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FREQUÊNCIA DE DÉFICITS NEUROPSICOLÓGICOS APÓS TRAUMATISMO CRANIOENCEFÁLICO

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Resumo

O traumatismo cranioencefálico (TCE) pode acarretar mudanças no cotidiano e prejuízos social, laboral, comunicativo e cognitivo (dificuldades atencionais, mnemônicas e executivas). Este estudo buscou caracterizar a ocorrência de déficits neuropsicológicos após o TCE em uma amostra de adultos e verificar se há impacto do nível de severidade do trauma no desempenho cognitivo dos pacientes. Participaram 96 adultos, divididos em dois grupos: TCE leve (n=39) e grave (n=57). A gravidade do trauma foi classificada pela Escala de Coma de Glasgow, pela duração da perda de consciência, ou pela amnésia pós-traumática. Não houve diferença nas variáveis sociodemográficas idade e escolaridade entre os grupos. Para a comparação entre grupos quanto a ocorrência de déficits neuropsicológicos, utilizou-se o Qui-quadrado. Tarefas verbais e visuoespaciais de funções executivas, habilidades linguísticas, mnemônicas verbais compuseram uma bateria neuropsicológica flexível.Os pacientes com TCE leve tiveram menos déficits comparados aos com TCE grave (erros e categorias completadas do Wisconsin Teste de Classificação de Cartas; erros da parte B do Teste Hayling; e na interferência pró e retroativa do teste de aprendizagem verbal de Rey). A severidade do trauma parece diferenciar indivíduos no desempenho de memória episódica no contexto de maior sobrecarga de informações novas e no controle da interferência entre memórias; o mesmo se aplica às funções de flexibilidade e inibição. Faz-se necessário um maior investimento em ações de políticas públicas de saúde, priorizando intervenção neurognitiva remediativa e métodos de prevenção para acidentes relacionados a lesões traumáticas com alta ocorrência de sequelas.
Palavras-chave: traumatismo cranioencefálico, neuropsicologia, avaliação neuropsicológica, disfunção executiva.

FREQUENCY OF NEUROLOPSYCHOLOGICAL DEFICITS AFTER TRAUMATIC BRAIN INJURY

Abstract

Traumatic brain injury (TBI) can lead to significant changes in daily life, as well as in social, labor, communicative, and cognitive domains (attention, memory and executive functions). This study aimed to characterize the occurrence of post-TBI neuropsychological deficits as well as to determine whether there is an impact related to the level of severity of the trauma on the patient's performance. Ninety-six adults participated in the study, who were divided in two groups to assess the trauma's level of severity: mild TBI (n=39) and severe TBI (n=57). This severity was classified by the Glasgow Coma Scale, by the duration of consciousness loss, or by post-traumatic amnesia. There were no differences between the groups regarding variables of age and years of schooling. A Chi- square test was used to do a comparison between the two groups in terms of occurrence of neuropsychological deficits. Verbal, visuospatial, mnemonic, linguistic and executive tests composed a flexible neuropsychological battery. Patients with mild TBI had better scores compared to those with severe TBI (number of errors and in completed categories of the Modified Wisconsin Card Sorting Test (MWCST); errors in Part B of The Hayling Test; and proactive and retroactive interference in the Rey Auditory Verbal Learning Test (RAVLT). The severity of the trauma seems to differentiate individual's performance on episodic memory of new information and in the control of interference between memories; the same is applied to flexibility and inhibition functions. These results suggest the need for more investments in public health policy actions, prioritizing neurocognitive remedial intervention and prevention methods for such condition with high incidence of sequelae.
Key words: traumatic brain injury, neuropsychology, neuropsychological assessment, executive dysfunction

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FRECUENCIA DE DÉFICITS NEUROPSICOLÓGICOS POSTERIORES A LESIÓN CEREBRAL TRAUMÁTICA

Resumen

El traumatismo craneoencefálico (TCE) puede conllevar impactantes cambios en la vida cotidiana, que incluyen alteraciones a nivel social, profesional, comunicativo y cognitivo (dificultades atencionales, mnemónicas y ejecutivas). Este estudio tuvo por objeto caracterizar la ocurrencia de déficits neuropsicológicos post-TCE y constatar el impacto ocasionado por el nivel de severidad del trauma en el desempeño cognitivo de los pacientes. Participaron 96 adultos en la muestra total, que fue dividida en dos grupos para evaluar el nivel de severidad del trauma: TCE leve (n=39) y TCE grave (n=77). La gravedad de la lesión se clasificó por medio de la Escala de Coma de Glasgow, por la duración de la pérdida de consciencia, o por la amnesia post-traumática. No había diferencias entre la edad y la escolaridad de los participantes. Para la comparación entre los grupos en cuanto a la distribución de ocurrencia de déficits neuropsicológicos, se utilizó el Chi-cuadrado. Se utilizó una batería de evaluación neuropsicológica flexible conformada por tareas verbales y visoespaciales de habilidades lingüísticas, mnemónicas y ejecutivas. Los grupos no se diferenciaron en cuanto a las variables sociodemográficas. Los pacientes con TCE leve tuvieron mejores puntajes comparados con los de TCE grave (número de errores y categorías completadas del Test de clasificación de tarjetas de Wisconsin- [WCST, por sus siglas en inglés]; errores en la parte B del Test de Hayling; y en la interferencia retro y proactiva del Test de aprendizaje auditivo verbal de Rey [RAVLT, por sus siglas en inglés]. El nivel de severidad del trauma parece mostrar diferencias en los individuos en cuanto al desempeño en memoria episódica de información nueva y en el control de interferencia entre los recuerdos; lo mismo se aplica a las funciones de flexibilidad e inhibición. Estos resultados sugieren que es necesaria una mayor inversión en acciones de políticas públicas, priorizando intervenciones neurocognitivas reeducativas y métodos de prevención de accidentes relacionados con lesiones traumáticas que tengan alta incidencia de secuelas.
Palabras clave: lesión cerebral traumática, neuropsicología, evaluación neuropsicológica

INTRODUCTION

Traumatic brain injury (TBI) is a neurological condition that often occurs in adults with age lower than 50 years. Also, it causes cognitive impairments with significant impact on daily life, on relationships, study, work and leisure activities, (Chabok et al., 2012; Draper, Ponsford & Schönberger, 2007; Mathias, Harman-Smith, Bowden, Rosenfeld & Bigler, 2014; Podell Gifford, Bougakov & Goldberg, 2010; Tashlykov et al, 2007). In the United States, there is an estimation that around 500 thousand new cases of deaths per year are due to TBI. Similarly, Latin America replicates the epidemiological data from North America, with estimates of 31% of deaths. From patients that survive, at least 54% present neurological damage of greater or minor severity (Roozenbeek Maas & Menon, 2013). In the city of São Paulo, Brazil, young adult men have the highest rates of hospitalization (Silva, Brazil, Bonilha, Masson & Ferreira, 2008). Therefore, TBI is not only a public health problem for developed and underdeveloped countries, but also a socio-economic reason for concern (Bener, Omar Ahmad Al-Mulla, & Abdul Rahman, 2010; Roozenbeek et al, 2013).

Regarding assessment and intervention after a TBI, the neuropsychological approach contributes by aiding in the diagnosis and prognosis of cognitive and behavioral disorders of neurological origin. The neuropsychological assessment works as a set of complex and rigorous methods to characterize the cognitive profile of people after having suffered brain injury such as TBI (Fonseca, Zimmermann & Kochhann, 2015; Podell et al., 2010). Many studies identify cognitive deficits by comparing performance between groups of TBI patients and controls. These studies present results of several cognitive components assessed through the batteries comparing TBI and controls (Gaines, Soper & Berenji, 2016; Marsh, Ludbrook & Gaffaney, 2016) or by more specific tests to asses specific cognitive components, such as memory systems (Russell, Arenth, Scanlon, Kessler & Ricker, 2011) and language (Marini, Zettin & Galetto, 2014). Also, several studies compared the effect of different levels of severity of TBI on cognitive functioning (Aragón, Arango-Lasprilla, Bartolomé, Fernández & Krch, 2012; Channon & Watts, 2003; Jurado, Mataro, Verger, Bartumeus & Junque, 2000; Perlstein et al., 2004; Spitz et al., 2013). However, few studies have investigated cognitive performance profiles delineated by standard scores from normative data sets in different cognitive components, as mnemonic, attentional (Zimmermann et al., 2014) and executive tasks (Anderson & Knight, 2010; Clune-Ryberg et al., 2011; Fonseca et al., 2012). The frequency of cognitive deficits is relevant to the neuropsychological characterization of the conditions (mild and severe) as well as to the advance of scientific and clinical knowledge regarding cognitive assessment and rehabilitation. A recent study from Israel found that 87% of patients of a chronic TBI sample showed impaired performance on scores of semantic verbal fluency and 70% in phonemic-orthographic verbal fluency (Kave, Heled, Vakil & Agranov, 2011). Demery Larson, Dixit, Bauer & Perlstein (2010) found that 54% of a moderate to severe TBI sample performed as expected on concentrated attention tasks, cognitive flexibility and working memory; 38% of those same patients had adequate performance on Part A of the Trails Making Test (TMT) and 27% had an adequate performance on Part B of TMT. Furthermore, 65% of these same patients performed well on a Digit Span task (indirect order).

A recent Brazilian study evaluated a sample of 12 patients with TBI (mild to moderate) and found the following frequency of severe deficits on several tasks: verbal episodic memory (50 to 100%); visuospatial episodic memory (50%); short-term memory (0%); nomination (50%); executive functions (25% to 50%); intellectual functions (25%) and visual perception functions (25%) (Miotto et al., 2010). Therefore, this study showed evidences that the most frequent deficits were in episodic memory and executive functions. However, it was a descriptive study, investigating the role of clinical factors such as local and lateral injury in the event of neurocognitive sequelae.

In Latin America, as far as it is known, there is a limited amount of descriptive studies on cognitive profiles of TBI patients. Together with that, there is a lack of studies that verify the impact of the severity level (mild and severe) on these cognitive profiles. Therefore, the objective of this study was to (1) verify the frequency of deficits post-TBI in the following verbal and nonverbal cognitive components: concentrated and alternated attention, semantic, recent and working memory, cognitive flexibility, selection and maintenance of successful strategies, inhibition, planning, processing speed, and initiative capacity; (2) investigate whether there are differences in the frequency of deficits in mild TBI patients versus severe TBI patients. Such knowledge is particularly important for public and private health care systems to promote initiatives so patients and their families can be properly oriented and reintegrated into society.

METHOD

Sample

In a first moment, an initial screening was conducted via hospital records, which was followed by contact via telephone in order to verify or confirm whether they met the following inclusion criteria: (a) being over 18 years old, (b) having been diagnosed with mild or severe TBI, classified according to: Glasgow Coma Scale (Teasdale & Jennett, 1974), assigned at the time of hospital admission (from medical records); self-report of the duration of loss of consciousness (less than 30 minutes – mild; 30 minutes to 24 hours – moderate; more than 24 hours - severe); self-report of the duration of post-traumatic amnesia (less than 24 hours - mild; one a to seven days – moderate; more than seven days - severe) (Iverson & Lange, 2011); (c) having no previous history of other neurological diseases (stroke, prior TBI, pre-morbid epilepsy), according to information from medical records, or in the lack of this one, from self-report; and (d) having suffered a non-penetrating TBI, without loss of brain tissue.

Finally, participants were excluded if they (a) were illiterate or had less than 4 years of formal schooling; (b) were unable to be subjected to formal cognitive assessment due to medical reasons (excessive sleepiness, bedridden patients or patients with uncontrolled acute pain, for example); (c) presented non-corrected sensory, auditory or motor limitations, and / or (d) had history of substance abuse. It was decided to include patients with psychiatric disorders pre and post-TBI, due to the high incidence of this condition in the TBI population (Mainland, 2010).

The flow of the clinical group of patients in this study occurred in the following way: 2.901 records were investigated, of which 1,694 did not meet some criterion for inclusion, leaving just 1.207 (100%) patients who would be contacted to participate in the research; of those, 504 (41.76%) had invalid or incorrect phone numbers, or it was not possible to talk with the patient at any time of the research; 372 (30.82%) patients died after hospital discharge; 78 (6.46%) patients refused to participate in the study after a brief telephone explanation; 98 agreed to participate but did not attend the first session of assessment and 18 (1.49%) patients discontinued the evaluation process after signing the informed consent. Thus, 137 (11.35%) patients were entered into the database. However, 41 individuals were excluded from this analysis for not having performed all the tasks described in this study.

Thus, 96 adults who suffered TBI without loss or extravasation of brain mass) participated in this study, in which 39 patients had a mild TBI and 57 had a severe TBI. The gender distribution was n=22 female participants and n=74 males. Table 1 shows the demographic data and the comparison between groups regarding these variables. The groups did not differ among themselves when compared. As for the clinical parameters of the group of patients, 96 TBI showed: Glasgow coma scale ranging from 3 to 15 points (mild and severe TBI groups) with mean and standard deviation of 13.00 (3.88). The patients' post-injury time was between 1 and 263 months with an average of 22.00 (32.75). As for injury lateralization, according to data from medical records, 15.6% (15) of the patients had the injury on the right hemisphere; 16.7% (16) on the left hemisphere, 24.0% (23) had bilateral lesion and 32.3% (31) did not have an identified parenchymal injury or there was insufficient information in the clinical record for it to be classified. Neuroimaging reports were obtained in 90.5% of the cases through CT scans still held at the time of hospitalization.

Finally, the distribution of the presence of brain lesion by site was: occipital lobe 3.1% (3); frontal lobe 33.3% (32); temporal lobe 26.0% (25); 6.3% parietal lobe (6); cerebellar 5.2% (5); diffuse axonal injury 5.2% (5); contusion 12.5% (12); epidural hemorrhage 8.3% (8); subdural 27.1% (26); arachnoid 30.2% (29). Furthermore, the presence of cranial fractures 25.0% (24) or sinking of the skull 7.3% (7). From this sample, 4.2% (4) of the patients passed by hematoma drainage procedures; 10.4% (10) decompressive craniotomy and, finally, 1.0% (1) ventricular cerebrospinal fluid drainage.

Instruments

All participants were examined by a flexible neuropsychological battery composed of tasks assessing executive function (EF) and a gold standard task for assessment of language skills and episodic memory. The instruments used are described below; it is important to highlight that some of them had been used in a case study of traumatic brain injury carried out previously (Pereira, Pereira, Rebouças, & Zimmermann, 2012).

Socio cultural, medical and neuropsychological data questionnaire for traumatic brain injury (TBI) (Zimmermann, Rebolledo & Fonseca, n.d.). It investigates age, years of formal education, handedness (Oldfield, 1971; Brito, Brito, Paumgartten & Lins, 1989), socioeconomic level (Brazilian Association Research Companies - ABEP, 2008), among other sociodemographic data. In addition, it inquired about health conditions that may influence the evaluation results, such as the presence of neurological, psychiatric, heart disease, vision, hearing or motor problems, alcoholism and use of psychoactive drugs. Also, the frequency of reading and writing habits pre-injury and post-injury (Pawlowski et al., 2012) and data on severity of the injury and neuroimaging results were collected. Finally, it included open questions regarding attention, memory and executive functions as well as questions that allow exploring whether there were complaints characteristic of retrograde and/or anterograde post-traumatic amnesia.

The *Modified Wisconsin Card Sorting Test (MWCST)* (adapted by Nelson, 1976, and standardized by Zimmermann, Cardoso, Trentini, Grassi-Oliveira & Fonseca, 2015). It is an instrument consisting of 48 cards which aims to assess cognitive flexibility, maintenance of successful strategies, inhibition, and planning. This test consists of a deck of cards with different geometric shapes, colors and numbers, in which the participant must find rules of combination of cards. The first category is freely chosen by the participant. The classification rules change every six correct answers, being informed by the evaluator when there is a change of category. The standard rules shall be deduced by the participant through the feedback given by the evaluator. In this test, perseveration errors, non-perseveration errors, ruptures and completed categories are assessed.

The *Hayling Test* (Burgess & Shallice, 1996, adapted and standardized by Fonseca, Oliveira, Gindri, Zimmermann & Reppold, 2010) aims to evaluate the inhibition and planning verbal components, concentrated attention and process speed. The participant is asked to complete, in the fastest possible way, a number of sentences which are missing the last word. In part A of the test, the word must

Table 1.
Sociodemographic characteristics for the total sample and by severity group

Variable	Mild TBI M (SD) (N=39)	SevereTBI M (SD) (N=57)	Total Sample	p*
Patient's age in years	37,92 (15,47)	35,63 (14,49)	36,56 (14,85)	0,53
Years of formal study	10,00 (3,73)	9,70 (3,92)	9,82 (3,82)	0,46
Socioeconomic level	23,64 (6,93)	22,46 (6,36)	22,95 (6,58)	0,38
FRWH* post-TBI	10,79 (5,50)	9,93 (6,02)	10,28 (5,79)	0,26
FRWH* pre-TBI	11,37 (5,24)	10,82 (6,02)	11,04 (5,68)	0,43

Note. Significance was considered if p≤0,05; FHLE: Frequency of Reading and Writing Habits complete the sense of the phrase; in part B, the sentence must be completed with a word that has not relation to the context of the sentence. Errors and time in part A, and quantitative and qualitative errors, as well as time in part B are evaluated.

The subtests of *Verbal Fluencies of the Montreal Battery Communication Evaluation (MAC)* (Fonseca, Parente, Cote, Ska & Joanette, 2008; Joanette, Coté & Ska, 2004) has as objective to evaluate the initiation, inhibition and verbal planning capacity, selection strategies, memory and lexical-semantic language. In the semantic verbal fluency task (SVF) the patient is asked to evoke the highest possible number of words regarding clothes or garments for two minutes. In the phonemic-orthographic verbal fluency task (PVF), the participant must evoke, for a period of two minutes, the highest possible number of words beginning with the letter P that are not names or surnames. The total number of correct words evoked is recorded.

The *Trail Making Test (TMT)* (Army Individual Test Battery, 1944, adapted and standardized by Fonseca et al., unpublished manuscript) aims to investigate the processing speed, inhibition, alternated attention, and cognitive flexibility. In this test, the participant is required to connect numbers distributed on an A4 sheet in Part A and switch the connection of numbers and letters in Part B. It records errors and time in part A and successes, errors and time part B.

The *Rey Auditory-Verbal Learning Test (RAVLT) (*Rey, 1958, adapted and standardized by Salgado et al., 2011) aims to assess recent memory, learning, interference, retention and recognition memory. This test consists of a list of 15 words (List A) read five consecutive times by the examiner, followed by a free recall task. After five readings, an interference list is presented, list B, also with 15 words, also followed by free recall. Then the participant is asked to recall what were the words from the A list. After 20 minutes, the memory of the A list is tested again. Finally, the recognition of the A list is made through a list of 50 words containing words from the A list, the B list and also words that did not appear in any of these two lists. The total number of words evoked in each list is recorded, in addition to forgetting speed, proactive interference scores (list B1 /list A1) and retroactive interference (list A6 / A5 list).

The *Auditory Span of Words in Sentences - Brief Neuropsychological Assessment Instrument NEUPSILIN* (Fonseca, Salles & Parente, 2009; Fonseca, Salles & Parente, 2008). It focuses on the evaluation of the working memory, specifically the central executive component. Sentences are presented to the patients for them to repeat them, memorizing the last word of each sentence at the same time. At the end of each sentence the patient is asked to repeat it completely. At the end of each sentence block, the patient is requested to repeat all the memorized words in order.

Procedure

All the steps of this study were explained to the participants and their voluntary participation was confirmed by the signature of the informed consent term (Ethics Committee Nºs 10/05134 and 11-077 and 001.017641.12). The evaluation was conducted in two meetings of 40 minutes each and a third meeting of return was held so all the evaluation results could been given to participants and their families.

Data analyses

Descriptive and inferential analysis was performed using the Statistical Package for Social Sciences (SPSS 20.0). The operating concept of the deficits occurrence was represented in this study by categorizing the scores obtained by each patient as deficient or not, thus generating, *a posteriori,* a percentage of deficits occurrence. This distribution in percentage was compared between groups by means of the Chi-square test. Thus, it was decided to use the Z score since it is the conversion of the raw scores using norms that considered factors such as age and education. Thereby, it becomes possible to make inferences about the frequency distribution in this population. Performance in the Z score ≤-1.5 was considered deficient (Schmidt, 1996; Schoenberg et al., 2006). Then to carry out the comparative distribution between groups, a Chi-square test was performed, considering that it is a test in which data are analyzed by the distribution among frequency groups (or the number of individuals who are in certain categories in a variable). Differences with p ≤0,5 were regarded as significant.

RESULTS

The data of deficits occurrence for the total sample are presented below, from the most frequent to the least frequent, and subsequently, these same frequency data are shown by groups (mild and severe).

The occurrence of deficits in the overall sample and by severity subgroup can be seen in Table 2. Looking at the overall sample, the high rate of patients with deficient performance is highlighted, being the most frequent the RAVLT scores that ranged from 75% to 56.3% such as: retroactive interference (58.3%), a total of 4 (four) correct words of the blocks (56.3%) 5 (five) correct words (66.7%) 6 (six) correct words (75%) and 7(seven) correct words (72.9%). The second task with the highest frequency of deficits was the SVF of the MAC battery with 58.5%.

In contrast, the variables with less frequency of deficits were ruptures in the MWCST (9.4%), time B- time A/time

A (11.5%), and time B/time A (13.5%) and errors part A (14.7%) of TMT. Analyzing the descriptive data, the severe TBI group had high levels of deficits in the RAVLT recall lists, as knowledge A3 (57.9%) and A4 (61.4%), A5 (71.9%), A6 (80.7%) and A7 (78.9%), the quantitative errors of Part B Hayling Test (50.9%) and perseverative errors in the MWCST (49.1%).

For the mild TBI sample, the high frequency of impaired performance in the trials of RAVLT, A3 and A4 (48.7%), A5 (59.0%). A6 (66.7%) and A7 (64.1%), time part B Hayling Test (36.8%), as well as in SFV and time B-time A of Hayling Test (34.2%) is emphasized. With the exception of the proactive interference variable of RAVLT, all the others showed a higher deficit frequency in the severe TBI group than in the mild TBI group.

Finally, the comparison of deficits occurrences by group (mild and severe TBI) indicated significant differences only in the retroactive and proactive interference variables of the RAVLT (See table 2).

Table 2.
Table of deficits occurrence by group

	Mild TBI N (%)	**Severe TBI** N (%)	**Total Sample** N (%)	p*
Modified Wisconsin Card Sorting Test				
Completed categories	8 (20,5%)	22 (38,6%)	30 (31,3%)	0,07
Ruptures	4 (10,3%)	5 (8,8%)	9 (9,4%)	1,00
Non-perseverative errors	3 (7,7%)	12 (21,1%)	40 (41,7%)	0,09
Perseverative errors	12 (30,8%)	28 (49,1%)	15 (15,65%)	0,09
Hayling Test				
Errors part A	8 (20,5%)	15 (26,3%)	23 (24%)	0,62
Time part A	13 (33,3%)	19 (33,3%)	32 (33,3%)	1,00
Quantitative errors part B	12 (31,6%)	29 (50,9%)	41 (43,2%)	0,09
Qualitative errors part B	4 (10,3%)	13 (22,8%)	17 (17,9%)	0,17
Time part B	14 (36,8%)	20 (35,1%)	34 (35,8%)	1,00
Time B – Time A	13 (34,2%)	18 (31,6%)	31 (32,6%)	0,82
Verbal Fluencies of the Montreal Battery Communication Evaluation				
Total Semantic Verbal Fluency	13 (34,2%)	26 (46,4%)	55 (58,5%)	0,28
Total Phonemic-orthographic Verbal Fluency	7 (19,8%)	20 (35,7%)	27 (28,1%)	0,10
Rey Test of Auditory-Verbal Learning (RAVLT)				
Total of correct words list A1	5 (12,8%)	14 (24,6%)	19 (19,8%)	0,19
Total of correct words list A2	14 (35,9%)	25 (43,9%)	39 (40,6%)	0,52
Total of correct words list A3	19 (48,7%)	33 (57,9%)	52 (54,4%)	0,41
Total of correct words list A4	19 (48,7%)	35 (61,4%)	54 (56,3%)	0,29
Total of correct words list A5	23 (59,0%)	41 (71,9%)	64 (66,7%)	0,19
Total of correct words list A6	26 (66,7%)	46 (80,7%)	72 (75,0%)	0,15
Total of correct words list A7	25 (64,1%)	45 (78,9%)	70 (72,9%)	0,16
Total of correct words list B1	14 (35,9%)	24 (42,1%)	38 (39,6%)	0,67
Proactive interference (B1/A1)	9 (23,1%)	3 (5,4%)	12 (12,5%)	**0,02**
Retroactive interference (A6/A5)	16 (41%)	40 (70,2%)	56 (58,3%)	**<0,001**

(Cont. Table 2)

	Mild TBI N (%)	**Severe TBI** N (%)	**Total Sample** N (%)	p*
Trail Making Test				
Errors part A	6 (15,4%)	8 (14,3%)	14 (14,7%)	1,00
Time part A	10 (25,6%)	21 (36,8%)	31 (32,3%)	0,27
Correct part B	3 (10,3%)	10 (21,7%)	13 (13,5%)	0,34
Errors part B	9 (23,1%)	18 (32,1%)	27 (28,1%)	0,36
Time part B	9 (23,1%)	22 (39,3%)	31 (32,3%)	0,12
Time B/Time A	4 (10,3%)	9 (16,1%)	13 (13,5%)	0,54
Time B-Time A/Time A	3 (7,9%)	8 (14,5%)	11 (11,5%)	0,51
Auditory Span of Words in Sentences				
Total score of Span	6(15,4%)	9(15,8%)	15 (15,6%)	1,00
	4(10,3%)	8(14,0%)	12 (12,5%)	0,41

*p≤0,05 is considered significant

DISCUSSION

This study sought to answer two research questions: (1) what is the frequency of cognitive deficits after TBI regarding language and mnemonic skills (prospective, semantic and working memory) and executive (planning, initiation and inhibition, strategy selection, self-monitoring and cognitive flexibility) in verbal and visuospatial tasks? And (2) is there an impact of severity level (mild and severe) of TBI on the occurrence of such deficits? The most common deficits in this general clinical sample occurred in episodic memory (learning new information) (50-65%), initiation, inhibitory control and verbal planning. More specifically, regarding the levels of TBI severity, significant differences were found in the scores that depend on the mediation of executive functions in the consolidation of auditory-verbal learning.

With regard to the findings of the first aim of this study, the higher frequency of cognitive deficits found is higher than the one observed in a study of Skandsen et al. (2010). The authors investigated among some cognitive constructs, processing speed and delayed recall task, and found about 43% of impairment in these abilities when comparing groups with moderate and severe TBI patients and controls. In addition, Rabinowitz and Levin (2014) characterized the difficulty in spontaneous recall of information as the most common in the TBI sample. A previous research by Kave et al. (2011) also identified deficiencies but in a higher frequency than this study in two modes of verbal fluency task.

In relation to the variables with lower frequency of impaired performance in the total sample, the ones that can be highlighted are working memory indexes for successful rules maintenance (MWCST ruptures), proactive interference variables of the RAVLT, executive indices of cognitive flexibility of the TMT (time B minus time A divided by time A, and time B divided by time A) and difficulty in maintaining rules and focused attention (errors of part A of TMT). The variables of the Trail Making Test were also identified as deficient in the study by Skandsen et al. (2010) with an occurrence of 24 to 35 patients.

In addition, the results concerning the second objective of this study suggest that the impact of the level of severity of TBI is discriminative only for RAVLT interference indexes. Patients with moderate/severe TBI showed more deficits than the mild group in maintaining verbal learning after interference. On the other hand, the mild TBI group had more deficits in the variable that measures the ability to tolerate overload of prior learning for encoding new learning, which highlights the poor retention of information while other activities are held, managed or learned. This sample showed a double dissociation, confirming to some degree the distinct nature of the two episodic memory processes studied by Skandsen et al. (2010).

More specifically, concerning the profile of the two severity groups it is hypothesized that the post-injury time variable has been one of the factors for which no more significant differences have been found in this sample. In general, the studies with TBI include patients in the acute stage of injury, or in the chronic stage, with up to two years' duration (Christensen et al., 2008). In this sample, 25.6% of the patients had two years or more post-injury time, which may have balanced difficulties between the two severity groups. Another hypothesis is that there may be an interaction between clinical variables of injury severity and post-injury time with different cognitive functions. In this case, only longitudinal studies could answer this question. It is known in the literature that cognitive difficulties persist after a certain period of occurrence of the brain injury, and that just the severity of the injury is not enough to explain the complex interaction between factors that contribute to neuroplasticity after a TBI.

The heterogeneous distribution of patients' performance, especially when comparing groups, emphasizes that critical thinking about the relationship between injury severity and cognitive dysfunction (classical research paradigm in neuropsychology) does not seem to be the best to explain post-TBI cognitive manifestations. For example, studies intended to investigate difficulties in the Trail Making Test, especially in part B, as a marker for important executive dysfunction associated with frontal damage appear not to be consistent. The authors concluded that regardless of the site of brain injury, TBI patients are susceptible to hold errors in this task and that good performance seems to be associated with an activation network involving frontal regions, non-frontal and subcortical regions commonly affected in TBI patients and present in the same heterogeneous way of this sample (Jacobson, Blanchard, Connolly, Cannon & Garavan, 2011; Zakzanis, Mraz, & Graham, 2005).

Likewise, the important difference in the frequency of deficits between the two modalities of verbal fluency: semantic and phonemic-ortographic may be related to diffuse lesion aspects of TBI, in which there is a reduction in access and retrieval of information in a general manner (Crawford, Knight, & Alsop, 2007; McWilliams & Schmitter-Edgecombe, 2008; Schroeter, Ettrich, Menz, & Zysset, 2010; Yang, Fuller, Khodaparast, & Krawczyk, 2010).

Despite the marginal differences between the groups, deficit performance percentages showed that this population presents some level of executive dysfunction and mnemonic difficulty that must be considered. When evaluating a patient after a TBI, it is necessary to pay attention to the relationship between premorbid variables, clinical and current functional outcome of the patient (whether measured by formal or ecological tasks, when the first ones cannot be used). These results highlight the importance of using tasks with variables that provide the clinical precise information of the neuropsychological profile to an extend in which these deficits may be associated and might be a causal relationship between one deficit and the other (which is understood as a primary deficit that results in a secondary deficit).

In daily life these cognitive deficits are dysfunctions which will be open to complaints from patients and their families, although it is common to find more frequent complaints related to memory and concentration skills, which are considered constructs easily understood by people (Prigatano & Borgaro, 2004). Thus, it is the responsibility of those involved in the health sector to properly evaluate and provide psychoeducation to families and caregivers about the preserved and impaired skills, since planning abilities, flexibility and inhibition are functionally extremely demanding for patients and sometimes can be confused as memory difficulties (Fyock & Hampstead, 2015).

Considering the results of this study, in addition to all the reflections presented here, it is noteworthy that health professionals need to identify the factors that contribute to recovery and are important for social, cognitive and emotional performance (Diamond, 2013). In addition, more actions are needed within a subarea as health neuropsychology that should be focused on community and daily activities, on vocational training of professionals involved in patient recovery (therapists, health workers), as well as in providing help and guidance to caregivers. Hospital and community neuropsychologists can play important roles in prevention, diagnosis and sudden neurological post-onsets interventions, such as TBI. Thus, this study can contribute to provide guidance for neuropsychological observation and assessment of the most typically affected functions of this clinical condition in the Brazilian socio-cultural context. It also presents an actual percentage of patients that is not always served in the public sector, taking into account the need to create public spaces for this specific demand.

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