Cognitive performance in children and adolescents at high-risk for obsessive-compulsive disorder

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Abstract

Background: Cognitive performance has been studied in adults with obsessive-compulsive symptoms (OCS) and in adult relatives of patients with obsessive-compulsive disorder (OCD). Meanwhile, few studies have been conducted with children under the same conditions. This study compared the neurocognitive domains previously associated with dysfunction in OCD, especially visuoconstructive ability, visuospatial memory, executive functions, and intelligence, in children and adolescents at high risk (HR) for OCD (n = 18) and non-OCD controls (NOC) (n = 31).

Methods: For the HR group, we considered the first-degree relatives of patients with OCD that present OCS, but do not meet diagnostic criteria for OCD. Psychiatric diagnosis was assessed by experienced clinicians using the Structured Clinical Interview for DSM-IV and OCS severity was measured by the Yale-Brown Obsessive-Compulsive Scale. Neurocognitive assessment was performed with a comprehensive neuropsychological battery. Performance on the cognitive domains was compared between groups using Multivariate Analysis of Variance, whereas performance on the neuropsychological variables was compared between groups using independent t-tests in a cognitive subdomain analysis.

Results: The cognitive domain analysis revealed a trend towards significance for impairments in the motor and processing speed domain (p = 0.019; F = 3.12) in the HR group. Moreover, the cognitive subdomain analysis identified a statistically significant underperformance in spatial working memory in the HR group when compared to the NOC group (p = 0.005; t = −2.94), and a trend towards significance for impairments in non-verbal memory and visuoconstructive tasks in the HR group.

Conclusions: Our results suggest impairments in spatial working memory and motor and processing speed in a non-clinical sample of HR participants. Considering the preliminary nature of our findings, further studies investigating these neurocognitive domains as potential predictors of pediatric OCD are warranted.

Keywords: Obsessive-compulsive symptoms, High-risk, Obsessive-compulsive disorder, First degree relatives, Neuropsychological assessment, Cognitive functions

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Background

Obsessive-compulsive disorder (OCD) is a neuropsychiatric disorder characterized by intrusive thoughts (obsessions) and repetitive behaviors (compulsions) [1]. With a lifetime prevalence of 1.5–2.5% [2, 3], OCD constitutes a common disorder which onset typically occurs during childhood or early adulthood [4] and that presents two peaks of onset, being the first one during preadolescent childhood (around eleven years) and the other around late adolescence and early adulthood [5]. Current pharmacological and psychotherapeutic treatments can benefit 60–70% of patients [6, 7] and treatment-refractory disease is common [8, 9]. In addition, untreated OCD usually persists and becomes chronic [10]. As such, further investigations are warranted for advances in OCD care and prevention.

Consistent with its genetic underpinnings [11], several family studies have demonstrated that first-degree relatives (FDRs) of individuals with OCD are at an increased risk for developing the disorder [12, 13]. In addition, diverse genetic approaches have indicated that subclinical OCD and the full-blown disorder share a considerably similar genetic predisposition [14, 15]. Since subclinical OCD can portend the full-blown disorder in children and adolescents, especially those with greater genetic susceptibility [16], the discovery of markers of vulnerability to OCD in this high-risk population could lead to the development of novel approaches for early detection and management of susceptibility to OCD in the pediatric population. Such approaches would, therefore, improve OCD prevention.

Impairment in multiple cognitive functions has been consistently reported among patients with OCD [17]. Underperformance in the intelligence quotient (IQ) has been demonstrated in adult OCD, with more severe deficits in performance IQ as compared to verbal IQ [18]. Moreover, deficits in visuospatial abilities, executive functions, verbal memory, verbal fluency, and attention have been reported in adults with OCD [19]. Given the genetic nature of the disorder, putative impairment in several cognitive functions has been extensively investigated in unaffected FDRs of individuals with OCD [20–27]. Consistently, deficits in inhibitory control [21, 22], decision making [23, 24], long-term verbal and visual memories [25], planning [26], working memory, verbal fluency and motor speed [27] have been found in adult FDRs of individuals with OCD. Considering the contribution of genetic factors in the etiology of early-onset OCD [28], impaired inhibitory control and cognitive flexibility were recently reported for an adult sample of early-onset OCD patients and their unaffected FDRs [29].

Cognitive function has been less extensively investigated in pediatric OCD when compared to adult OCD [30], which could account for the inconsistency of findings reported in previous studies. Indeed, a meta-analysis revealed no significant impairments in cognitive functions associated with pediatric OCD, possibly due to the small number of studies included [31]. Conversely, deficits in visual memory, visual organization, processing speed, cognitive flexibility, and planning have been reported for pediatric OCD [30, 32–34]. Moreover, the assessment of cognitive function in pediatric FDRs of individuals with OCD has been largely unexplored. To our knowledge, only one study so far has assessed the cognitive performance of pediatric patients with OCD, their unaffected FDRs, and healthy individuals [34]. Both patients with OCD and their FDRs exhibited underperformance in planning tasks. Such findings warrant further investigations of the cognitive function in pediatric FDRs of individuals with OCD.

Furthermore, research has been conducted on the association between cognitive dysfunction and subclinical OCD. Previous investigations have not found neuropsychological deficits among adults with obsessive-compulsive symptoms (OCS) [35, 36], notwithstanding preliminary evidence supports an association between cognitive function and OCS among children. For instance, response inhibition and set-shifting have been shown to predict OCS in children younger than six-years-old, and response inhibition has been shown to predict OCS in children older than six-years-old [37]. Such findings suggest that cognitive impairment is associated with subclinical pediatric OCD. Considering the combined evidence of cognitive impairment in pediatric FDRs of individuals with OCD and in pediatric individuals manifesting subclinical OCD, the investigation of cognitive dysfunction as a marker of vulnerability to OCD in children and adolescents may enhance OCD prevention.

Therefore, in the present study, our aim was to assess the cognitive performance of pediatric individuals at high risk (HR) for OCD in comparison to non-OCD controls (NOC). Accordingly, we defined the presence of subclinical OCD and being an FDR of a patient with OCD as the criteria for the inclusion of pediatric participants in the HR group. To our knowledge, the present study is the first to investigate cognitive functioning in pediatric FDRs with subclinical OCD.

Method

Design and recruitment

As part of the ongoing projects conducted by the National Institute of Developmental Psychiatry for Children and Adolescents [14, 38], the present cross-sectional study was conducted in a pediatric sample of 18 HR and 31 NOC (see flowchart in the supplementary files for details). The participants were recruited through media advertisements and an active search conducted at private...
and public schools. The inclusion criteria for the HR group were: 1) age between 7 and 18 years; 2) being a first-degree relative (sibling or offspring) of an individual with OCD; 3) presenting OCS; 4) not meeting diagnostic criteria for OCD and 5) not having undergone currently undergoing any sort of psychiatric treatment. The exclusion criteria for the HR group were: 1) history of head injury; 2) history of substance abuse; 3) presence of intellectual disability or any other neuropsychiatric diagnosis; 4) the presence of any neurological condition and 5) pregnancy or lactation. Apart from being a first-degree relative of an individual with OCD and presenting OCS, the inclusion and exclusion criteria for the NOC group were similar to the aforementioned criteria.

Diagnostic assessments to confirm OCD status and assess other comorbidities were conducted by experienced clinicians using the Structured Clinical Interview for DSM-IV (SCID-I) [39]. Once the OCD participants were confirmed to meet study criteria and after permission, we contacted the first relatives (siblings and offspring) of the participants. For assessment of psychiatric diagnosis among the FDRs, the SCID-I was administered for adults and the Kiddie Schedule for Affective Disorders and Schizophrenia [40] was administered for pediatric individuals. The Yale-Brown Obsessive-Compulsive Scale (Y-BOCS) [41] was used for measuring the severity of OCS. Additionally, the Petersen Puberty Scale [42] and the Edinburgh Handedness Inventory [43] were administered to ascertain the pubertal status of pediatric participants and their handedness, respectively.

Neuropsychological assessment
The neuropsychological battery comprised tests that assessed the following cognitive domains: intelligence, attention, motor and processing speed, visuocognitive abilities, verbal and visuospatial memories, working memory, cognitive flexibility, and inhibitory control. The neuropsychological tests administered and cognitive domains were outlined in Tables 1 and 2, respectively. The neuropsychological tests were administered by experienced psychologists in sessions which duration on average lasted ninety minutes. No issues in terms of fatigue or cooperation from the part of the participants were reported for those sessions.

Ethical considerations
This study was approved by the Medical Ethics Committee of the Faculty of Medicine at the University of Sao Paulo. All participants and their respective parents or legal guardians were informed about the procedures pertaining to the study and provided their written informed consent prior to enrollment of the participants in the study.

Data analysis
Demographic and clinical variables were analyzed using the independent samples t-test for continuous variables and the Chi-squared test for categorical variables. Normality assumptions of neuropsychological variables were evaluated using the Shapiro-Wilk test. Violations of the normality assumptions were assessed according to the statistical significance threshold (p-value) set at 0.01. In the cases of non-normal distribution, a correction was applied using the ‘bestNormalize’ function of RStudio (package ‘bestNormalize’). After that, the normality of the variables was reassessed.

The neuropsychological variables were analyzed at the domain and the subdomain levels. In an initial analysis at the domain level, neuropsychological variables were grouped as follows: intelligence, attention, motor and processing speed, visuocognitive abilities, visuospatial memory, verbal memory, working memory, cognitive flexibility, and inhibitory control. The global performance on each cognitive domain was compared between the groups using the Multivariate Analysis of Variance (MANOVA) (R package ‘stats’, function ‘manova’). Moreover, a further analysis was conducted at the subdomain level, whereby performance on the neuropsychological variables within each domain was compared between the groups using the independent samples t-test (R package ‘stats’, function ‘t.test’). Additionally, effect sizes (Cohen’s d) for each between-group comparison were also computed (R package ‘lsr’, function ‘cohen’). After group comparisons, a post-hoc power calculation analysis was performed for the cognitive subdomain analysis. The Bonferroni correction was applied to all analyses conducted considering the number of cognitive domains assessed, as in Purcell and colleagues [55]. As such, a stricter statistical significance threshold was set at $p = 0.0055$ (0.05/9). Considering the exploratory nature of this study, $p$ values between 0.05 and 0.0055 were considered as a trend towards significance, which is referred as nominal significance from this point onwards. Statistical analyses were performed using the RStudio, version 1.2.1335 (2019).

Results
Demographic and clinical variables
No statistically differences between the groups were found in terms of sex, pubertal development, handedness, years of education, and total IQ (Table 3). Both groups presented total IQ scores in the normal range. As measured by the Y-BOCS, the severity of OCS in the HR group was below the clinical range.

Cognitive domains analysis
The cognitive domain analysis revealed that the HR group exhibited a nominally significant overall
underperformance in tasks measuring the motor and processing speed abilities ($p = 0.019; F = 3.115$) (Fig. 1a). No statistically or nominally significant difference in overall performance was found for the other cognitive domains (Table 4). Only the scores in the immediate recall condition of the ROCF paradigm were removed.
### Table 2  Neuropsychological Domains and Tests Evaluated in the Study

| Domain Definition                                                                                      | Subtest variables                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| **Intelligence**                                                                                       | Wechsler abbreviated scale of intelligence (WASI) [44, 45] Block Design; Matrix; Vocabulary; and Similarities.                                |
| General intelligence (IQ)                                                                             | Rey auditory verbal learning test (RAVLT) [46] Span A; Span B                                                                                     |
| **Attention**                                                                                          | Trail making test (TMT) – Delis-Kaplan executive function scale (D-KEFS) [47] 1st condition omissions; and 4th condition sequence errors          |
| Endogenous processing of selecting relevant stimuli (concentrating) in the environment (e.g., objects)* | Design fluency test (DFT) – D-KEFS [47] DFT 1 and 2 - % errors                                                                               |
|                                                                                                       | Wisconsin card sorting test (WCST) [48] WCST failures to maintain set.                                                                           |
|                                                                                                       | Go/NoGo [49]                                                                                                                                     |
|                                                                                                       | Go/NoGo omissions.                                                                                                                                |
| **Motor and processing speed**                                                                         | Color-word interference test (CWIT) - D-KEFS [47]                                                                                               |
| Ability to quickly process information and execute it (fine motor skills)                              | Color naming time (CWIT 1); and word reading time (CWIT 2)                                                                                      |
|                                                                                                       | Grooved pegboard test [50] Dominant hand time; and non-dominant hand time                                                                         |
|                                                                                                       | TMT – D-KEFS [47] 5th condition time                                                                                                             |
| **Visuocostructive abilities**                                                                        | Block Design test - WASI [44, 45]                                                                                                                |
| Coordination of fine motor skills with spatial abilities                                               | Rey-Osterrieth complex figure (ROCF) [51] Copy total score                                                                                      |
| **Visuospatial memory**                                                                                | Corsi block-tapping test (CBTT) - Wechsler Memory Scale (WMS-R) [52] Forward hits                                                              |
| Memory for visual and spatial information                                                              | ROCF [51] Immediate recall; and Delayed recall                                                                                                |
|                                                                                                       | Digit span test (DST) - Wechsler Intelligence Scale for Children (WISC-III) [53] Forward hits                                                     |
| **Verbal memory**                                                                                      | Rey auditory verbal learning test (RAVLT) [46] Immediate recall; and delayed recall                                                             |
| Memory for verbal information                                                                          |                                                                                                                                                |
| **Working memory**                                                                                    | DST – WISC-III [53] Backward hits                                                                                                               |
| Ability to retain information and perform mental operations from them                                  | CBTT – WMS-R [52] Backward hits                                                                                                                  |
|                                                                                                       | WCST [48] Perseverative errors; and categories                                                                                                   |
| **Cognitive flexibility**                                                                              | DFT – D-KEFS [47] DFT 3 - % perseverative responses                                                                                                |
| Ability to change the perspectives, thinking of new possibilities for solving a problem                | Brixton [54] Brixton hits                                                                                                                        |
|                                                                                                       | TMT – D-KEFS [47] 4th - 5th condition time difference                                                                                             |
| **Inhibitory control**                                                                                 | Go/NoGo – commission errors                                                                                                                     |
| Ability to resist an inclination to perform an action and, opting for a more convenient one             | CWIT – D-KEFS [47] CWIT 3 errors; CWIT 4 errors; and CWIT 3-1 time difference                                                                |

*Attention is not a unitary system – it refers to several different capacities of how the organism comes receptive to stimuli and the ability to maintain concentration focused on stimuli over time (sustained attention). WASI – Wechsler abbreviated scale of intelligence; TMT – Trail making test; D-KEFS – Delis-Kaplan executive function scale; DFT – Design fluency test; WCST – Wisconsin card sorting test; CWIT – Color-word interference test; CBTT – Corsi block-tapping test; WMS – Wechsler Memory Scale; ROCF – Rey-Osterrieth complex figure; DST – Digit span test; WISC III – Wechsler Intelligence Scale for Children 3rd edition; RAVLT – Rey auditory verbal learning test.
from the cognitive domain analysis due to multicollinearity (r > 0.9).

Cognitive subdomain analysis
Means and standard deviations for each of the neuropsychological variables are displayed in Table 5. The cognitive subdomain analysis revealed that the difference between the groups in the number of correct taps in the forward condition of the Corsi Block Tapping Test was statistically significant after the Bonferroni correction [t (45) = −2.94, p = 0.0050, d = 0.79] (Fig. 1b). In addition, group-differences in the following outcome variables achieved nominal significance: the number of correct taps in the backward condition of the Corsi Block Tapping Test [t (44) = −2.31, p = 0.0260, d = 0.67], the time to complete the fifth condition of the Trail Making Test [t (28) = 2.27, p = 0.0301, d = 0.69], the scores in the Block Design subtest [t (43) = −2.08, p = 0.042, d = 0.57] and the discrepancy between the scores of verbal IQ and performance IQ [t (29) = 2.11, p = 0.043, d = 0.66]. No statistically or nominally significant difference between the groups in other outcome variables was found. A secondary subdomain analysis was performed to compare the neuropsychological variables between the groups adjusting for sex and age, which revealed results in the same direction as those obtained in the comparison using independent t-tests (data not shown). A power analysis conducted after the group comparisons revealed that the cognitive subdomain analysis had 80% power to detect group differences with Cohen’s d = 0.75 and 37.65% power to detect group differences with Cohen’s d = 0.4, in both cases considering alpha = 0.05 (one-tailed).

Discussion
The purpose of this study was to investigate the cognitive performance of pediatric individuals at HR for OCD in comparison to NOC control pediatric individuals. At the cognitive domain level, our analyses revealed nominally significant motor and processing speed impairments in the HR group as compared to the NOC group. On the other hand, at the subdomain level, we observed spatial working memory deficits in the HR group and nominally significant impairments in non-verbal memory and visuoconstructive tasks in the HR group.

Previous studies evaluating adults with OCD have consistently reported impairments in processing speed [56–61], which have also been reported for adult FDRs of patients with OCD [27]. Likewise, the assessment of neuropsychological function in the largest pediatric sample to date identified significant underperformance in tasks measuring processing speed among patients with OCD, in comparison to individuals who do not have the disorder [30]. Moreover, deficits in this cognitive domain have been associated with ordering and symmetry symptoms manifested by youth with OCD [62]. Since treatment response has been shown to improve the deficits in processing speed among both pediatric [63] and adult patients [64, 65] with OCD, it could be hypothesized that impairments in this cognitive domain represent a modifiable vulnerability marker for OCD across the lifetime. In this sense, a study reported that pathological uncertainty in adult OCD patients underlies deficits in processing speed [66], which suggests that behavioral interventions could improve processing speed skills and consequently benefit children and adolescents at higher risk for the disorder. Consistent with the transdiagnostic etiologies of psychiatric disorders [67, 68], deficits in

| Table 3 Demographic and clinical characteristics of the high-risk and non-OCD control individuals |
|---|---|---|
|   | High-Risk (n = 18) | Non-OCD Control (n = 31) | p-value |
|   | n (%) / M (SD) | n (%) / M (SD) |   |
| Sex | | | |
| Male | 12 (66%) | 18 (58%) | 0.551 a |
| Puberty Development | | | |
| Age | 11.1 (2.4) | 11.7 (1.9) | 0.365 b |
| Handedness | | | |
| Right | 16 (89%) | 30 (96.8%) | 0.377 a |
| Education Level | | | |
| Years of Education | 6.1 (2.5) | 6.3 (2.1) | 0.743 b |
| Total IQ | 103.5 (12.2) | 105.6 (13.5) | 0.592 b |
| Y-BOCS | | | |
| Total | 7.1 (5.3) | – | – |
| Obsessions | 3.6 (2.6) | – | – |
| Compulsions | 3.5 (2.9) | – | – |

a Chi-squared Test \ b Independent t-test. M – mean; SD – standard deviation; IQ – Intelligence quotient; Y-BOCS – Yale-Brown Obsessive Compulsive Scale
processing speed have been found in adult patients with schizophrenia and comorbid OCD [69] or OCS [70], suggesting that such impairments may constitute a broader vulnerability marker for related psychiatric disorders.

The cognitive subdomain analysis revealed significant underperformance in spatial (nonverbal) working memory, as measured by the Corsi Block Tapping Test in the pediatric participants at HR for OCD, in comparison to NOC. Associations between pediatric OCD and impairments in nonverbal memory have been inconsistently reported [30–32, 71, 72]. Likewise, the only study, to our knowledge, which investigated neuropsychological dysfunction among pediatric FDRs of patients with OCD found no impairments in spatial working memory [34]. Nonetheless, accumulating evidence supports the association between deficits in nonverbal memory and adult OCD [55, 73–82]. Indeed, comprehensive meta-analyses revealed significant associations between deficits in nonverbal memory and adult OCD [19, 83]. Moreover, a recent meta-analysis indicated that adult FDRs of patients with OCD exhibit impairments in short-term visuospatial memory [84].

Moreover, the cognitive subdomains analysis revealed a nominally significant discrepancy between higher verbal and lower performance IQ scores among pediatric participants at HR for OCD, as compared to NOC. Supporting the impairment in processing speed detected in the cognitive domain analysis, a nominally significant difference between groups was found in the time to complete the fifth condition of the Trail Making Test. In accordance with these findings, a recent study identified a significant discrepancy between higher verbal and lower performance IQ scores in pediatric OCD patients, as compared to pediatric healthy developing individuals [89]. Those findings are consistent with a recent meta-analysis indicating a discrepancy between higher verbal and lower performance IQ scores in adult patients with OCD [18], which could be explained by their poorer processing speed negatively affecting the performance IQ scores [18, 85, 86]. Previous investigations have indicated that such discrepancy is associated with reduced motor competence among preschoolers [87] and functional neuroimaging-detected alterations during cognitive conflict resolution among children and adolescents [88]. In this regard, the appropriate school environment has reportedly contributed to improvements in the

![Fig. 1 Groups’ average scores for a) the motor and processing speed MANOVA (higher punctuation means worse performance), and b) total IQ and IQ discrepancy (the difference between verbal IQ and performance IQ). Error bars means a 95% confidence interval (CI). OCD - obsessive-compulsive disorder; CWIT – Color-Word Interference Test; TMT – Trail Making Test; CBTT - Corsi Block Tapping Test. * p-value < 0.0055 (Bonferroni corrected)

Table 4 Difference Within Neurocognitive Domains

| Neuropsychological measure              | F   | Df   | p-value MANOVA |
|----------------------------------------|-----|------|----------------|
| Estimated intellectual efficiency      | 2.085 | 4    | 0.099          |
| Attention                              | 0.718 | 7    | 0.657          |
| Motor and processing speed             | 3.115 | 5    | 0.019<sup>1</sup> |
| Visuomotor abilities                   | 1.868 | 2    | 0.166          |
| Visuospatial memory                    | 2.787 | 3    | 0.051          |
| Verbal memory                          | 0.679 | 3    | 0.570          |
| Working memory                         | 3.046 | 2    | 0.057          |
| Cognitive flexibility                  | 2.362 | 5    | 0.057          |
| Inhibitory control                     | 0.325 | 4    | 0.859          |

MANOVA – multivariate analysis of variance; Df – Degree of Freedom; * p-value < 0.05 (nominal significance)
### Table 5: Mean, standard deviation, range and between-groups comparison of neuropsychological variables

| Neuropsychological measure | High Risk n=18 | Non-OCD Control n=31 | t-test | p-value |
|----------------------------|----------------|-----------------------|--------|---------|
| **IQ**                     |                |                       |        |         |
| Total (WASI)               | 103.5 (12.2)   | 105.6 (13.4)          | 0.07   | 0.938   |
| Verbal (WASI)              | 112.5 (15.2)   | 110.5 (15.4)          | 1.02   | 0.313   |
| Performance (WASI)         | 93.9 (9.8)     | 99.7 (10.1)           | −1.28  | 0.207   |
| Verbal-Performance Discrepancy<sup>a</sup> | 18.61 (13.2)   | 10.8 (11.6)           | 2.11   | 0.043<sup>o</sup> |
| **ATTENTION**              |                |                       |        |         |
| RAVLT span A               | 6.2 (1.5)      | 6.4 (1.6)             | −0.49  | 0.622   |
| RAVLT span B               | 5.7 (1.9)      | 5.6 (1.5)             | 0.19   | 0.843   |
| TMT 1st condition omissions | 0.2 (0.7)     | 0.2 (0.4)             | −0.08  | 0.936   |
| TMT 4th condition sequence errors | 0.4 (1.0)   | 0.4 (0.6)             | −0.15  | 0.879   |
| DFT 1 e DFT 2 - %errors    | .12 (0.2)      | .04 (0.1)             | 1.47   | 0.152   |
| WCST failures to maintain set | 1.1 (1.2)     | 1.2 (1.0)             | −0.30  | 0.764   |
| Go-NoGo omissions          | 3.6 (6.5)      | 2.6 (4.0)             | 0.78   | 0.439   |
| **MOTOR AND PROCESSING SPEED** |            |                       |        |         |
| CWIT color naming time     | 42.1 (7.8)     | 39.9 (9.1)            | 0.86   | 0.390   |
| CWIT word reading time     | 27.8 (4.3)     | 28.9 (7.4)            | −0.67  | 0.503   |
| TMT 5th condition time     | 47.1 (21.5)    | 34.0 (14.4)           | 2.27   | 0.030<sup>o</sup> |
| Grooved dominant hand time | 89.5 (24.9)    | 83.7 (15.0)           | 0.90   | 0.376   |
| Grooved non-dominant hand time | 95.8 (28.9) | 92.4 (19.0)           | 0.44   | 0.662   |
| **VISUOCONSTRUCTIVE ABILITIES** |          |                       |        |         |
| Block Design Test           | 19.0 (9.5)     | 25.6 (12.4)           | −2.08  | 0.042<sup>o</sup> |
| ROCF total score – copy    | 28.8 (6.5)     | 30.5 (3.7)            | −0.59  | 0.558   |
| **VISUOSPATIAL MEMORY**    |                |                       |        |         |
| CBTT forward hits          | 6.5 (1.5)      | 8.1 (2.3)             | −2.94  | 0.005<sup>*</sup> |
| ROCF immediate recall      | 18.7 (6.7)     | 19.2 (5.4)            | −0.26  | 0.792   |
| ROCF delayed recall        | 18.3 (6.8)     | 18.4 (5.6)            | −0.08  | 0.930   |
| **VERBAL MEMORY**          |                |                       |        |         |
| DST forward hits           | 7.5 (1.3)      | 7.0 (2.1)             | 1.15   | 0.254   |
| RAVLT immediate recall     | 9.9 (2.2)      | 10.3 (2.6)            | −0.55  | 0.583   |
| RAVLT delayed recall       | 9.9 (2.3)      | 10.3 (2.9)            | −0.21  | 0.828   |
| **WORKING MEMORY**         |                |                       |        |         |
| CBTT backward hits         | 5.9 (1.2)      | 7.0 (1.7)             | −2.31  | 0.026<sup>o</sup> |
| DST backward hits          | 4.8 (1.7)      | 4.7 (1.7)             | 0.25   | 0.797   |
| **COGNITIVE FLEXIBILITY**  |                |                       |        |         |
| WCST Perseverative errors  | 10.4 (3.5)     | 9.8 (3.8)             | 0.46   | 0.642   |
| WCST categories            | 2.4 (1.2)      | 2.5 (1.2)             | −0.10  | 0.913   |
| DFT %Perseverative errors  | .13 (0.2)      | .03 (0.1)             | 0.74   | 0.464   |
| TMT 4–5                    | 96.2 (86.3)    | 84.3 (50.6)           | 0.15   | 0.877   |
| Brixton hits               | 36.6 (8.5)     | 40.0 (4.1)            | −1.16  | 0.254   |
| **INHIBITORY CONTROL**     |                |                       |        |         |
| Go-NoGo Commission errors  | 8.8 (3.9)      | 8.5 (3.7)             | 0.25   | 0.800   |
| CWIT 3 errors              | 2.8 (3.5)      | 2.0 (2.8)             | 0.64   | 0.525   |
discrepancy between verbal and performance IQ scores [90] (Lapierre et al., 1992). Further investigations are warranted to confirm this discrepancy in children and adolescents at HR for OCD, which could foster early interventions in the course of the disease.

The major limitation of the current study is the small sample size, which limits the detection of significant differences between the groups. Therefore, the reported findings should be considered preliminary, requiring further confirmation in larger samples. Nonetheless, the present study has raised pertinent hypotheses that are well integrated into the existing literature on the topic. Indeed, one longitudinal study reported that impairments in motor and visuospatial skills predict the maintenance of OCD from childhood into adulthood [91].

Conclusions

In summary, this neuropsychological study of children and adolescents at HR for OCD identified impairments in spatial working memory and trend in significance for impairment in motor and processing speed when compared to NOC. Future longitudinal studies following children at HR for OCD are required to investigate cognitive dysfunction as a vulnerability marker for the disorder, which may enhance the prevention of OCD among children and adolescents.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s12888-020-02751-5.

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Authors’ contributions

All authors have read and approved the manuscript. ETB has made substantial contributions to the conception of the work; analysis, and interpretation of data; has drafted the work and approved the submitted version (and any substantially modified version that involves the author’s contribution to the study); and has agreed both to be personally accountable for the author’s own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. LS has made substantial contributions to the analysis and interpretation of data; has reviewed the work and approved the submitted version (and any substantially modified version that involves the author’s contribution to the study); and has agreed both to be personally accountable for the author’s own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. MQH has substantively revised the work and approved the submitted version (and any substantially modified version that involves the author’s contribution to the study); and has agreed both to be personally accountable for the author’s own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. MMS has contributed collecting the data and revising the work; has approved the submitted version (and any substantially modified version that involves the author’s contribution to the study); and has agreed both to be personally accountable for the author’s own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

Table 5

Mean, standard deviation, range and between-groups comparison of neuropsychological variables (Continued)

| Neuropsychological measure | High Risk n = 18 | Non-OCD Control n = 31 | t-test | p-value |
|----------------------------|------------------|------------------------|--------|---------|
| CWIT 4 errors              | Mean (SD)        | Mean (SD)              |        |         |
| 2.0 (2.2)                  | 2.5 (3.4)        | −0.17                  | 0.863  |
| CWIT 3–1 time difference   | 39.1 (18.8)      | 36.5 (18.0)            | 0.37   | 0.709   |

* The Verbal – Performance difference is calculated by subtracting the performance IQ from the verbal IQ. WASI – Wechsler abbreviated scale of intelligence; RAVLT – Rey auditory verbal learning test; TMT – Trail making test; DFT – Design fluency test; WCST – Wisconsin card sorting test; CWIT – Color-word interference test; ROCF – Rey-Osterrieth complex figure; CBTT – Corsi block-tapping test; DST – Digit span test. a p-value < 0.05 (nominal significance); a p-value < 0.0055 (according to Bonferroni correction)

Additional file 1: Figure S1. Flow chart - design and recruitment of High Risk and non-OCD controls.

Abbreviations

CBTI: CBTi block-tapping task; DSM-IV: Diagnostic and Statistical Manual of Mental Disorder Fourth Edition; DST: Digit span test; EF: Executive function; FDRs: First-degree relatives; FSIQ: Full-Scale Intelligence Quotient; HR: High-risk; IQ: Intelligence Quotient; K-SADS-PL: Kiddie Schedule For Affective Disorders And Schizophrenia for School-Aged-Children; MANOVA: Multivariate Analysis of Variance; NOC: Non-OCD controls; OC: Obsessive-compulsive; OCD: Obsessive-compulsive disorder; OCS: Obsessive-compulsive symptoms; PIQ: Performance Intelligence Quotient; SCID-IV: Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Patient Edition; TMT: Trail making test; VIQ: Verbal Intelligence Quotient; Y-BOCS: Yale-Brown Obsessive-Compulsive Scale
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