funcionamiento social, rol físico, dolor corporal, vitalidad y salud general) de cuidadores de personas con TCE de la ciudad

Tabla 2-2. Coeficientes canónicos estandarizados de las correlaciones 1 a 5

Salud Mental					
Correlación canónica	1	2	3	4	5
Satisfacción con la vida	-.252	1.100	-.194	.615	-.068
Autoestima	.009	-.475	-.341	.297	1.045
Depresión	.333	.068	-1.150	.095	-.277
Sobrecarga	**.607**	.388	.505	.792	-.112
Ansiedad	.102	.561	.232	-.402	1.104
CV					
Correlación canónica	1	2	3	4	5
Función física	-.234	-.061	-.261	1.057	-.180
Rol físico	.126	-1.318	.214	-.496	.084
Energía	**-.598**	.981	-.149	-.055	.334
Funcionamiento social	**-.613**	-.041	.773	.107	-.897
Dolor corporal	.165	.189	.071	.360	1.132
Salud general	-.011	-.180	-.989	-.639	-.204

de Barranquilla, Colombia. Los resultados de las correlaciones canónicas muestran que existe un gran solapamiento en la varianza de la calidad de vida estimada por el cuidador y su estado de salud mental. Concretamente, las personas que tienen grandes limitaciones para el funcionamiento social y poca vitalidad tienden a sentir mayor sobrecarga derivada del desempeño de su rol de cuidador. Complementariamente, los resultados de las correlaciones bivariadas describen asociaciones significativas entre los componentes de la salud mental y de la calidad de vida, reafirmando la fuerte relación entre ambos constructos.

La existencia de una estrecha relación entre CV y SM indica la importancia que tiene la salud mental en la vida cotidiana de los cuidadores. Esta relación ha sido frecuentemente documentada en estudios con cuidadores familiares de personas con discapacidad. Cummins(44) en una revisión de la literatura concluye que los niveles bajos de calidad de vida se relacionan con niveles clínicos de ansiedad y depresión en los cuidadores. Para profundizar en la relación encontrada en este estudio entre la sobrecarga y el funcionamiento social del cuidador de pacientes con TBI, debemos destacar que, hasta ahora, la sobrecarga se ha relacionado fundamentalmente con las características del paciente. Algunos de esos aspectos del paciente que influyen en el cuidador son la intensidad de la discapacidad (45), el estado de ánimo y el grado de aislamiento del paciente (7) o sus alteraciones neuroconductuales y motóricas(33). Sin embargo, hace tiempo, algunos autores indicaron que el nivel de sobrecarga del cuidador no se podía explicar suficientemente si sólo se tenían en cuenta las características del paciente, y que era necesario incluir el funcionamiento social que presentaba el propio cuidador (46). Los resultados obtenidos mediante correlación canónica en este estudio apuntan en esa misma dirección, el funcionamiento social del cuidador se relaciona en gran medida con su nivel de sobrecarga. Para relacionar de una forma más amplia el funcionamiento social con la literatura actual, debemos recurrir al concepto de apoyo social, tradicionalmente asociado al funcionamiento social del cuidador (47) y que ha sido un elemento ampliamente estudiado (16).

Ergh, Hanks (48) también indican que existe una relación positiva entre el apoyo social y la satisfacción con la vida en cuidadores de pacientes con

TCE. Estos autores determinaron que, en realidad, el apoyo social funcionaba como un moderador de la influencia que la discapacidad del paciente tenía sobre la vida de su cuidador, de modo que cuando el apoyo social era bajo, las alteraciones del paciente con TCE se relacionaban con la satisfacción con la vida del cuidador, pero en cambio, cuando el apoyo social era alto, éstos no afectaban a la satisfacción con la vida del cuidador (48). Sin embargo, si se analiza el apoyo social de forma más pormenorizada, midiendo sus componentes en vez de hacerlo de forma global, los resultados aportan mayores connotaciones. Stevens, Perrin(49) encontraron que tres componentes del apoyo social (appraisal, belonging, and tangible) estaban relacionados con factores de la salud mental como la sobrecarga, la ansiedad y la depresión. Sin embargo, la satisfacción con la vida de los cuidadores mexicanos del estudio de Stevens, Perrin (49), al contrario que en el estudio actual, se mostró como un factor de la salud mental del cuidador diferente al resto, no asociado al apoyo social sino relacionado directamente con el número de horas dedicadas a cuidar al paciente con TCE. Otros estudios (7, 10, 46) también indican que existe relación entre el funcionamiento social y los niveles de ansiedad y depresión del cuidador.

Los hallazgos sobre la relación de la vitalidad y la CV del cuidador concuerdan con los encontrados en el ámbito de la discapacidad en general (50), el daño cerebral por ictus (51) y también los TBI (4). La alta correlación encontrada entre los distintos componentes de la salud mental del cuidador apoya los hallazgos en cuidadores mexicanos de pacientes con TBI. Concretamente, Coy, Perrin (52) mostraron que, en la relación existente entre la sobrecarga y el estado de ánimo del cuidador, la sobrecarga funcionaba como un factor mediador de los efectos que tiene el funcionamiento familiar sobre el estado de ánimo del cuidador.

Las relaciones entre factores específicos de la CV y la SM encontradas en el presente estudio tienen implicaciones sociosanitarias relevantes. Es bien conocido que la SM del cuidador va a repercutir sobre los resultados de la rehabilitación del paciente con TBI (53). El estado de salud del cuidador no está siendo tenido en cuenta adecuadamente por los sistemas de salud (54) y debiera serlo, por dos motivos fundamentales. En primer lugar, desde un punto de vista netamente sanitario para atender directamente al cuidador como un usuario con problemas de salud mental. En segundo, como recurso del sistema, ya que como proveedor de cuidados es un factor influyente en los resultados de la rehabilitación del paciente con TCE, y por tanto, un elemento a tener en cuenta en el balance coste-eficiencia del sistema de salud (55). Brown, Potter (56) mostraron que la puntuación de sobrecarga del cuidador en la escala de Zarit era mejor predictor de la institucionalización que el estado mental o los problemas de conducta del paciente.

Aún se disponen de pocos datos sobre lo que sucede con los cuidadores en países Latinoamericanos, por lo que los hallazgos de este estudio cobran mayor importancia, ya que puede haber una gran influencia cultural en la percepción de los constructos de CV y SM en esta población. El efecto de la cultura impide la simple generalización de los resultados de unos grupos sociales a otros, por lo que estudios como éste contribuyen a la programación de acciones bien fundamentadas dirigidas a mejorar la salud mental de los cuidadores y que, por tanto, tendrán mayores garantías de éxito. Este estudio aporta hallazgos que permiten incluir en las políticas sociosanitarias acciones concretas dirigidas a componentes específicos relacionados con la SM, como el funcionamiento social y la vitalidad del cuidador. La implicación principal está dirigida a los programas de rehabilitación de personas con TCE. Está ampliamente recomendado incluir a los cuidadores en los planes de actuación con personas con discapacidad (44), sin embargo, es necesario incluir actividades específicas, basadas en la evidencia para propiciar una mayor eficacia. Los patrones específicos de relación encontrados en el estudio indican que para un buen abordaje terapéutico para reducir la sobrecarga de esta muestra de cuidadores necesita dos elementos fundamentales, mejorar su funcionamiento social e incrementar su nivel de vitalidad o energía. Para cubrir el primer objetivo podrían incluirse actuaciones dirigidas a incrementar la participación y el apoyo de otras personas del entorno en el cuidado del paciente con TCE, ya que esto han mostrado su asociación con la salud mental del cuidador (49). Además, fomentar que el entorno valore el cuidado que presta el cuidador mejora sus expectativas de autoeficacia. Esta estrategia terapéutica podría ser relevante porque la autoeficacia percibida es uno de los 3 componentes factoriales encontrados en la escala de sobrecarga de Zarit (57) y por tanto, influiría directamente en la percepción de sobrecarga del cuidador. De acuerdo con otros estudios, la reducción de la sobrecarga servirá para mejorar el funcionamiento familiar, que repercute positivamente sobre el estado de ánimo del cuidador (52). El segundo objetivo terapéutico sería mejorar la vitalidad o nivel de energía del cuidador, por ejemplo con programas de respiro familiar, que están siendo reclamados desde hace décadas (11) pero que siguen siendo escasos en Latinoamérica. Existen evidencias de que, frente a la no intervención, algunas actuaciones sencillas como el entrenamiento en solución de problemas evita problemas de salud mental como la depresión en éste tipo de cuidadores, facilitando un mejor funcionamiento social, mayores niveles de vitalidad y menor limitación en sus roles (22).

Los resultados del presente estudio deben de interpretarse a la luz de las siguientes limitaciones: 1) La definición de salud mental en el presente estudio no abarca otros aspectos que podrían hacer parte de la misma y que al no ser evaluados no se pudieron incluir en los análisis. 2) La calidad de vida se evaluó mediante el SF 36 y en especial mediante los componentes que evalúan la calidad de vida en su aspecto más físico, es probable que otros aspectos de la calidad de vida de estos cuidadores que no se midieron en este estudio pudieran estar relacionados con la salud mental de los mismos. 3) debido a la naturaleza transversal de la presente investigación, no se puede determinar si la relación que se encontró entre los componentes de la salud mental del cuidador y su calidad de vida cambien o permanezcan así a través del tiempo. 4) Debido a las características específicas de la muestra y al tamaño de la misma, los resultados no deberían generalizarse a cuidadores de personas con TCE en otros sitios de Colombia o Latinoamérica que tengan características diferentes a las de los sujetos de este estudio.

En conclusión, el propósito de este estudio fue determinar la relación entre la salud mental, y la calidad de vida de un grupo de cuidadores de personas con TCE de la ciudad de Barranquilla, Colombia. Los resultados muestran que a mayores problemas de salud mental en los cuidadores, peor es su calidad de vida. Más específicamente, se encontró que a mayor sobrecarga, peor funcionamiento social y peor vitalidad en estas personas. Estos hallazgos apuntan a la imperiosa necesidad de desarrollar e implementar programas que busquen mejorar el funcionamiento psicológico y la calidad de vida de los cuidadores, lo cual podría llevar a que esto se vea reflejado en la calidad de los servicios y en la atención que estas personas prestan a sus pacientes.

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Emotion regulation and neuropsychological status in functional neurological disorder variants

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ABSTRACT

Few clinically meaningful treatment options exist for patients with functional neurological disorders (FND) due to limited understanding of within-group differences in cognitive and emotional factors that may differentially influence mental health outcomes. This study aimed to determine the relationship between emotion regulation strategies (suppression vs. reappraisal), psychological symptoms, and cognitive status in two FND variants: non-epileptic seizures (NES) and other functional (hyperkinetic) movement disorders (FMD). Thirty-two patients (NES = 16; FMD = 16) completed a neuropsychological battery including self-report questionnaires of emotion regulation and psychopathology. In the NES group, lower cognition was associated with more severe PTSD symptoms, greater suppression and lower positive emotions. In the FMD group, lower cognition was associated with more severe PTSD symptoms and greater reappraisal. When controlling for general cognition, individuals classified as "suppressors" had more trauma events and symptoms of dissociation, greater internalizing dysfunction, and more severe emotional distress than individuals classified as "re-appraisers." Results suggest individual differences in cognitive function and habitual behavioral tendencies such as emotion regulation may be important considerations in tailoring treatment of posttraumatic distress for FND variants. Current findings also suggest that future clinical trials considering FND variants separately may facilitate the development of symptom-specific treatment approaches.

Key Words:

Functional neurological disorders; Psychogenic, Conversion; Cognition; Executive function

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Introduction

Functional neurological disorders (FND) include a myriad of sensorimotor symptoms with unknown neurologic etiology. Until recently, this group of disorders was also referred to as "psychogenic" disorders and both terms are currently used interchangeably[1]. These symptoms are thought to reflect a conversion disorder variant[2]. The most common symptom phenotypes in a population of patients with FND presenting as functional (psychogenic) movement disorders (FMD) are tremor (40%), dystonia (31%), and myoclonus (13%), but other movement disorders such as parkinsonism, tics, stereotypies hemifacial spasm, and oculomotor and speech abnormalities can also occur[3,4]. Another FND variant, more commonly seen in epilepsy centers are individuals with non-epileptic seizures (NES). These individuals have paroxysmal episodes resembling epilepsy—most commonly imitating epileptic complex partial episodes—but which occur in the absence of electroencephalographic (EEG) abnormalities[5,6].

Traditionally, FND has been viewed as the physical manifestation of traumatically induced psychological distress, as trauma and stress-related symptoms are frequently observed in these patients[1,7]. The significantly higher prevalence of posttraumatic stress disorder (PTSD) and associated symptoms of dissociation in this patient population have led some researchers to suggest that FND may be a related condition[7,8]. The dissociative symptoms commonly seen in these patients have been shown to correlate significantly with both physical and sexual abuse[9], as well as other forms of childhood trauma[10]. However, not all individuals suffering from FND report a history of abuse or trauma, and there remains a paucity of research investigating variables that may potentially mediate the relationship between psychological distress and the development of FNDs. While this void may have contributed to the conflicting findings regarding FNDs, such results could also be the product of inappropriate methodology, the most notable of which includes the heterogeneity of FND samples utilized in research, along with a tendency for investigators to neglect phenotype distinctions.

The few studies that have compared the features of FND patients with different motor manifestations have yielded significant results. For instance, a recent study conducted by Hopp et al.[11] suggested different demographic profiles and clinical manifestations (e.g., altered consciousness, episodic symptoms, and lateralization) may characterize patients with other FMD phenotypes as compared to those with NES. Additional differences observed have included a higher rate of reported trauma and environmental stressors, as well as greater borderline personality features and external control orientation associated with NES patients than those with other FMD phenotypes[12,13]. There is also now preliminary data suggesting various facets of emotional processing (e.g., attributional style, coping strategies, etc.) may mediate the relationship between early life experiences and subsequent development of these sensorimotor disturbances[14-16]. Although such findings have yet to be replicated, this recent trend in empirical investigations with FND patients suggests that distinguishing symptom-specific subgroups with potentially divergent neurobiological underpinnings may improve our understanding of these sensorimotor disturbances and thus be more useful in tailoring treatment.

The overall goal of the current study was to advance our conceptualization of FND by examining the relationship between emotion regulation strategies, psychological symptoms, and cognitive status in two FND variants: NES and FMD. We had two specific aims: (1) To determine whether cognitive dysfunction is associated with emotion regulation strategies and psychological symptoms in FND; and (2) To identify potential emotional and neurocognitive differences between NES and FMD. Our working hypothesis was that the cognitive profile of the combined sample would be characterized by frontal-executive inefficiencies (i.e., working memory, inhibition, set-shifting), and that lower cognitive function would be associated with greater emotional distress. This hypothesis is based on two lines of evidence: (1) neuroimaging findings that have implicated functional abnormalities in frontal and limbic regions in FND patients; and (2) observations that emotion regulation efficacy is predicated upon intact cognitive control mechanisms[17-19]. Based on the view that frontal-executive control is necessary for effective emotion regulation[20], we also hypothesized that NES patients would demonstrate worse cognitive dysfunction than FMD patients given previous observations of more severe psychopathology in patients with NES[13].

Materials and Methods

Participants

Data collection was conducted at Baylor College of Medicine (BCM) and St. Luke's Episcopal Hospital in Houston, Texas, as well as Martin Neurobehavioral Center (MNC) in Tyler, Texas. Potential participants were identified based on previous neurological evaluations and appropriate medical assessments establishing an FND diagnosis. For NES patients, this included continuous video-EEG monitoring showing no indications of epileptiform activity, and for FMD patients, adherence to Fahn and Williams diagnostic criteria (i.e., inconsistency/incongruency, other false neurological signs, distractibility, multiple somatizations, psychiatric disturbance)[21]. Other inclusion criteria were male and female English-speaking adults ages eighteen to sixty-five. The following exclusion criteria were employed: 1) presence of an underlying neurological disorder; 2) current or past psychotic symptoms that could interfere with assessment; 3) substance abuse disorder within the past six months; 4) traumatic brain injury; 5) unstable medical condition or clinically significant abnormal laboratory results; and 6) mixed etiologies (e.g., concurrent epilepsy and NES). Altogether, 84 patients with an FND diagnosis were identified as potential participants and screened for possible inclusion. Of those patients screened, twenty-seven were excluded due to age (9), poor English mastery (2), traumatic brain injury (3), cerebrovascular accident (4), multiple sclerosis (1), and other comorbid neurological conditions (8). Eighteen patients declined to participate, and seven others were scheduled to participate but did not complete the evaluation.

The final sample consisted of thirty-two patients who ranged in age from 18-64 years (M = 42.2, SD = 12.3) with 10-20 years of education (M = 13.6, SD = 2.3). Each patient's clinical presentation was characterized based on symptoms documented by the neurologist in their electronic medical chart. This resulted in the following symptom classifications: 16 NES (50.0%), 2 dystonia (6.3%), 1 bilateral tremor (3.1%), 1 left-sided tremor (3.1%), 3 right-sided tremor (9.4%), 1 myoclonus (3.1%), 2 gait disturbance (6.3%), 2 bilateral tremor and gait disturbance (6.3%), 1 tic and stereotypies (3.1%), and 3 mixed facial symptoms (e.g., dystonia, tics, orofacial dyskinesia, and blepharospasm; 9.4%). Because the research protocol used for the present study is not a routine component of standard clinical care for individuals with these diagnoses, it was offered as a free service with no incentive. This study was approved by BCM's IRB and all participants provided informed consent.

Procedure

Each patient participated in a clinical interview eliciting information about any interim changes in their medical history, including psychiatric, psychosocial, and potential trauma history, as well as the circumstances surrounding the onset and course of their motor symptoms. Participants were administered a brief neuropsychological battery consisting of standardized measures to assess frontal-executive functions, determine the validity of test performance, and provide an estimate of premorbid intellect and general cognitive status. These included: a) measures of effort (Test of Memory Malingering [TOMM][22], Rey Fifteen Item Memory Test [Rey-15][23,24]); b) a cognitive screener (Montreal Cognitive Assessment [MoCA][25]); c) an estimate of premorbid intellect (Wechsler Test of Adult Reading [WTAR])[26]; d) auditory attention span (Digit Span subtest of the Wechsler Adult Intelligence Scale, Fourth Edition [WAIS-IV])[27]; and e) executive function tasks associated with problem solving (Wisconsin Card Sorting Test, 64 Card Version [WCST-64])[28]; verbal fluency (Letter Fluency [FAS] and Semantic Fluency [Animals])[29,30]; and speeded set-shifting (Trail Making Test, Part A [TMT-A] and B [TMT-B])[31].

Participants completed six standard self-report questionnaires to assess mood and trauma-related symptoms, use of emotion regulation strategies, and personality/behavioral tendencies previously associated with FND[6]. These included: the Beck Depression Inventory, Second Edition (BDI-II)[32]; Penn State Worry Questionnaire (PSWQ)[33]; the Posttraumatic Stress Disorder Checklist – Civilian version (PCL-C)[34]; Dissociative Experiences Scale, Second Edition (DES-II)[35]; Emotion Regulation Questionnaire (ERQ); and the Minnesota Multiphasic Personality Inventory, Second Edition, Restructured Format (MMPI-2-RF)[36]. All instruments were administered and scored according to standardized procedures. Additional data regarding each participant's current condition, treatment, and medical history were later obtained via review of medical records.

Raw scores were used for measures involving raw score cutoffs (i.e., MoCA < 26, TOMM: Trial 2 < 45, Rey-15 < 9, BDI-II ≥ 14, PSWQ ≥ 40, PCL ≥ 30, ERQ: Dominant > Non-dominant strategy, and DES-II ≥ 30). Age-adjusted standard scores were used for the WTAR[26] and demographically adjusted T-scores were used for the MMPI-2-RF[36], WAIS-IV Digit Span[27], WCST-64[28], TMT - Parts A and B, and Verbal Fluency measures[29].

Statistical analyses

Statistical analyses were conducted via IBM® SPSS version 18.0 for Windows. Pearson's correlations were used to examine relationships between variables, while multi-dimensional chi-square tests were used to compare categorical variables between groups, including demographic variables and classifications of performance on the outcome measures. Due to a limited sample, each continuous variable was carefully screened for potential violations of assumptions underlying parametric procedures. Standard statistical transformations as outlined by Tabachnick & Fidell[37] were applied to those variables violating the assumption of normality. Mann-Whitney tests were used to examine between-group differences for variables that failed to achieve normalization with statistical transformations, while independent sample t-tests were used to compare all other continuous variables between groups.

As age and education are demographic variables known to significantly influence performance on neuropsychological tests, these two variables were screened for their potential utility as covariates for group comparisons on neurocognitive measures not already corrected for both of these demographic variables (i.e., WTAR and WAIS-IV Digit Span). When examined as covariates, age was not significantly related to either outcome measure, and education was only significantly related to WTAR scores. Analysis of covariance (ANCOVA) with education as a covariate was used to examine between-group differences on WTAR scores, while all other neurocognitive measures were assessed via independent sample t-tests and Mann-Whitney tests, as outlined above. Additionally, linear regression analyses were used to examine potential predictors of cognition for the total sample. The stepwise method was used in these analyses due to the exploratory nature of the present study. Finally, a binary logistic regression analysis was employed to identify potential predictors of group membership (i.e., NES versus FMD).

Results

Demographic comparisons

A comparison of NES and FMD groups along demographic variables is provided in Table 3-1. As shown, FMD participants were more educated and more likely to be married and employed at the time of testing than their NES counterparts. A significantly greater proportion of NES patients (75.0%) reported a sudden onset of their motor symptoms, whereas gradual symptom onset characterized the majority of FMD participants (68.8%). A history of some form of traumatic experience was reported by the majority of participants in both the NES (81.3%) and FMD (75.0%) groups. However, the only significant between-group difference in trauma history was self-reported sexual abuse (NES = 37.5%; FMD = 6.8%).

Neuropsychological results

The neuropsychological profile of the combined groups in relation to demographically-corrected normative data is provided in Figure 1. As a group, performance on a general cognitive screening measure (MoCA) and two measures of executive function (Letter fluency and Trail Making Test, Part B), fell

Table 3-1. Demographic and clinical characteristics of NES and FMD groups.

Variable	NES	FMD	t/χ^2	*p*
Age (years)				
At Time of Testing	39.8 (10.3)	44.6 (14.0)	—	*ns*
At Symptom Onset	36.2 (10.2)	41.3 (12.1)	—	*ns*
Type of Symptom Onset				
Sudden	12 (75.0%)	5 (31.3%)		
Gradual	4 (25.0%)	11 (68.8%)	6.15	0.01
Education[a]	12.9 (2.36)	14.3 (2.08)	73.0	0.03
Gender (% female)	15 (93.8%)	15 (93.8%)	—	*ns*
Handedness (% right)	13 (81.3%)	11 (68.8%)	—	*ns*
Ethnicity				
Caucasian	11 (68.8%)	10 (62.5%)		
Hispanic	3 (18.8%)	3 (18.8%)		
African American	2 (12.5%)	3 (18.8%)	—	*ns*
Marital Status				
Married	6 (37.5%)	13 (81.3%)		
Single	6 (37.5%)	1 (6.30%)		
Widowed	2 (12.5%)	-		
Divorced	2 (12.5%)	2 (12.5%)	8.15	0.04
Employment Status				
Employed	2 (12.5%)	9 (56.3%)		
Disability/Unemployed	14 (87.5%)	7 (43.8%)	6.79	0.009
Trauma History				
Sexual abuse	6 (37.5%)	1 (6.30%)	4.57	0.03
Physical abuse	2 (12.5%)	5 (31.3%)	—	*ns*
Emotional/Verbal abuse	-	3 (18.8%)	—	*ns*
Neglect/Abandonment	5 (31.3%)	4 (25.0%)	—	*ns*
Natural disaster	4 (25.0%)	5 (31.3%)	—	*ns*
Family Conflict	2 (12.5%)	3 (18.8%)	—	*ns*
Psychiatric History				
Mood disorder	6 (37.5%)	6 (37.5%)		
Anxiety-related disorder	7 (43.8%)	6 (37.5%)		
Somatoform disorder	2 (12.5%)	2 (12.5%)		
Dissociative disorder	-	2 (12.5%)		
Personality disorder	1 (6.30%)	-	—	*ns*
Current Treatment				
Antidepressant	5 (31.3%)	10 (62.5%)		
Benzodiazepine	8 (50.0%)	7 (43.8%)		
Anticonvulsant	10 (62.5%)	10 (62.5%)		
Opiate agonist	7 (43.8%)	9 (56.3%)		
Counseling	5 (31.3%)	5 (31.3%)	—	*ns*

Note. Mean (SD) and frequency (%) are provided for each variable; Data regarding each participant's current condition, treatment, medical and psychiatric history were obtained during a clinical interview with the patient and confirmed via review of their electronic medical records; NES = non-epileptic seizures; FMD = functional (psychogenic) movement disorders.

ns = not statistically significant at $p < 0.05$

[a] Mann-Whitney U test was performed for this variable.

more than 1.0 standard deviation below the mean[29]. Performance on three other measures (Animal Fluency, Digit Span, and WCST-64 Perseverative Errors) ranged from -1.0 to -0.5 standard deviations below the mean. Overall, mean estimated IQ scores were in the average range (WTAR: NES = 95; FMD = 101)

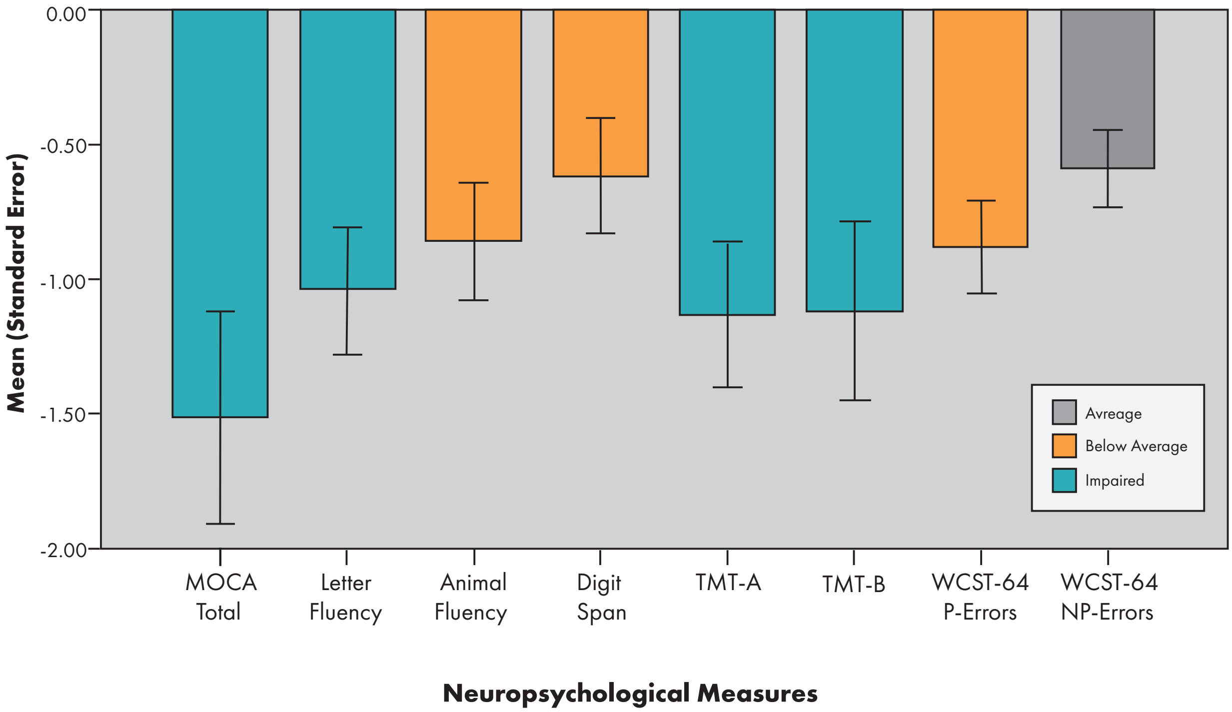

Figure 1. Neuropsychological profile of combined sample.
Impairment classification based on Heaton et al. (2004) cutoff score of -1 standard deviation below the normative mean. *Abbreviations*: TMT: TMT-A = Trail Making Test, Part A; TMT-B = Trail Making Test, Part B: WSCT-64 = Wisconsin Card Sorting Test, 64 Card Version; P-Errors = Perseverative Errors; NP-Errors = Non-Perseverative Errors

and all participants scored within normal limits on symptom validity measures (TOMM and Rey-15). As shown in Table 3-2, the two FND groups scored similarly across neurocognitive measures except for statistically worse performance by NES patients on the following: MoCA Attention subscale score, Letter Fluency, and WCST-64 Perseverative Responses.

Mood and emotion symptom findings

The majority of participants scored above clinical cut-off on three self-report measures: depression symptoms (BDI-II ≥ 14 = 56.8%), worry/rumination (PSWQ ≥ 40 = 72%) and PTSD symptoms (PCL-C ≥ 30 = 76%). Less than 1/3 of the combined sample scored above

Table 3-2. Comparison of NES and FMD group means on self-report and neuropsychological measures.

Variable	NES	FMD	*t*	*p*
Beck Depression Inventory, 2nd Ed. (BDI-II)	22.8 (14.4)	16.3 (10.2)	—	*ns*
Penn State Worry Questionnaire (PSWQ)	51.3 (15.1)	48.8 (15.8)	—	*ns*
Emotion Regulation Questionnaire (ERQ)				
Suppression subscale score	4.02 (1.64)	3.35 (1.37)	—	*ns*
Reappraisal subscale score	4.81 (1.01)	4.69 (1.21)	—	*ns*
Dissociative Experiences Scale, 2nd Ed. (DES-II)	20.3 (16.3)	20.9 (18.1)	—	*ns*
PTSD Checklist – Civilian version (PCL-C)	43.7 (14.8)	42.4 (16.9)	—	*ns*
Test of Memory Malingering *(max = 50)*	49.2 (1.60)	49.9 (0.26)	—	*ns*
Rey 15-Item Memory Test *(max = 15)*	12.7 (0.90)	14.4 (1.24)	—	*ns*
Wechsler Test of Adult Reading[a]	95.4 (12.7)	101.5 (14.5)	—	*ns*

Table 3-2. Comparison of NES and FMD group means on self-report and neuropsychological measures. (continuation)

Variable	NES	FMD	*t*	*p*
Montreal Cognitive Assessment				
Total Score *(max =30)*	23.1 (4.27)	25.0 (3.46)	—	*ns*
Visuospatial/Executive *(max = 5)*	4.69 (1.25)	5.19 (1.68)	—	*ns*
Naming *(max = 3)*	3.00 (0.00)	3.00 (0.00)	—	*ns*
Attention *(max = 6)*	3.94 (1.57)	5.25 (0.93)	-2.88	0.007
Language *(max = 3)*	1.94 (1.18)	2.37 (0.72)	—	*ns*
Abstraction *(max = 2)*	1.00 (0.82)	1.19 (0.75)	—	*ns*
Memory *(max = 5)*	3.56 (1.55)	3.31 (1.99)	—	*ns*
Orientation *(max = 6)*	5.88 (0.34)	5.94 (0.25)	—	*ns*
Digit Span (WAIS-IV)[b]	41.8 (11.7)	45.1 (6.46)	—	*ns*
Trail Making Test				
Trails A	40.9 (15.6)	38.2 (13.4)	—	*ns*
Trails B	38.6 (17.0)	35.8 (13.4)	—	*ns*
Verbal Fluency				
Letter (FAS)	33.1 (9.26)	43.7 (9.54)	-3.44	0.002
Semantic (Animals)	38.2 (8.87)	42.3 (11.4)	—	*ns*
Wisconsin Card Sorting Test-64 Card Version				
Total Errors	42.5 (11.3)	44.4 (9.05)	—	*ns*
Perseverative Errors	41.3 (10.3)	42.6 (7.98)	—	*ns*
Perseverative Responses	55.5 (10.5)	72.8 (14.4)	-3.87	0.001

Note. Mean (SD) are provided for each variable, with the exception of the Rey-15 (raw scores), WTAR (standard scores), and MoCA (raw scores); NES = non-epileptic seizures; FMD = functional (psychogenic) movement disorders. Clinical cutoff scores for each scale are as follows: BDI-II ≥ 14; PSWQ ≥ 40; ERQ: Dominant > Non-dominant strategy score; DES-II ≥ 30; PCL-C ≥ 30.
ns = not statistically significant at $p < 0.05$
[a] ANCOVA with education as a covariate was performed for this variable.
[b] WAIS-IV: Wechsler Adult Intelligence Scale, 4th Edition; Mann-Whitney U test performed for this variable.

the clinical cutoff on a measure of dissociation symptoms (DES-II = 29.2%). However, the two FND subgroups did not differ significantly in their mean scores on measures of depression (BDI-II), worry/rumination (PSWQ), posttraumatic symptoms (PCL), dissociation (DES-II), or use of suppression and reappraisal strategies for regulating emotion (ERQ). Table 2 shows the mean scores of the two groups across these psychological measures.

Figure 3-2 depicts the profile scores of the NES and FMD subgroups across the 9 clinical scales (i.e., Restructured Clinical [RC] Scales) of the MMPI-2-RF. Using the traditional clinical cutoff of T ≥ 65, the only clinically significant elevation for both groups was on the Somatic Concerns scale (RC Scale 1). Group means on all other RC Scales were within normal limits. The two groups did not differ significantly in their mean RC Scale scores, with the exception of significantly higher mean scores on the Cynicism scale (RC Scale 3) by the NES group (M = 54.7) than the FMD group [M = 45.6; $t(24) = 2.34$, $p = 0.03$]. A significantly higher proportion of FMD participants had elevated scores on the Negative Emotionality/Neuroticism scale [NES = 6.30%, FMD = 43.8%; $\chi^2(1) = 4.21$, $p = 0.04$] of the Revised Personality Psychopathology Five (PSY-5) Scales, while a significantly greater number of NES patients obtained clinically elevated scores on the Suicidal Ideation scale [NES = 18.8%, FMD = 0.0%; $\chi^2(1) = 5.11$, $p = 0.02$] of the Internalizing Scales.

Predictors of cognition

A series of stepwise linear regression analyses were used to determine if emotional distress was associated with cognitive function in general and with executive function specifically. The MoCA total scores were used as an index of general cognition. An Executive

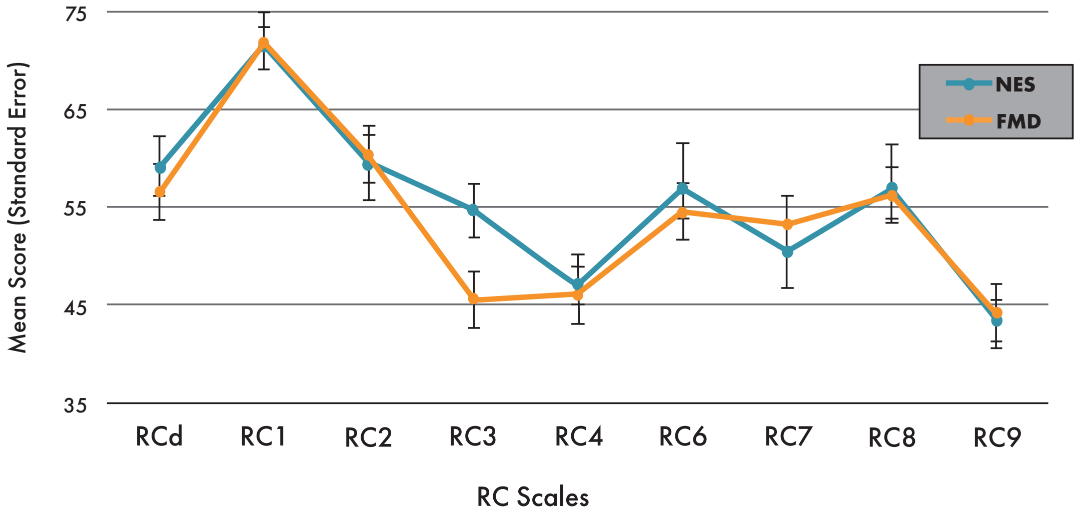

Figure 3-2. Comparison of MMPI-2-RF Restructured Clinical (RC) scales between groups
Mean T scores for NES and FMD groups on MMPI-2-RF Restructures Clinical (RC) scales.
Abbreviations: RCd-Demoralization; RCI = Somatic Complaints; RC2-Low Positive Emotion; RC3 = Cynicism; RC4 = Antisocial Behavior; RC6 = Ideas of Persecution; RC7 = Dysfunctional Negative Emotions; RC8 = Aberrant Experiences; RC9 = Hypomanic Activation

Function Composite score was computed by taking the average of the mean T-scores of two frontal lobe mediated tasks, Letter Fluency and WCST-64 Perseverative Responses, both of which differed based on group membership. Given the limited sample, we restricted our selection of independent variables to those emotion measures with a strong theoretical basis for inclusion: 1) trauma symptoms (PCL); 2) emotion regulation strategies (ERQ); and 3) dissociable facets of emotional distress from the MMPI-2-RF, represented by Low Positive Emotions [RC Scale 2] and Dysfunctional Negative Emotions [RC Scale 7].

Table 3-3 shows the results of these linear regression analyses predicting general cognitive function. As shown, the overall model was significant [$F(3, 28) = 22.5$, $p < 0.001$, Adjusted $R^2 = 0.737$] for the total

Table 3-3. Predictors of general cognitive function.

	F	Adj. R^2	β	*t*	*p*
Total Sample Analysis					
Overall Model	**22.5**	**0.737**			**< 0.001**
PCL-C			-0.52	-4.57	< 0.001
ERQ-Reappraisal			-0.29	-2.64	0.02
ERQ-Suppression			-0.44	-3.74	0.001
NES Group Analysis					
Overall Model	**76.1**	**0.966**			**< 0.001**
PCL-C			-0.52	-5.13	0.004
ERQ-Suppression			-0.59	-5.54	0.003
RC Scale 2			0.24	3.44	0.02
FMD Group Analysis					
Overall Model	**6.9**	**0.535**			**0.01**
PCL-C			-0.57	-2.87	0.01
ERQ-Reappraisal			-0.51	-2.56	0.03

Note. Separate linear regression analyses using the stepwise method were conducted for the total sample and each FND subgroup. Dependent variable = Montreal Cognitive Assessment (MoCA) total scores; Independent variables = PTSD Checklist – Civilian version (PCL-C) total scores; Emotion Regulation Questionnaire (ERQ) subscale scores for Reappraisal and Suppression; Restructured Clinical (RC) Scale 2 (Low Positive Emotions) and Scale 7 (Dysfunctional Negative Emotions).

sample, such that lower MoCA scores were associated with higher PTSD symptoms (PCL-C) and higher ERQ-Reappraisal and Suppression scores. However, slightly different findings emerged when the two groups were examined separately. For the NES group, lower MoCA scores were associated with higher PTSD symptoms (PCL-C), greater use of emotional suppression (ERQ-Suppression scores), and lower positive emotions (RC Scale 2). This combination of variables accounted for 99.6% of the variance in general cognitive function in the NES group. For the FMD group, lower MoCA scores were associated with higher PTSD symptoms (PCL) and greater use of emotion reappraisal (ERQ-Reappraisal scores), with this combination of variables accounting for 53.5% of the variance in general cognitive function.

With respect to executive function, a significant model was found for the total sample [$F(1, 30) = 6.34$, $p = 0.02$, Adjusted $R^2 = 0.224$]. Lower Executive Function scores were associated with higher endorsement of emotional suppression strategies (ERQ-Suppression: $\beta = -0.47$, $t = -2.52$, $p = 0.02$). No other emotion scores were associated with MoCA performance. There were no significant findings when similar regression analyses were conducted separately for each group.

Exploratory analyses

Psychological Differences Based on Emotion Regulation Strategies. Given that emotion regulation strategies, particularly greater suppression, were associated with worse MoCA performance, we examined the relationship between emotion regulation and other psychological symptoms (i.e., PTSD, etc.). Participants were classified as "reappraisers" or "suppressors" based on their highest mean ERQ subscale score. Using this metric, 56% of the participants were classified as reappraisers and 44% were classified as suppressors. After controlling for MoCA performance, analyses of covariance indicated that individuals in the suppressor group reported greater psychological distress than those in the appraiser group. Thus, the suppressor group had significantly more trauma events [$F(1, 30) = 12.5$, $p = 0.002$], more interpersonal and internalizing dysfunction (Family Problems: $p = 0.003$; Social Avoidance: $p = 0.01$; Suicidal Ideation: $p = 0.009$; Self-Doubt: $p < 0.001$), more severe emotional distress (BDI-II: $p = 0.008$; PSWQ: $p = 0.004$), and more symptoms of dissociation (DES-II: $p = 0.004$) than the reappraisers.

Predicting Subgroup Membership. We also examined possible predictors of group membership (NES versus FMD). Given our small sample, a conservative analytic approach was adopted—using four variables with significant ($p < 0.01$) between-group differences: Employment status, MoCA Attention subscale score, WCST-64 Perseverative Responses, and Letter Fluency. Based on this criterion, a single binary logistic regression analysis was conducted and two significant models were generated (Table 3-4). The first model included all four predictor variables, yielding a classification accuracy of 86.2%

Table 3-4. Predictors of group membership.

	Omnibus χ^2	β	SE	p	Classification Accuracy
Model 1				**< 0.001**	**86.2%**
Employment Status	**21.8**	-3.34	1.70	0.04	
MoCA Attention Subscore		0.76	0.63	ns	
Letter Fluency		0.17	0.11	ns	
WCST-64 Perseverative Responses		0.10	0.05	0.04	
Model 2				**< 0.001**	**79.3%**
Employment Status	**20.1**	-3.07	1.47	0.03	
Letter Fluency		0.14	0.09	0.09	
WCST-64 Perseverative Responses		0.11	0.05	0.02	

Note. A single binary logistic regression analysis was conducted using four variables with significant ($p < 0.01$) between-group differences as potential predictors of group membership (i.e., NES versus FMD). Data from the only two significant models generated from this analysis are presented above.

(NES = 87.5%; FMD = 84.6%). Separately, however, only employment status and WCST-64 Perseverative Responses were statistically significant predictors ($p < 0.05$). A second model was generated consisting of functional status, WCST-64 Perseverative Responses, and a trend for Letter Fluency. This combination of variables resulted in 79.3% of the total sample being correctly classified (NES = 75.0%; FMD = 84.6%). These findings are considered preliminary, however, and must be interpreted with caution given the limited sample.

Discussion

There were three major findings. First, consistent with previous observations, FMD participants endorsed a higher prevalence of clinically significant post-traumatic symptoms and other emotion/mood symptoms relative to the general population[7]. Second, as a group, both NES and FMD patients demonstrated a general cognitive inefficiency (i.e., reduced total MoCA score) as well as executive weaknesses. The latter was based on mild reductions on tasks of letter fluency and set-shifting. These frontal-executive weaknesses occurred in the context of average premorbid intellect and valid effort during the neuropsychological assessment. Although the disruptive effects of psychological distress may underlie these frontal-executive and cognitive inefficiencies, we found that greater use of emotion regulation strategies involving "suppression" (rather than re-appraisal) was associated with worse executive function. In terms of overall cognitive status, both posttraumatic distress and the habitual use of either suppression or reappraisal was associated with lower overall cognitive function. Findings are consistent with previous neuroimaging studies documenting functional abnormalities in neural regions involved in emotion regulation (e.g., anterior cingulate, ventromedial PFC, amygdala), cognitive control and motor inhibition (e.g., anterior cingulate, dorsolateral PFC, inferior frontal gyrus) in FMD patients[38].

The third major finding pertained to differences between the two FND subgroups. While FMD patients generally outperformed their NES counterparts across neuropsychological measures, frank statistical differences were found on measures of simple auditory attention, letter fluency and perseverative responding, with the NES group performing worse than the FMD group. On mood and emotion measures, NES and FMD participants reported similar rates of self-reported trauma, post-traumatic symptoms, worry and depressive symptoms. However, consistent with previous research[12,13], NES patients reported a significantly higher occurrence of sexual abuse than FMD patients (i.e., 6 to 1), were less educated (by 2 years), and less frequently married and employed at the time of testing. The three factors that distinguished the NES and FMD groups were employment status, letter fluency and perseverative response tendencies. Based on these findings, we conclude that executive inefficiencies are more evident in patients with NES than FMD. This may result in diminished capacity to navigate social interactions and appropriately modify behavioral strategies according to environmental feedback by patients with NES than those with FMD.

Alternatively, the unexpected association observed between cognition, traumatic stress and different emotion regulation strategies in NES vs. FMD groups may refine our conceptualization of FND. Specifically, while findings support the traditionally proposed role of trauma in FND, they[39] further implicate individual differences in emotion regulation strategies as important variables that may mediate the relationship between early adverse experiences and mental health outcomes. Consistent with previous research by Gross and John[40], the habitual use of emotional suppression was associated with greater negative emotional experience (depression and worry/rumination) and interpersonal dysfunction (family problems and social avoidance). However, there was an exponentially higher number of traumatic events and dissociative symptoms found among habitual suppressors vs. reappraisers. Results suggest that victims of multiple traumatic experiences may rely on suppression strategies to manage their distressing emotions, and perhaps more likely to experience dissociative symptoms of posttraumatic stress. These findings complement the results of previous investigations suggesting various facets of emotional processing may mediate the relationship between early life experiences and subsequent development of these sensorimotor disturbances[14-16].

Overall, the results of this study add to a growing body of literature suggesting that NES and FMD may represent phenotypic variants of similar underlying conditions. To date, the majority of research investigating FND subgroup differences has been limited to either a single phenotypic variant or a single functional domain of interest (e.g., psychological distress or neurocognitive function). In contrast, the present study included a heterogeneous sample of hyperkinetic FND (NES and FMD) who were examined across multiple domains, including psychologic-emotion, psychosocial and neurocognitive. Although such findings are considered preliminary, results of the current study will provide a foundation for future investigations of FND variants that may facilitate the development of symptom-specific treatment approaches. For instance, the greater emotional suppression tendencies and suicidal ideation in NES patients may be targeted with adaptive emotion regulation training and perhaps off-label use of pharmacological agents with demonstrated efficacy in reducing suicidal ideation. Alternatively, the greater negative emotionality found in FMD patients has been associated with general deficits in attentional control including difficulty disengaging attentional resources from negatively valanced stimuli[41]. Thus, patients with similar functional neurological symptoms may benefit from therapeutic interventions incorporating biofeedback training, in which patients learn to restructure targeted patterns of brainwaves through the provision of information on their cortical electrical activity[42,43].

Limitations & future directions

The current findings should be interpreted with caution due to the small sample and the high number of statistical comparisons. Moreover, our limited sample precluded further subdivision of the FMD group into more homogeneous motor subgroups (e.g., tremor versus gait disturbances, etc.). Given that these participants were seen at specialized tertiary care centers, the sample may have included more severe FND cases. Future investigations should strive to investigate a larger sample, provide comparisons between more homogeneous motor subgroups, and examine the frequency and type of previous therapeutic interventions. Future research efforts should also be directed toward furthering our understanding of important biological and psychosocial differences between FND patients that may facilitate the development of more effective and individualized therapeutic interventions.

Closing remarks

In sum, the current study adds to the literature by highlighting (1) the clinical utility of examining FND patients with different sensorimotor symptoms separately and (2) the importance of investigating reciprocal relationships between psychological symptoms, cognitive functioning, and habitual behavioral tendencies (i.e., emotion regulation strategies) that may mediate the relationship between early adverse experiences and mental health outcomes. Although the causative mechanisms underlying the development of FND have yet to be determined and are probably multi-factorial, our findings suggest that both cognitive weaknesses and habitual behavioral tendencies may play an important role in the clinical presentation of patients with FND.

Financial Disclosure/Conflict of Interest

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Development and efficacy of a compensatory skill building program: Parkinson's disease cognitive rehabilitation for executive functioning (PD-CoRE)

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ABSTRACT

Objective: *Cognitive dysfunction is a major clinical feature of PD that contributes to disability, caregiver strain, and diminished quality of life over the disease course. Cognitive rehabilitation has mounting evidence as an intervention relevant for improving quality of life for people living with PD. The Parkinson's Disease Cognitive Rehabilitation of Executive functioning (PD-CoRE) program is a new cognitive rehabilitation program designed to teach compensatory skills that address daily struggles secondary to executive dysfunction and to break the cycle of cognitive impairment, depression, apathy, poor self-efficacy, reduced quality of life, and increased caregiver burden. The aim of the current study was to evaluate the efficacy of the PD-CoRE program in improving executive functions of individuals with PD and mild cognitive impairment.*

Methods: *Standardized neuropsychological tests and ecologically valid outcome measures were administered to assess executive functions in addition to mood, apathy, self-efficacy, life satisfaction, quality of life, and caregiver burden. A series of Wilcoxon signed-rank tests were performed.*

Results: *Results revealed initial improvements in immediate attentional capacity and long-term improvements in inhibition, delayed verbal recall, and verbal memory discrimination. 50% of participants reported subjective improvement in their ability to engage in daily activities, and 50% reported increased self-efficacy. Results from informants revealed that 40% of spouses perceived improvements in the participant's self-regulatory abilities, and 60% reported observing improvements in the participants' ability to manage activities of daily living.*

Conclusion: *Findings from the present study provide support for the feasibility and, if cross-validated, the efficacy of the PD-CoRE program in PD patients with executive dysfunction.*

Keywords:

Parkinson's disease, executive functions, cognitive rehabilitation, mild cognitive impairment, compensatory strategies, quality of life

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Introduction

The hallmark of Parkinson's disease (PD) is its motor features, but selective cognitive impairments are evident in over 40% of patients (1). Cognitive dysfunction is now recognized as a major clinical feature of PD that contributes more to disability, caregiver strain, and diminished quality of life over the disease course than motor deficits (2-4). Cognitive deficits associated with PD arise in part from neural changes in the frontostriatal circuits, leading to executive dysfunction (5). Thus, difficulties in executive skills such as working memory, inhibition, and cognitive flexibility (or set-shifting) are some of the most prominent and early cognitive changes associated with PD (6-7). With advances in medical interventions for motor symptoms, individuals with PD are living longer and facing greater disability related to cognitive impairments. Unfortunately, pharmacological treatments for PD cognitive changes are currently limited and have not demonstrated efficacy in reducing executive functioning impairments (8). The importance of investigating non-pharmacological treatment options for cognitive dysfunction is clear.

Cognitive rehabilitation is one such behavioral technique with promising evidence to improve and maintain cognitive skills in those with PD-related cognitive impairment. This type of intervention was originally designed for traumatic brain injury but has been adapted for other neurological conditions. However, research is in its infancy and there are no standardized guidelines for treatment in PD. Cognitive rehabilitation programs generally seek to reduce functional impairment and increase engagement in activities of daily living through skills training. Calleo and colleagues (9) conducted a critical integrative review of the PD cognitive rehabilitation literature at the time and found limited evidence for effectiveness across four studies (two of which were randomized controlled trials [RCTs]) [11-12]. However, the authors noted numerous potential areas of improvement for future studies, such as the need for ecologically valid outcome measures and generalizability of findings to a larger sample of PD patients. A more recent review (13) found promising benefits for cognitive functioning in mild to moderate PD across seven RCTs, a reflection of both the growing attention to cognitive rehabilitation in this population and the increasing feasibility in this population. Five RCT studies have found statistically significant improvements with moderate effect sizes of cognitive rehabilitation on executive functioning in PD (11, 14-17). While these emerging studies highlight the increasing centrality of non-pharmacological approaches in the care of PD, these findings are preliminary in nature. Participants in these studies tended to be cognitively intact, which limits our understanding of the role of cognitive rehabilitation among those who may benefit the most (i.e., PD patients with mild cognitive impairment). These studies examined a variety of cognitive domains, which limit the generalizability of treatment effects. Executive dysfunction is the most prominent cognitive change in PD, and is more strongly associated with deleterious motor and neuropsychiatric effects in PD (18); therefore, it warrants targeted attention in the development of interventions.

In addition to findings that cognitive rehabilitation may ameliorate cognitive impairment associated with PD, growing attention has been paid to the generalizability of intervention effects to neuropsychiatric symptoms. However, even less research has been conducted in these domains, and the limited findings are inconclusive. Cognitive rehabilitation appears to have a moderate effect on improving depression (11, 14-16, 19), albeit with mixed findings. Even fewer studies have explicitly assessed quality of life, also with mixed findings (11, 16). Apathy, or the reduction in goal-oriented behavior, often overlaps with depression and cognitive impairment but can be evaluated separately (20). As such, apathy is prevalent in PD and associated with poorer quality of life and increased caregiver burden (21-22). Apathy has only been assessed in one RCT(15), with no change noted by authors. Therefore, little is known about potential improvements in apathy following cognitive rehabilitation. A related construct of self-efficacy, or the expectations one has around one's ability to successfully execute goal-directed behavior(23), has also received limited attention in the PD literature. Self-efficacy is associated with social withdrawal, depression, and diminished functional capacity in patients with Alzheimer's disease(24). It may operate similarly to the cycle in PD, in which physical deconditioning and cognitive deficits create a loop of helplessness and poor self-efficacy as patients increasingly cease to engage in hobbies, reduce physical activity, rely on others, and feel uncertain about their future. A decrease in self-efficacy may further accelerate physical and cognitive decline. Finally, executive dysfunction and related neuropsychiatric effects of depression, apathy, and poor self-efficacy have deleterious effects on caregiver burden and quality of life(25-27). However, interventions to reduce caregiver burden and improve patient quality of life are scarce. No study to date has assessed all of these interrelated constructs, so it is unknown which of these neuropsychiatric and psychosocial factors are the most amenable to change following participation in a cognitive rehabilitation intervention.

Cognitive rehabilitation has mounting evidence as an intervention relevant for improving quality of life for people living with PD (28-29). Using Calleo and colleagues' (9) recommendations as a foundation, we developed a novel PD group cognitive rehabilitation program to target the executive functioning impairments in PD, called the Parkinson's disease Cognitive Rehabilitation of Executive functioning (PD-CoRE) program. We addressed limitations of previous studies by implementing ecologically valid outcome measures in our neuropsychological battery and targeting the intervention to the cognitive deficits most commonly demonstrated in PD patients (i.e., executive functions).

The aim of the current study was to evaluate the efficacy of the PD-CoRE program in building compensatory strategies to improve applied executive functioning in individuals with PD and mild cognitive impairment. Standardized neuropsychological tests and ecologically valid outcome measures were used to assess executive functions in addition to mood, apathy, self-efficacy, life satisfaction, quality of life, and caregiver burden. The goal of PD-CoRE is to teach compensatory skills that address daily struggles secondary to executive dysfunction and to break the cycle of cognitive impairment, depression, apathy, poor self-efficacy, reduced quality of life, and increased caregiver burden. With the skills learned in the PD-CoRE program, the following was hypothesized: 1) Participants would perform better on objective measures of executive functioning following the group; 2) Participants would report an improvement in problem-solving and adaptive abilities in their everyday lives, improved mood, increased quality of life, and greater sense of self-efficacy; and 3) Informants would report improved adaptive and self-regulatory abilities. .

Study 1. Initial Feasibility Study

Methods

Participants

A preliminary feasibility study was implemented in January 2016 in which PD-CoRE was delivered in a small group setting. The PD-CoRE program was created to be delivered via groups instead of individual sessions as groups are traditionally more cost-effective than individual sessions (e.g., less time intensive for therapists, require fewer resources; 30). Nine participants (67% male, Age$_{mean}$ = 66.9, Education$_{mean}$ = 16.22 years), with mild PD (baseline Montreal Cognitive Assessment [MoCA$_{mean}$] = 25.7/30) and self-reported executive dysfunction were successfully recruited and retained for the initial feasibility group.

Process

The Baylor College of Medicine Institutional Review Board approved the study protocol and informed consent was obtained from all participants. The initial program consisted of 8 1.5-hour group sessions providing education and hands-on experiences targeting inhibition, working memory, and set-shifting abilities. Participants were recruited via flyers distributed in the corresponding author's clinic and via a posting in the Houston Area Parkinson Society (HAPS) newsletter. Potential subjects who expressed interest were contacted by a group leader and completed an eligibility screener to gather basic demographics (age, sex, race, handedness, and education) and to complete a baseline MoCA, Beck Depression Inventory, 2nd Edition (BDI-II), Columbia- Suicide Severity Scale (CSSR-S), and Parkinson's Daily Activities Questionnaire-15 (PDAQ-15). Participants were included if they had a diagnosis of idiopathic PD, were between the ages of 45 and 75 years old, were fluent English speakers, and were able to give informed consent. Exclusionary criteria included: active psychosis, significant depression (BDI-II > 14), impaired instrumental activities of daily living (PDAQ-15 < 60), concurrent cognitive rehabilitation treatment, and diagnosis of dementia. All participants completed at least 7 of the 8 weekly sessions. Participants underwent comprehensive neuropsychological batteries prior to the start of group and immediately following the completion of the group.

Materials/instruments

Participants completed standardized measures pre- and post-treatment assessing global mental status (MoCA; [31]) and memory (Hopkins Verbal Learning Task- Revised [HVLT-R]; [32]), as well as multiple aspects of executive functioning including working memory (Digit Span; [33]), verbal fluency (Delis-Kaplan Executive Functioning System [D-KEFS] Letter Fluency & Category Fluency; [34]), semantic set-shifting (D-KEFS Category Switching, [34]), visual scanning/tracking (Trail Making Test Part A, TMT A; [35]), psychomotor set-shifting (Trail Making Test Part B, TMT B; [35]), and inhibition (Stroop Color Word Test; [36]). Participants also completed self-report measures of perceived cognition (Everyday Problems Test, EPT; [37]), perceived executive dysfunction (Dysexecutive Questionnaire, DEX; [38]), depression (Beck Depression Inventory, 2nd edition, BDI-II; [39]), anxiety (Generalized Anxiety Disorder, 7-item scale, GAD-7; [40]), impact of PD on functioning and well-being (The Parkinson's Disease Questionnaire, PDQ-39; [41]) and a patient satisfaction questionnaire.

Statistical analysis

All neurocognitive measures were corrected based on appropriate normative data and converted to a common metric (i.e., T Score with $M = 50$, $SD = 10$). Examination of the data showed departure from normal distribution for most dependent variables, therefore nonparametric analyses were utilized. All analyses were run using SPSS (Version 24.0, IBM Corp., Armonk, NY). Wilcoxon signed-rank tests (nonparametric paired samples tests) were utilized to evaluate differences between testing prior to the start of PD-CoRE and immediately following the end of PD-CoRE treatment. Alpha was set at 0.10, one-tailed, for all inferential tests.

Results

Preliminary analyses revealed an improvement in set-shifting ability (TMT B; $t(8) = 2.14$, $p = 0.06$, $d = 0.73$; $M_{T1} = 43.89$, $SD_{T1} = 13.10$, $MD_{T2} = 49.56$, $SD_{T2} = 15.89$) and a decline in verbal learning (HVLT-R Total; $t(8) = 3.45$, $p = 0.009$, $d = 1.20$; $M_{T1} = 50.00$, $SD_{T1} = 7.91$, $MD_{T2} = 42.44$, $SD_{T2} = 9.77$). No other changes were noted on the outcome measures. Examination of mood variables revealed subclinical depressive symptoms at baseline and did not change following treatment ($t(8) = -1.769$, $p = 0.115$). Acceptability and satisfaction with the program was high on self-report evaluations; 100% of participants reported enjoying the social interaction with other PD patients, 89% agreed that the program provided them with ecologically valid skills for use in daily life, 78% reported improved problem-solving skills, and 89% would recommend it to other PD patients.

Study 2. PD-CoRE Efficacy Study

Based on participant feedback and expert consensus, the structure and content of the PD-CoRE program was modified to include additional interactive activities and decrease the number of sessions. The expert consensus panel consisted of a Neuropsychologist, a Movement Disorders Neurologist, a Psychiatrist, a community Social Worker from the local Parkinson's community group, and an individual with Parkinson's disease. The consensus panel met on two occasions to discuss the development and revision of the manualized treatment program. The revised PD-CoRE format consisted of 6 weekly 1.5-hour group sessions. In the current study, a range of neuropsychiatric and psychosocial variables were assessed at three time-points (pre-group, post-group, and 3 months post-group) to extend preliminary findings identified by Leung and colleagues' (13) review. Spouse informants were also included to provide collateral ratings. In addition, more stringent inclusion/exclusion criteria were adopted to better assess intervention effects, including selectively targeting those with PD-related mild cognitive impairment (MCI; based on PD-MCI diagnostic criteria published by the Movement Disorder Society Task Force; 42) who may stand to benefit the most from cognitive rehabilitation relative to those with intact abilities. The specific eligibility criteria are discussed below.

Methods

Participants

Six patients with PD (50% male, $\text{Age}_{\text{mean}} = 68.3$, $\text{Education}_{\text{mean}} = 15$ years) were recruited along with six spouse informants via flyers distributed in the corresponding author's clinic and via a posting in the Houston Area Parkinson Society (HAPS) newsletter. Potential subjects who expressed interest were contacted by one of the group leaders and completed an eligibility screener to gather basic demographics (age, sex, race, handedness, and education) and to complete a baseline MoCA, BDI-II, CSSR-S, and PDAQ-15. Participants were included if they had a diagnosis of idiopathic PD, were between the ages of 45 and 75 years old, were fluent English speakers, were able to give informed consent, and had MoCA scores between 21 and 25 with ≥ 3 items on delayed recall (43). Exclusionary criteria included: active psychosis, significant depression (BDI-II ≥ 14), impaired instrumental activities of daily living (PDAQ-15 < [60]), concurrent cognitive rehabilitation treatment, and diagnosis of dementia.

Process

All group members underwent a comprehensive neuropsychological battery prior to the start of the PD-CoRE program that included the original measures from the feasibility study (described above) as well as the Iowa Gambling Task (IGT; [44]; measure of decision-making), Satisfaction with Life Scale (SLS; Diener, [45]), Generalized Self-Efficacy Scale (SES; [46]), Apathy Evaluation Scale (AES; [20]), the self-report form of the Penn Parkinson's Daily Activities Questionnaire-15 (PDAQ; [47]; assessment of cognitive instrumental activities of daily living in PD), and the self-report Behavior Rating Inventory of Executive Functions, Adult Version (BRIEF-A; [48]). Informants completed the Zarit Burden Scale (49), the informant version of the PDAQ, and the informant version of the BRIEF-A. Following the final group session, all group members underwent a repeat comprehensive neuropsychological battery with the above measures. Three months after the group ended, subjects returned to complete a second repeat neuropsychological evaluation.

Statistical analysis

Similar to the feasibility study, all neurocognitive measures were corrected based on appropriate normative data and converted to a common metric (i.e., T Score with $M = 50$, $SD = 10$). Wilcoxon signed-rank tests (nonparametric paired samples tests) were run to evaluate differences before and after the PD-CoRE treatment as well as before treatment and during the 3-month follow-up evaluation. Reliable Change Indices (50) were calculated based on information provided in the original test manuals to evaluate significant change over time for each participant. Given the small sample size, alpha was set at 0.10, one-tailed, for all inferential tests.

Results

Cognitive outcomes:

Comparison of neuropsychological performance at various time points (pre-group, post-group, and follow-up) revealed variable interim changes. As compared to their pre-group performance, participants demonstrated improvement (i.e., higher scores) on immediate attentional capacity (LDSF, $z = -1.643$, $p = 0.10$; $M_{T_1} = 44.83$, $SD_{T_1} = 7.41$, $MD_{T_2} = 49.50$, $SD_{T_2} = 7.45$) post-group. Participants demonstrated decline (i.e., lower scores) on measures of speeded word reading (Stroop Word Reading, $z = -2.626$, $p = 0.009$; $M_{T_1} = 32.50$, $SD_{T_1} = 11.20$, $MD_{T_2} = 27.67$, $SD_{T_2} = 10.09$), initial verbal learning (HVLT-R Total Recall; $z = -3.081$, $p = 0.002$; $M_{T_1} = 54.17$, $SD_{T_1} = 6.08$, $MD_{T_2} = 41.67$, $SD_{T_2} = 9.48$), and delayed verbal recall (HVLT-R Delay Recall, $z = -1.886$, $p = 0.059$; $M_{T_1} = 51.33$, $SD_{T_1} = 6.68$, $MD_{T_2} = 43.83$, $SD_{T_2} = 13.47$). Results from the three-month follow-up testing revealed improved inhibition (Stroop Color-Word, $z = -1.633$, $p = 0.10$; $M_{T_1} = 40.17$, $SD_{T_1} = 14.80$, $M_{T_3} = 34.50$, $SD_{T_3} = 12.12$), delayed verbal recall (HVLT-R Delay, $z = -1.826$, $p = 0.068$; $M_{T_1} = 51.33$, $SD_{T_1} = 6.68$, $M_{T_3} = 42.75$, $SD_{T_3} = 14.52$), and verbal memory discrimination (HVLT-R Discrimination, $z = -1.604$, $p = 0.10$; $M_{T_1} = 48.00$, $SD_{T_1} = 4.52$, $M_{T_3} = 37.50$, $SD_{T_3} = 11.85$) as compared to baseline performance. There were no significant changes between the post-group evaluation and the three-month follow-up.

Affective/behavioral outcomes

Comparison of affective and behavioral measures at various time points (pre-group, post-group, and follow-up) on a group level revealed no significant differences. However, given the heterogeneity of patient presentation at group onset, analysis of the overall group may mask within participant changes. Table 4-1 provides patient level specifics on various affective/behavioral outcome measures. 50% of participants reported perceived improvement in their ability to engage in daily activities (as measured by the PDAQ) and 50% reported increased self-efficacy.

Informant report

Comparison of informant ratings on a group level revealed no significant changes. Table 4-2 depicts the individual changes in participants as rated by the spouse informants. 40% of the spouses reported improvements in the participant's self-regulatory abilities, specifically with their ability to regulate thoughts and cognitions (i.e., metacognition) and their ability to regulate behaviors and emotions (i.e., behavioral regulation). 60% of spouses reported observing improvements in the participants' ability to manage activities of daily living.

Table 4-1. Affective/Behavioral Outcomes of PD-CoRE Group 2

ID #	Sex	Age	Edu.	BDI-II*			GAD-7*			PDAQ			DEX*			PDQ-39*			SES			SLS			AES*		
				T1	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ
1	M	57	16	8	10	–	2	1	–	33	31	–	22	36	↓	26%	27%	–	36	33	–	27	23	–	39	38	–
2	F	73	12	4	5	–	0	0	–	52	48	–	31	30	–	1%	5%	–	33	40	–	35	34	–	27	27	–
3	F	77	16	13	16	–	6	5	–	34	43	↑	46	43	–	39%	39%	–	22	29	↑	17	29	↑	31	27	↑
4	F	61	14	32	24	↑	19	12	↑	13	41	↑	57	47	↑	58%	46%	–	18	29	↑	9	11	–	57	51	↑
5	M	74	16	4	4	–	1	1	–	51	52	–	30	38	–	5%	10%	–	39	30	↓	33	35	–	22	30	↓
6	M	68	16	15	14	–	4	5	–	38	49	↑	42	55	↓	20%	27%	–	28	35	↑	18	22	–	33	40	↓

Note: Significant change (95% Reliable Change Index) denoted by: ↑ = Improvement, ↓ = Decline, – = Stable. Asterisk (*) indicates a measure in which higher scores reflects worse outcomes. Abbreviations: BDI-II = Beck Depression Inventory, 2nd Edition; GAD-7 = Generalized Anxiety Disorder 7-item scale; PDAQ = Penn Parkinson's Daily Activities Questionnaire, Self-Report; DEX = Dysexecutive Questionnaire; PDQ-39 = Parkinson's Disease Questionnaire; SES = Generalized Self-Efficacy Scale; SLS = Satisfaction with Life Scale; AES = Apathy Evaluation Scale.

Table 4-2. PD-CoRE Group 2 Informant Ratings

	BRIEF- A MetaCognition*			BRIEF-A Behavioral Regulation*			PDAQ-I			Zarit*		
	T1	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ	*T1*	*T2*	Δ
1	56	87	↓	43	57	↓	34	33	–	24	30	–
2	67	49	↑	64	48	↑	32	47	↑	8	11	–
3	53	47	–	52	51	–	50	59	↑	15	15	–
5	48	44	–	51	45	–	54	54	–	21	11	↑
6	67	50	↑	63	52	↑	40	48	↑	22	38	↓

Note: Significant change (95% Reliable Change Index) denoted by: ↑ = Improvement, ↓ = Decline, – = Stable; Asterisk (*) indicates a measure in which higher scores reflects worse outcomes. Abbreviations: BRIEF-A = Behavioral Rating Inventory of Executive Functions- Adult Version; PDAQ-I = Penn Parkinson's Daily Activities Questionnaire, Informant Report; Zarit = Zarit Caregiver Burden Scale

Patient satisfaction

All participants completed a post-group satisfaction survey. 100% of the group participants reported that they could apply the skills from the program to their daily life, they reported improved self-confidence and sense of self-efficacy, and also reported enjoying the social interaction with other PD patients. 100% of the participants indicated strong satisfaction with the program, interest in participating in similar programs in the future, and would recommend the program to other Parkinson's disease patients. Participants commented on the changes they noticed after participating in the group. Responses included "I don't feel as overwhelmed by trying to do a difficult task, now I can break it down," and "[I am] more deliberative, better organized, engaged, and more confident."

Discussion

Cognitive dysfunction is a major clinical feature of PD that contributes more to disability, caregiver strain, and diminished quality of life over the disease course than motor deficits (2-4). Unfortunately, pharmacological treatments for PD-related cognitive changes are limited and have not demonstrated efficacy in reducing executive functioning impairments (8). As such, it is important to investigate non-pharmacologic treatment options for cognitive dysfunction. The present study evaluated the feasibility and efficacy of a novel cognitive rehabilitation program (PD-CoRE) in improving executive functions in patients with PD. Results from the initial feasibility study suggested that patients with PD enjoyed the program, believed the program provided them with ecologically valid skills for use in daily life, and improved their problem-solving skills. The small group setting also provided immediate emotional support and created a richer learning environment where participants were able to serve as role models for each other, learn from each other's experiences, and share resources.

Though the participants reported high satisfaction with the program, results from the neuropsychological measures were mixed. The PD-CoRE treatment did not have a significant impact on levels of depression or anxiety. As compared to their baseline performance, participants demonstrated slight improvement in immediate attentional capacity following the PD-CoRE treatment but demonstrated subtle declines on speeded word reading, verbal learning, and delayed verbal recall. Results from the three-month follow-up testing revealed slight improvement in inhibition, delayed verbal recall, and verbal recognition discrimination. The variable and subtle changes on neuropsychological outcome measures was, in the end, unsurprising. The PD-CoRE program focuses on building compensatory strategies to improve applied executive functioning in daily life and is not a form of cognitive training, therefore it does not attempt to improve the underlying cognitive ability. A common issue within neuropsychology is the poor convergence between performance on executive functioning measures (unpracticed ability to execute cognitive processes) and application of executive functioning abilities within the context of real-life situations. As such, capturing changes within a person's ability to successfully use executive abilities day-to-day is difficult and often relies on patient or informant self-report. In order to address this issue in the current study, we included both patient and informant report.

A strength of the current study is the inclusion of quality of life, self-efficacy, and daily functioning measures in combination with informant ratings and objective neuropsychological data. Biundo and colleagues (51) highlight the disconnect between definitions of "successful" outcomes within the cognitive rehabilitation literature. Empirical research often considers an intervention successful if patients demonstrate improved performance on traditional neuropsychological measures; however, patients and families expect functional improvements or at least functional stability when considering whether a treatment was "successful." In the current study, 50% of participants self-reported improvement in daily functioning and 50% reported increased self-efficacy. Similarly, more than half of the informants reported noticing improvements in their spouse's ability to function on a daily basis and 40% reported noticing improved self-regulation.

Limitations

There are several limitations in the present study that must be acknowledged. First, the sample was quite small and a larger sample would have increased the power to detect treatment effects. The small sample size also precluded more detailed analyses of relationships between variables. Second, participants in the feasibility study tended to be cognitively intact with self-report of mild executive functioning changes; therefore, ceiling effects may have limited detection of intervention effects. Third, the clinical characteristics of the patients in the efficacy study varied widely within the group. In fact, heterogeneity of patients is often considered one of the main critiques of the cognitive rehabilitation for PD literature as the diversity of samples makes it difficult to understand the long-term effectiveness of the treatments (51).

Another limitation of the present study is that changes associated with the group (both positive and negative) were presumed to be related to the group treatment. However, there were participants who reported acute stressors that were unrelated to PD and may have impacted self-report responses. These acute stressors may have impacted the participant's receptiveness to group teachings. Similarly, information on participant's medication regimen was not gathered and it is unclear whether any change to the regimen occurred during the course of treatment. As such, it is unknown whether the patient's pharmacological treatment impacted the cognitive and emotional outcomes.

It is also important to note that the measurement of treatment efficacy is limited to only the functions assessed within the current neurocognitive test battery. Future studies should include additional informant ratings (including informants' report of program satisfaction) and additional measures of self-regulation. An additional limitation is the lack of a non-treatment PD control group, which would be useful in further investigating the efficacy of the PD-CoRE program.

Conclusions

Overall, the present study's findings provide support for the feasibility and, if cross-validated, the efficacy of the PD-CoRE program in PD patients with self-reported executive dysfunction. Clinically, professionals working with PD should be aware of potential executive function deficits and potential obstacles that might arise from such impairments within patients' daily lives as well as the possibility of improvement in executive functioning with appropriate compensatory skill building. By providing PD patients with psychoeducational information and ecologically valid compensatory strategies regarding executive functioning, PD-CoRE may be able to break the negative cycle of PD by improving mood, self-efficacy, and quality of life and reducing caregiver burden.

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Appendix 1. Overview of PD-CoRE Program Content*

Session No.	Session Title	Summary of Content
1	Introduction: Managing Life with Parkinson's Disease	• Introductions • Overview of group processes/expectations • Overview of PD and Executive Functioning • Overview of Breaking the Cycle of PD • Homework for Session 2
2	Inhibition	• Review Session 1/Homework • Explain Inhibition • Introduce "I GOT IT" Model • In-Session Activity: Medication Management • Homework for Session 3
3	Working Memory	• Review Session 2/Homework • Use "I GOT IT" • Explain Working Memory • In-Session Activity: Bill Paying • Homework for Session 4
4	Task-Shifting	• Review Session 3/Homework • Use "I GOT IT" • Explain Task-Shifting • In-Session Activity: Errand Planning • Homework for Session 5
5	Executive Functioning: Putting the Pieces Together	• Review Session 4/Homework • Use "I GOT IT" • Review of Executive Functioning • In-Session Activity: Trip Planning • Homework for Session 6
6	Maintenance and Wrap-Up	• Review Session 5/Homework • Use "I GOT IT" • Review Breaking PD Cycle • Recap group aims and treatment goals • Process group experience and obtain feedback

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Executive functioning performance of bilingual and monolingual children with a traumatic brain injury

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ABSTRACT

Objective. *The main purpose of this research study was to assess the difference between bilingual speakers and monolingual children who have sustained a TBI and their performance on a measure of executive functioning. It is hypothesized that 1) age would be a significant contributor to performance on executive functioning tasks, 2) neurocognitive performance on measures of executive functioning will be lower for the TBI group as compared to the control group, and 3) neurocognitive performance on measures of executive functioning will be lower for monolingual as compared to bilingual peers.* **Method.** *The total sample consisted of 48 children. Each subject was administered the D-KEFS (1), as part of a larger neuropsychological battery. The hypotheses were tested using appropriate independent-samples tests to determine whether statistically significant differences existed in executive functioning performance between groups. Furthermore, age was treated as a continuous variable, and was tested for normality. Results: Significant difference were found between the TBI and Control groups for CW4 [t(36)=3.121, p =.003], TMT 2 [t(40)=3.175, p =.003], and TMT 3 [t(40)=3.259, p =.002]. When comparing the performance of monolinguals and bilinguals, statistically significant results where found for the control group (Mann Whitney U = 11,* n_1*=10,* n_2*=6, p=0.044), but not for the TBI group (Mann Whitney U = 54,* n_1*=11,* n_2*=10, p=0.968). Age was not found to be be a significant contributor to performance.* **Conclusion.** *Bilinguals without a TBI demonstrated a significant advantage in a verbal task of inhibition and switching. Overall results demonstrate children's higher order functioning abilities are significantly impacted by a TBI. Interestingly, bilingual children seem to be at an increased risk of executive functioning impairments after a TBI. This could be the result of a newly acquired skill and the damage to a less mature region of the brain.*

Keywords:

executive functioning, brain injury, bilingualism, children.

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Introduction

Acquired brain injuries occurring after 3 months of age can be divided into traumatic brain injury (TBI), caused by trauma to the brain, or non-traumatic brain injury (NTBI), due to medical pathologies (stroke, hypoxia, tumor)[2]. TBI results from acute external forces to the skull resulting in extensive lesions to the neural tissue and diffuse axonal damage[3]. TBI results in neurocognitive deficits, affecting attention, motor performance, executive functioning, visuospatial abilities, auditory functioning, memory, language, emotional regulation, and sleep functions (3, 4, 5, 6). Multiple studies have demonstrated that the damaged brain may never return to its previous trajectory of development (7).

Although TBI is devastating at any point in the human development, research shows that young brains might be more vulnerable to slower recover and more severe, diffuse, and enduring deficits (8, 3, 5). Sadly, there is a high incidence of TBIs during childhood and early adulthood, time frames of rapid brain development (5, 7). According to the Center for Disease Control and Prevention (2016), children younger than 4 years of age have the highest rates (2193.8 per 100 000) of any age group, typically with almost twice the rate of those in the next highest age group (15–24 year-olds). Thousands of neural cells and synaptic connections are formed during brain development. Longitudinal analyses have shown that after a brain injury, late maturing regions of the frontal and temporal areas, fail to undergo expected cortical thinning producing long-standing cognitive impairment (7). Brain injury has the potential to affect subsequent development and prevents the brain from returning to its pre-injury baseline (7).

Interestingly, minorities in the United States of America seem to be at a greater risk of suffering a brain injury, as well as having worse predicted recovery outcome related to independent living, engagement in leisure activities, and return to work or school (9). Most of these minorities are bilingual. The U.S. Department of Education (2013) established that about 4.65 million individuals in the United States of America are identified as bilinguals. Bilingualism is defined as the constant use of two (or more) languages (10). Bilingual proficiency varies across the Hispanic population in the United States of America and it depends on many variables, such as the language exposure at school, language spoken at home, years of residence in countries with majority and minority languages, language deficits, and socioeconomic status (SES) (11).

Calabria et al., (12) suggested that bilinguals utilize a complex neural network involved in the use of more than one language. According to this hypothesis, each neural area is in charge of a specific cognitive function. Research also found that in bilinguals who sustained a brain injury, the level of activation and inhibition of both languages was significantly impaired (12). Tavano, et al., (5) proposed that executive functions appeared as a characterizing cognitive sequel after brain injury. Banich (13) described executive functioning as action planning towards a goal, flexibility, sequencing, fluency, switching, inhibition, concept formation, estimation, prediction, and maintaining attentional sets. Executive control and inhibition develops during early adulthood and declines during aging. Such cognitive functions are responsible for the management of more than one language and in the language processing of bilinguals (14, 15, 16, 17, 18, 19).

Recent studies have demonstrated that cognitive reserve serves as an important moderator in the correlation between brain damage and clinical performance (20). Extensive research suggests that bilingualism acts as an important protective factor (cognitive reserve), delaying the manifestation of the symptoms of Alzheimer's disease (15, 16, 20, 21, 22). According to this, the increased requirement of managing two languages seems to modify the clinical effects of brain damage (20). However, research has focused on two main issues, neurodegenerative diseases and bilingual aphasia. Up until now, only a small number of available studies have looked at the possible effects of bilingualism in children after sustaining a TBI. Given the high incidence of pediatric TBI, it is imperative to assess possible protective factors.

The main purpose of the current research study was to evaluate the difference between bilingual speakers and monolingual children who have sustained a TBI and their performance on measures of executive functioning. These results could be used to evaluate expected outcomes after brain injury and add information to the literature in an attempt to provide children with appropriate measures and remediation after a TBI.

Based on the available scientific data presented above, the current study proposes three hypotheses:

1. It is hypothesized that age would be a contributor to performance on executive functioning tasks among the TBI and control groups.
2. It was hypothesized that neurocognitive performance on measures of executive functioning would be lower for the TBI group as compared to the control group.
3. It was hypothesized that neurocognitive performance on measures of executive functioning would be lower for monolinguals as compared to bilingual peers.

Methodology

Archival data consisted of comprehensive neuropsychological testing completed at Jackson Memorial Hospital Pediatric Neuropsychology Outpatient Clinic. Data collection also included demographic information such as age, gender, grade level, educational status, ethnicity, family demographics, and dominant language, as well as related medical condition and diagnosis.

Participants

The total sample consisted of 48 children with a mean age of 14 (SD = 2.1) and ranged from 8 to 17 years old. Of those subjects, 56% was male and 44% was female. The range of education (in years) was 3 to 12 years. The sample's ethnicity consisted of Hispanic/Latino (49%), African American/Black (25%), Caucasian/White (14%), and Multiracial (12%). The children each spoke between 1 and 4 languages, with most speaking only 1 language. 26 (54%) spoke only 1 language, 18 (37%) spoke 2 languages, and 4 subjects (9%) spoke more than 2 languages. Of all 48 individuals in the sample, 46 (96%) were tested in the English language. The last two individuals were tested with English and Spanish measures. A list of variables can be found in Table 5-2.

The data consisted of neuropsychological and intellectual measures from 2004 to 2017. Twenty subjects were included in the control group and met the following criteria: 1) medically healthy individuals with no previous history of TBI; 2) subjects who were identified as monolingual English speaker or bilingual speaker; and 3) subjects who had completed the D-KEFS and BRIEF measures. Exclusion criteria was based on history of a TBI and diagnosis including Cognitive Disorder NOS, Attention Deficit Hyperactivity Disorder (ADHD), and Anxiety and Related Disorders. Twenty-eight participants were included in the TBI group and met the following criteria: 1) subjects with confirmed moderate to severe TBI; 2) subjects who were identified as monolingual English speaker or bilingual speaker; and 3) subjects who had completed the D-KEFS measure. Due to the variability in presentation, not all subjects completed every subtest of the D-KEFS, and for this reason, some participants have missing scores for certain subtests (Table 5-3). Comorbid psychological or medical conditions were included to allow for greater generalization of this research project (Table 5-4).

Materials

A commonly used measure of executive functions was analyzed in the current study: the Delis-Kaplan Executive Function System (D-KEFS) The D-KEFS (Delis, Kaplan, & Kramer, 2001) is a set of measures that was designed to be used by well-trained clinicians in the comprehensive assessment of verbal and nonverbal executive functions, in both children and adults. The D-KEFS is composed of nine tests that assess a wide spectrum of verbal and nonverbal higher-order cognitive functioning. Each test was designed to be a stand-alone instrument that can be administered separately or together with other D-KEFS tests. For the purpose of this study, only the following tests would be analyzed: Trail Making Test; Verbal Fluency Tests; Design Fluency Tests; Color-Word Interference Test; Twenty Questions Test; and Tower Tests.

Design and methods

IBM SPSS 23.0 was used to obtain descriptive statistics for the control and TBI groups. All analysis were based on a Cronbach's alpha 0.05. The hypotheses were tested using appropriate independent-samples tests, which included t-tests for parametric data and a Mann-Whitney U for non-parametric analysis of data not meeting parametric assumptions to determine whether statistically significant differences existed in executive functioning performance between groups (bilingual and monolingual subjects) on the D-KEFS. Furthermore, age was treated as a continuous variable and was tested for normality.

Table 5-1. Descriptive statistics for the age and education

		N	Minimum	Maximum	Mean	Std. Deviation
Age (months)	Control	20	8	16	11	2.70
	TBI	28	12	17	16	1.64
Education	Control	20	3	11	5	2.45
	TBI	28	4	12	11	2.36

Table 5-2. Frequency statistics for the Control and TBI group

		Control		TBI	
Variable		N	%	N	%
Gender	Male	11	55	16	57
	Female	9	45	12	43
Ethnicity/Race	Caucasian/White	3	15	4	14
	Hispanic/Latino	9	45	14	50
	African American	5	25	7	25
	Multiracial	3	15	3	11
# of Languages Child Speaks	Monolingual	11	55	15	53
	2 Languages	6	30	12	43
	2+ Languages	3	15	1	4
Languages Spoken	English	12	60	16	57
	Spanish-English	6	30	9	32
	Other-English	2	10	3	11
Hand Dominance	Right	18	90	26	93
	Left	2	10	2	7

Note. N = 20 for control group analyses; *N* = 28 for TBI group analyses.

Table 5-3. Frequency statistics for TBI group

Variable		N	%
TBI Severity	Moderate	5	18
	Severe	23	82
	Total	28	
Location of Injury (Imaging Results)	Diffuse Axonal	7	25
	Right Frontal	4	14.3
	Left Frontal	2	7.2
	Right Temporal	3	10.7
	Left Temporal	1	3.5
	Right Parietal	3	10.7
	Multiple Location Right	2	7.2
	Multiple Location Left	2	7.2
	Bilateral Temporal	1	3.5
	Multiple Locations/Hemispheres	3	10.7
Loss of Consciousness	Yes	23	82
	No	4	14
	Unknown	1	4

Table 5-4. Descriptive statistics for control and TBI group

		Control				TBI			
Variable	Monolingual Bilingual	N	Mean	SD	Median	N	Mean	SD	Median
Tower- Total	Monolingual	9	95.8	10.3	90.0	9	92.8	6.67	94.0
	Bilingual	6	95.0	12.6	95.0	8	96.3	17.27	91.3
	Total	15	95.5	10.9	90	17	94.4	12.49	92.8
CW3- Inhibition	Monolingual	9	86.1	19.3	85.0	14	88.9	18.42	90.0
	Bilingual	6	100.8	4.9	102.5	11	78.2	19.91	81.7
	Total	15	92.0	16.7	95	25	84.2	19.46	87.5
CW4- Inhibition/ Switching	Monolingual	10	90.0	13.7	95.0	11	78.6	18.85	83.3
	Bilingual	6	104.2	8.6	105.0	10	77.5	18.89	74.2
	Total	16	95.3	13.7	97.5	21	78.1	18.40	83.3
DF3- Switching	Monolingual	8	96.9	12.2	95.0	12	88.8	15.83	90.0
	Bilingual	5	100.0	7.1	95.0	9	93.9	11.93	97.0
	Total	13	98.1	10.3	95	21	91.0	14.20	92.9
VF1- Letter fluency	Monolingual	11	87.7	15.7	85	13	91.9	18.09	86.7
	Bilingual	6	100.0	18.7	95	11	91.8	9.29	95.0
	Total	17	92.1	17.3	90	24	91.9	14.43	91.7
VF2- Category fluency	Monolingual	10	100.0	17.2	100.0	13	98.5	23.57	93.8
	Bilingual	6	95.0	10.0	95.0	11	88.2	18.20	85.0
	Total	16	98.1	14.7	97.5	24	93.8	21.48	91.0

Table 5-4. Descriptive statistics for control and TBI group (continuation)

		Control				TBI			
Variable	Monolingual Bilingual	N	Mean	SD	Median	N	Mean	SD	Median
VF3-Category switching	Monolingual	7	90.0	7.1	90.0	7	90.0	15.55	91.7
	Bilingual	4	95.0	24.5	95.0	10	90.5	11.41	91.7
	Total	11	91.8	14.7	95	17	90.3	12.81	91.7
TMT2-Number Sequencing	Monolingual	10	101.5	20.3	105.0	14	76.1	16.31	77.5
	Bilingual	6	90.8	16.3	95.0	11	82.3	19.92	78.0
	Total	16	97.5	19.1	100	25	78.8	17.87	76.9
TMT3-Letter Sequencing	Monolingual	10	96.5	17.8	100.0	14	74.6	17.59	76.3
	Bilingual	6	86.7	19.1	92.5	11	74.1	17.29	74.0
	Total	16	92.8	18.3	97.5	25	74.4	17.10	75.0
TMT4-Number-Letter Switching	Monolingual	8	92.5	21.2	85.0	12	83.3	18.75	90.0
	Bilingual	6	80.8	22.2	80.0	11	73.2	16.92	72.5
	Total	14	87.5	21.6	85	23	78.5	18.24	82.0
Twenty- Total	Monolingual	10	93.5	17.3	97.5	12	97.1	14.69	101.0
	Bilingual	5	92.0	16.8	95	11	95.5	16.35	98.3
	Total	15	93.0	16.6	95	23	96.3	15.17	100.0

Note. 1) Tower- Total Achievement Score; 2) Color Word3- Inhibition; 3) Color Word4- Inhibition/Switching; 4) Designfluency3-Switching: Total Correct; 5) Verbal- VF1- Letter fluency: Total Correct; 6) Verbal- VF2- Category fluency: Total Correct; 7) Verbal- VF3-Category switching: total correct responses; 8) TMT2- Number Sequencing; 9) TMT3- Letter Sequencing; 10) TMT4- Number-Letter Switching; and 11) Twenty Total Weighted Achievement Score.

Hypothesis 1

It is hypothesized that age would be a significant contributor to performance on executive functioning tasks among the TBI and control groups.

Descriptive statistics and results of the statistical tests are shown in Table 5-5. Age was treated as a continuous variable, and was tested for normality. It was found to be normally distributed for both TBI and control groups. The mean age for the TBI group was 192.3 months (*SD* = 18.3), and the median was 197 months. The mean age for the control group was 146.1 months (*SD* = 32.1), and the median was 144 months.

Regression analyses were used to fit models to each outcome variable, with age as a predictor, separately for TBI and control groups. The model-predicted values are plotted against the actual values for each outcome variable, with TBI and control groups presented together.

The models have reasonably good fits to the data. Even so, the R-squared values were relatively poor, with the highest value of 14.7% for Verbal – VF1. This is likely the result of having a smaller sample size. Results indicate that there were no statistically significant associations between the outcome variables and Age.

Hypothesis 2

It was hypothesized that neurocognitive performance on measures of executive functioning will be lower for the TBI group when compared to the control group. Results are compiled into Table 5-6.

Statistical comparisons of mean difference from the control group to those of the TBI group were made for each of the variables in Table 5-4. The results indicated a significant difference between groups for CW4 [t(36)=3.121, p =.003], TMT 2 [t(40)=3.175, p =.003], and TMT 3 [t(40)=3.259, p =.002]. In each instance, the mean difference between the control and TBI groups was 17 points or higher in the control group.

Table 5-5. Regression Models and Statistical Tests for outcome measures by age (months)

Age	Descriptive Statistics						Inferential Statistics					
	Control			TBI			Control			TBI		
Variable	N	Mean	SD	N	Mean	SD	F	df	P-Value	F	df	P-Value
Tower- Total	15	95.5	10.9	17	94.4	12.5	0.001	14	0.972	0.135	16	0.718
CW3- Inhibition	15	92.0	16.7	25	84.2	19.5	0.955	14	0.346	0.033	24	0.857
CW4- Inhibition/Switching	16	93.3	13.7	21	78.1	18.4	0.078	15	0.784	0.208	22	0.653
DF3- Switching	13	98.1	10.3	21	91.0	14.2	0.597	12	0.456	0.037	20	0.849
VF1- Letter fluency	17	92.1	17.3	24	91.9	14.4	2.420	16	0.141	3.781	23	0.065
VF2- Category fluency	16	98.1	14.7	24	93.8	21.5	1.507	15	0.240	0.766	23	0.391
VF3-Category switching	11	91.8	14.7	17	90.3	12.8	0.401	10	0.543	0.568	16	0.463
TMT2-Number Sequencing	16	97.5	19.1	25	78.8	17.9	0.131	15	0.723	3.284	24	0.083
TMT3-Letter Sequencing	16	92.8	18.3	25	74.4	17.1	0.632	15	0.440	1.468	24	0.238
TMT4-Number-Letter Switching	14	87.5	21.6	23	78.5	18.2	0.302	13	0.592	0.208	22	0.653
Twenty- Total	15	93.0	16.6	23	96.3	15.2	1.469	14	0.247	0.002	22	0.963

Note. * = $p \le .05$; 1) Tower- Total Achievement Score; 2) Color Word3- Inhibition; 3) Color Word4- Inhibition/Switching; 4) Designfluency3- Switching: Total Correct; 5) Verbal- VF1- Letter fluency: Total Correct; 6) Verbal- VF2- Category fluency: Total Correct; 7) Verbal- VF3- Category switching: total correct responses; 8) TMT2- Number Sequencing; 9) TMT3- Letter Sequencing; 10) TMT4- Number-Letter Switching; and 11) Twenty Total Weighted Achievement Score.

Table 5-6. Statistical comparison of neurocognitive performance on measures of executive functioning for the control and TBI groups

Variable	Df	t	p	Mean difference (control – TBI)
Tower- Total Achievement Score	31	0.253	0.802	1.05
Color Word3- Inhibition	39	1.291	0.204	7.80
Color Word4- Inhibition/Switching	**36**	**3.121**	**0.003***	**17.22**
Designfluency3- Switching: Total Correct	33	1.565	0.127	7.12
Verbal- VF1- Letter fluency: Total Correct	40	0.037	0.971	0.18
Verbal- VF2- Category fluency: Total Correct	39	0.710	0.482	4.38
Verbal- VF3- Category switching: total correct responses	27	0.290	0.774	1.52
TMT2- Number Sequencing	**40**	**3.175**	**0.003***	**18.70**
TMT3- Letter Sequencing	**40**	**3.259**	**0.002***	**18.41**
TMT4- Number-Letter Switching	36	1.358	0.183	9.02
Twenty Total Weighted Achievement Score	37	0.633	0.531	-3.30

Note. * = $p \le .05$

Hypothesis 3

It was hypothesized that neurocognitive performance on measures of executive functioning will be lower for monolinguals as compared to bilingual peers. Descriptive statistics and results of the statistical tests are shown in Table 5-7.

Color Word 4 – Inhibition/Switching The data for this variable were tested for normality and found to be non-normally distributed. A Mann-Whitney U test was used to compare monolingual children to bilingual children. There were found to be statistically significant results for the control group (Mann Whitney U = 11, n_1=10, n_2=6, p=0.044), but not for the TBI group (Mann Whitney U = 54, n_1=11, n_2=10, p=0.968). This indicates that the Color Word 4 score representing inhibition/switching was affected by the TBI, such that mono- and bi-lingual children did not differ in the TBI group, whereas mono- and bi-lingual children significantly differed in the control group.

There were found to be no statistically significant results for the rest of the variables for either the control group or TBI group.

Table 5-7. Statistical tests for hypotheses

			Control Group			TBI Group		
Variable	Mono- or Bilingual	Statistical Test	Test Statistic	df	P-Value	Test Statistic	df	P-Value
Tower- Total	Monolingual Bilingual	Mann Whitney U	Z-score 0.177 U=25	n1,n2=9,6 U=32.5	0.857	Z-score 0.289	n1,n2=9,8	0.772
CW3-Inhibition	Monolingual Bilingual	t-test	t -1.806	13	0.094	t 1.398	23	0.175
CW4-Inhibition/Switching	Monolingual **Bilingual**	Mann Whitney U	Z-score **-2.007** U=11	**n1,n2=10,6** U=54	**0.04*4**	Z-score **0.035**	**n1,n2=11,10**	**0.968**
DF3-Switching:	Monolingual Bilingual	t-test	t -0.515	11	0.617	t -0.814	19	0.426
VF1- Letter fluency	Monolingual Bilingual	Mann Whitney U	Z-score -1.106 U=21.5	n1,n2=11,6 U=64	0.267	Z-score -0.406	n1,n2=13, 11	0.682
VF2-Category fluency	Monolingual Bilingual	t-test	t 0.645	14	0.529	t 1.178	22	0.251
VF3-Category switching	Monolingual Bilingual	t-test	t -0.522	9	0.614	t -0.077	15	0.940
TMT2-Number Sequencing	Monolingual Bilingual	t-test	t 1.090	14	0.294	t -0.856	23	0.401
TMT3-Letter Sequencing	Monolingual Bilingual	t-test	t 1.041	14	0.316	t 0.078	23	0.938

Table 5-7. Statistical tests for hypotheses

			Control Group			TBI Group		
Variable	Mono- or Bilingual	Statistical Test	Test Statistic	df	P-Value	Test Statistic	df	P-Value
TMT4- Number-Letter Switching	Monolingual Bilingual	t-test	t 0.998	12	0.338	t 1.358	21	0.189
Twenty-Total	Monolingual Bilingual	Mann Whitney U	Z-Score 0.122 U=23.5	n1,n2=10,5 U=63	0.904	Z-Score 0.154	n1,n2=12, 11	0.880

Note. * = *p* ≤ .05; 1) Tower- Total Achievement Score; 2) Color Word3- Inhibition; 3) Color Word4- Inhibition/Switching; 4) Designfluency3- Switching: Total Correct; 5) Verbal- VF1- Letter fluency: Total Correct; 6) Verbal- VF2- Category fluency: Total Correct; 7) Verbal- VF3- Category switching: total correct responses; 8) TMT2- Number Sequencing; 9) TMT3- Letter Sequencing; 10) TMT4- Number-Letter Switching; and 11) Twenty Total Weighted Achievement Score.

Discussion

Based on the understood relationship between age and neurocognitive performance, it was hypothesized that age would be a significant contributor to executive functioning among the current TBI sample. Research has previously suggested that bilingualism promotes the integrity of white and grey matter in elderly individuals, increasing their cognitive reserve abilities (20, 21). However, due to the practice effect, the bilingual advantage has been found to be stronger in older adults as opposed to younger bilinguals. Contrary to what research suggests, this study did not generate significant results. A plausible explanation for these surprising results could be related to the older age of the participants of this study and the small sample size. Given these characteristics, the current finding might not be generalizable to the general population.

The main purpose of the current research investigation was to evaluate the difference between bilingual speakers and monolingual children who have sustained a TBI and their performance on two measures of executive functioning. It was hypothesized that neurocognitive performance on measures of executive functioning would be lower for the TBI group as compared to the control group. Supporting this hypothesis, results of the current study revealed that within the current population examined, there was a clinically significant difference in certain measures of executive functioning between patients with a TBI, as compared to those without a TBI. Explicitly, clinically significant differences were found in three verbal and non-verbal subtests of the DKEFS. The results of this study, demonstrated that the control group had higher scores as compared to the TBI group. Tavano, et al., (6) suggested that the frontal lobe's higher order abilities seem to be a common cognitive sequel after a brain injury. Commensurate, this study found that the mean of a measure of verbal inhibition and switching was 17 points higher, while the mean of two tasks of non-verbal sequencing was 18 points higher. These results demonstrate children's higher order functioning abilities were significantly impacted by a TBI. These results are consistent with previous research demonstrating that TBI is most likely to involve frontal and temporal brain areas which are the last to prune (7).

The current study was particularly interested in examining the impact of TBI on a bilingual versus a monolingual brain. For this reason, it was also hypothesized that neurocognitive performance on measures of executive functioning will be lower for monolinguals as compared to bilingual peers. Partially supporting hypothesis III, this study found a clinically significant difference in the control group, in which bilingual children outperformed monolinguals in the scores for the DKEFS

Color Word 4 – Inhibition/Switching, a measure of verbal executive functioning. The Color Word 4 task is believed to be a measure of both mental flexibility and the ability to inhibit a dominant response. Researchers propose this is a skill that bilinguals actively practice when switching/inhibiting a second language (16, 17).

Not surprisingly, the Stroop Task, which is similar to the DKEFS Color Word 4 – Inhibition/Switching subtest of the DKEFS, have been used multiple times in research to compare executive functioning of monolinguals versus bilinguals.

Wang, et. al. (23) explains:

> Stroop effect is a combined result of cognitive control and word recognition suggests that the reduction of the Stroop effect in bilinguals is caused not only by their enhanced cognitive control (Bialystok et al., 2008), but also by their delayed word recognition. Bilinguals enjoy better cognitive control than monolinguals, which helps to better inhibit the interference of the irrelevant lexical semantic information from the printed word and in turn to reduce the Stroop interference. In addition, as bilinguals have slower word recognition than monolinguals due to their reduced frequency of use in either of their languages (e.g., Gollan et al., 2008), the recognition of the irrelevant word should be delayed, leading to a further reduction of the Stroop effect. (p. 99)

Bialystok (16) concluded that the most consistent finding about the neurocognitive advantage of bilingual children is the favorable selective attention and inhibition. Putting this evidence together, might explain why bilinguals outperformed monolinguals in a verbal task of inhibition and switching and why that advantage was not seen in other non-verbal measures that are commonly used, such as the DKEFS Trails and Tower. Trails test is a measure of switching rather than inhibition. Also, it does not have a verbal component, on the other hand, the Tower test measures organization and planning. These findings suggest that Color Word 4 is the measure that best captures the bilingual advantage, as it includes inhibition of irrelevant information, as well as it requires word recognition. This finding has important implication for neuropsychological work with bilingual populations. The results of this study implicate that the DKEFS Color Word 4 – Inhibition/Switching subtest should be included in neuropsychological batteries used with bilinguals.

This study did not find significant differences in any of the verbal measures of executive functioning. Previous research has shown that bilinguals have slower responding and that the verbal abilities of bilinguals are deficient in both languages when compared to monolinguals (24). Lauchlan (25) found that the effortful steps required for word searching among a massive vocabulary bank (accumulative vocabulary of the two languages) might explain stammering, as inhibitory control is not fully developed in the early stages of language development, which in the current study, was expected to impact the performance of bilingual children in the Verbal Fluency subtests as measured by the DKEFS.

A significant finding from the current study was the lack of evidence to support that bilingualism acts as a protective factor after a TBI. These results suggest that bilingual children without a TBI history may benefit from being bilinguals, whereas that advantage was not found for bilingual children after sustaining a TBI. Research has found that cognitive sequels of a TBI are correlated with the current developmental stage. The results of this study might be explained by the development of the brain. The frontal lobe, the part of the brain responsible for higher-order cognitions, is not fully developed in children. Thus, after sustaining a TBI the frontal lobe might fail to undergo the expected pruning and myelination (7). Pruning is characterized by the loss of grey matter volume, which in turn, is correlated with the development of complex cognitive abilities, such as executive control (7). Previous research and this current study concur in that damage to less mature regions of the brain (such as the frontal lobe) is likely to produce life long difficulties in cognitive functions and emotional control (7), that counteracts with the bilingual advantage observed in the control group. As opposed to children, bilingual adults have been found to able to endure higher brain damage before cognitive functioning impairment, as opposed to those with lower cognitive reserve (monolinguals) (20). Other than brain development, this contrast might also be related to adults having the opportunity to practice being bilinguals for a longer time. Luo, L., Luk, G. & Bialystok, E. (26) suggested that longer duration of bilingualism is associated with the bilingual advantage.

In conclusion, bilinguals without a TBI demonstrated a significant advantage in a verbal task of inhibition and switching. Overall results demonstrate children's higher order functioning abilities are significantly impacted by a TBI. Interestingly, bilingual children seem to be at an increased risk of executive functioning impairments after a TBI. This could be the result of a newly acquired skill and the damage to a less mature region of the brain. For this reason, bilingual children who are in the process of acquiring a new skill (a second language), might fail to benefit from the "advantage" of being bilingual if they sustain a TBI and may have more deficits when compared to monolingual children.

Limitations of the study

In general, the TBI group had older subjects, which contrary to what it is suggested, should demonstrate improved executive functioning abilities. However, a very important factor that was not possible to be analyzed with this sample is the age of injury, which was not available in the archival data. One of the most salient limitations to the current study was the sample size. As only 48 children were included in this study, a larger sample size would increase the power to the statistical analysis. Another limitation of the study was that the population examined was a clinical sample. Although certain measures were put in place, such as including a control group, results obtained may not generalize to a non-clinical population. Additionally, there was a variety of conditions/diagnoses within the disorders included in the sample, due to the overall characteristics of the clinical group. Research has found that certain disorders, such as ADHD, have an impact on the performance of executive functioning measures. In this study, certain subjects in the TBI group had a diagnosis of ADHD, which was used as an exclusion criterion for subjects in the control group. Even though the control group that was included was meant to help understand the difference between monolingual and bilingual children with and without a TBI, given the clinical characteristics of this sample and the differences in demographics (e.g. educational level, age), it is believed to be a weakness of this present study and not a good representation of these differences.

Additionally, the bilingual group was considered to be heterogeneous as some subjects spoke more than two languages. Although it was not possible in this study due to the small sample size, it would be interesting to divide the groups by monolingual, bilingual, and multilingual. Moreover, proficiency level was not taken into consideration for the current study. This limitation was based on available measures to assess for language proficiency. Although some subject did complete the Woodcock Johnson Oral Language, not all subjects included in this study had completed the measure. It is well known that language proficiency, that which is self reported and that is reported by parents, might be inaccurate during neuropsychological evaluations. However, to the best of the licensed clinical neuropsychologist knowledge, reported language proficiency was accurate.

Future recommendations

The inconsistent results found could be further investigated by controlling for the age of injury. It is well known that young brains might be vulnerable to more severe and enduring deficits as new abilities are emerging. Additionally, skills established at one stage form the foundation for later-developing abilities. Based on this, if a child has a brain injury at a younger age, the higher order cognitions might not developed to its fullest, as opposed to a brain injury at a later stage of development. Since this study is among the first to examine executive functioning in a monolingual and bilingual clinical population, future research should examine a larger sample size and attempt to compare bilinguals versus multilingual with both clinical and non-clinical populations. It would be extremely valuable in the future to compare the executive functioning performance between balanced versus unbalanced bilinguals, as well as explore the differences and similarities between the languages spoken by the sample. Careful consideration should be taken when considering the clinical implications of these results, as the performance on standardized tests differs between Caucasians and individuals from other ethnicities.

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