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Cognitive Improvements in Child Sexual Abuse Victims Occur Following Multimodal Treatment Program: As Measured by MyCognition Quotient

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Abstract

Objective: It is well recognized that child sexual abuse (CSA) occurs frequently, with the vast majority of cases never being reported. The impact of such abuse has previously been shown to have both psychological and cognitive impacts that can be long-lasting. However, there is little research regarding any potential improvement in cognitive abilities following treatment. In the present publication, we examine cognitive functioning in victims of CSA, aged between 8 and 12, who were examined at baseline and again during treatment. The treatment program is designed and carried out by an independent charity, and has previously been shown to be very successful in improving symptoms of post-traumatic stress disorder, anxiety, and mood.

Methods: Children aged 8-12 underwent multiple intensive interventions located at a dedicated facility (the Be Brave Ranch) during a 12-month period. We examined cognitive changes during this program, as measured by MyCogntion Quotient (MyCQ), an online cognitive assessment program. Cognition was measured in five domains: attention, episodic memory, executive function, working memory, and processing speed. Changes in cognitive performance were analyzed to determine whether statistically significant improvement occurred.

Results: Of the 86 children enrolled in the study, 62 (72.1%) completed at least a baseline assessment. The mean baseline MyCQ score was below the age-group standard, but not significantly (p=0.344). Fifty-four (62.3%) children completed the 1-year program. Of these individuals, overall MyCQ scores improved by 9% (p=0.005), and statistically positive changes occurred in three domains: working memory (p=0.021), executive function (p=0.0001), and attention (p=0.009). Episodic memory was the only domain that had a negative change, but it was not statistically significant (p=0.466).

Conclusion: The present results show that cognitive abilities improve significantly with treatment. In general, these improvements mirror the degree of overall clinical improvement. This research adds to the evidence demonstrating that cognitive changes occur following CSA, and is among the first to demonstrate possible reversion of such changes in CSA victims following treatment. It also demonstrates that MyCQ is potentially a useful tool to track such changes.

Keywords: Cognition; Children; Sexual abuse; Rating; Treatment; Attention; Memory; Executive function; Processing speed

Introduction

Adverse Childhood Experiences (ACEs) encompass a variety of traumatic incidents commonly experienced in youth [1]. ACEs have been persistently associated with a variety of negative psychiatric outcomes, including early onset mental illness and cognitive deficits [2-6]. Child Sexual Abuse (CSA) is a common ACE with approximately 17% of women and 8% of men experiencing at least one incident [7,8]. In Canada, rates of CSA have been estimated at 15.2% for females and 4.8% for males [9], although it has been suggested that up to 97% of CSA is never reported to authorities [10]. Given its high prevalence rates, it is important to recognize that CSA is associated with a multitude of long-term negative outcomes, including increased risk for substance abuse, suicidal ideation, sexual dysfunction, and cognitive and processing deficits [11-17].

To date there has been only a limited amount of research examining cognitive impairment and ACEs. Preliminary studies have shown reduced verbal comprehension, executive function, and lower IQs, in abused and neglected children [18-21]. To our knowledge, no study has specifically focused on child cognitive impairment in CSA victims. However, some studies examining the link between post-traumatic stress disorder (PTSD) and cognitive functioning in children have suggested that PTSD could be a risk factor for cognitive impairment [22,23]. With just under half of CSA survivors experiencing PTSD symptoms, it is reasonable to assert that this population is at a higher risk for cognitive impairment [24]. Because the brain is most plastic in early childhood, it is imperative that a thorough understanding of the cognitive risk factors involved in sexual abuse be firmly understood. By developing a more comprehensive grasp on the cognitive domains most affected by CSA, better early-intervention and preventative strategies can be developed [13].

Previously we have carried out a significant amount of research aimed at determining the most effective range of approaches to help youth with mental health issues, often following a range of traumatic events [25-27]. From this, it appears that more intensive multi-modal programs are the most effective in treating trauma-induced mental

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illness [28-32]. It was these findings, in part, that led an independent charity focused on the prevention and treatment of CSA to develop the current successful program at a dedicated facility—called the Be Brave Ranch—located in Alberta, Canada [33-35].

As part of this treatment program the charity used an online assessment tool for cognitive functioning, MyCognition Quotient (MyCQ) [36] which has been shown to have high correlation with other, much more intensive, computer based cognitive testing programs. This online program examines cognitive functioning in five different domains: executive function, processing speed, working memory, episodic memory, and attention.

We hypothesized that, upon initial admission, children who had been sexually abused would score lower than the age-group standard. Secondly, we hypothesized that the intensive complex multimodal residential therapy would improve cognitive functioning throughout the course of treatment.

Methods

The treatment program was carried out at an independent facility, Be Brave Ranch, described below. The researchers carried out an independent analysis of the data collected by this organization, and used anonymized data throughout. This analysis was approved by the University of Alberta Human Research Ethics Committee.

Each child attended a residential facility known as the "Be Brave Ranch." The program involved an initial 4-week stay at the ranch, followed by three 2-week stays at 3-months, 6-months, and 12-months after initial admission. The ranch is located in a semi-rural area in Alberta, Canada and includes a number of communal lodges designed to accommodate the children and give the ranch a "camp-like" feel. The ranch contains a number of advanced security features designed to provide safety for the children; this includes a security-guarded gate, a secured fence, and a confidential location. The facility has been specifically designed to exceed the required safety and regulatory guidelines and is assessed regularly by the proper authorities.

During their stay at the ranch, each child was administered a daily comprehensive schedule that revolved primarily around Trauma-Focused Cognitive Behavioral Therapy (TF-CBT). Daily and weekly meeting with therapists and staff ensured that there was consistency in treatment. The TF-CBT program involved the following components: (1) skill-building phase that aimed at improving behavioural, affective, biological, and cognitive self-regulation; (2) careful and gradual exposure to the child's trauma in a safe and controlled setting; (3) cognitive processing of the child's personal traumatic incident as achieved through the development of a trauma narrative; (4) combined child-caregiver sessions and safety planning to develop treatment closure [33]. This approach has been shown to have lasting positive effects for CSA victims [37].

The children were also scheduled for a number of recreational activities that were designed to make the program more enjoyable and not solely therapeutic. These activities included: arts and crafts, structured play, animal therapy, cognitive-training, musical activities, and physical exercise. Each activity was properly supervised and carried out under strict guidelines. Roughly 6 hours each day were allocated to structured activities, with the remainder of the day being reserved for free time and meals. Each child also spent approximately 2 hours each week working on Eye Movement Desensitization and Reprocessing (EMDR), which is an empirically validated treatment for adverse childhood experiences and trauma [38]. As such, this program is considered a complex multimodal intervention focused around the TF-CBT.

Statistical analysis

In order to assess cognitive functioning, MyCognition Quotient (MyCQ), an online, self-administered assessment tool designed to measure cognitive performance, was used. MyCQ measures functioning in five primary cognitive domains: psychomotor processing speed, attention, episodic memory, working memory, and executive function. The program is comprised of the most validated psychometric tests used in neuropsychological research [36], and has been validated by comparison to the commonly used Cambridge Neuropsychological Automated Test Battery (CANTAB). It is considered a cost-efficient and easily administrable tool that is appropriate for a variety psychiatric populations [36].

Each individual assessment was given a score based on the MyCQ algorithm that incorporates accuracy and latency to derive the score. Values are compared to the standard performance of an individual in the same age group. These age-group standard scores are derived from a comprehensive database including data from more than 17,000 individuals who have been involved in standardized assessments previously. The scores follow a normal distribution curve and are therefore non-linear. For example, a score of 50 coincides with the average performance for an individual of that age group.

Thus, any score below 50 indicates performance below the standard score for an individual of the same age.

In order to compare the baseline assessment scores against the age-group standard, a two-tailed t-test was carried out for the overall score as well as each of the five cognitive domains. The mean score for each domain was calculated and subtracted by 50 to represent the reference number; that is, the difference between the mean score and the standard score for that age group. To compare the change in the mean scores for each domain over the course of treatment, a paired sample, two-tailed t-test was carried out.

Results

Baseline scores were collected for each individual based on their first successful completion of the assessment. Of the 86 children enrolled in the study, 62 (72.1%) completed at least a baseline assessment, while 54 (62.3%) completed more than one assessment. Reasons for missing baseline assessment were a combination of technical errors and incomplete assessments, while removal or dropout from the program accounts for those who completed only a baseline assessment.

Analysis of baseline MyCQ assessments scores compared to the age-group standard

At baseline, the mean MyCQ score was 48.61 ± 11.5. Although this value was not statistically significant (p=0.344) from the expected mean, it was below the age-group standard and suggested that the baseline cognitive functioning of our population may have been below mean levels compared to standardized age-matched controls.

It should be noted that the baseline MyCQ scores on Table 1 do not perfectly align with the baseline values in Table 2. This is because Table 1 includes all individuals who completed an assessment at initial admission but may or may not have completed the program (n=62). Table 2 only includes assessment scores for those who completed the full treatment program (n=54).

Domain	Overall	Attention	Episodic Memory	Executive function	Processing Speed	Working Memory
Mean Score	48.61	44.49	54.62	44.34	41.76	61.27
Reference Number	-1.39	-5.51	4.62	-5.66	-8.24	11.27
Standard Deviation	11.53	15.07	14.73	13.32	14.27	14.41
t-value	-0.953	-2.713	2.323	-3.152	-4.281	5.803
p-value*	0.344	**0.009**	**0.024**	**0.003**	**0.0001**	**0.0001**
*Statistically significant p-values are shown in bold text						

Table 1: Statistical results from an independent one-sampled, two-tailed t-test. Statistical significance considered at $p \leq 0.05$. Scores range from 0-100 on a normal distribution, with 50 representing the age-group standard. For each assessment, n=62.

Assessment Type	Baseline	1 (4-12 wks)	2 (13-22 wks)	3 (23-32 wks)	4 (33-42 wks)	5 (43-52 wks)
Attention	44.49	53.3	52.63	45.21	50.77	50.5
Episodic Memory	54.62	61.18	54.52	50.83	54.84	50.25
Executive Function	44.34	52.31	53.75	45.17	49.25	50.38
Processing Speed	41.76	42.04	44.97	41.24	43.34	45.9
Working Memory	61.27	65.54	68.2	59.72	61.85	65.83
Overall	48.55	49.6	55.93	48.41	51.18	52.99

Table 2: Mean MyCQ assessment scores for five different cognitive domains at different time-points for child sexual abuse victims undergoing a complex multimodal residential treatment program.

As shown in Table 1, of the five cognitive domains, three—processing speed, executive function, and attention—had mean scores below the age-group standard. Processing speed and executive function had the lowest overall performance; the mean score for processing speed 8.24 points below the age-group standard (p=0.0001); executive function 5.66 points below the age group standard (p=0.003). Working memory had the highest performance, 11.27 points above the age-group standard (p=0.0001).

Change in MyCQ assessment scores over course of treatment

Table 2 shows the mean MyCQ scores for each domain over the course of treatment. Because the children were encouraged to engage in the application on their own time, data collection was not regimented under a strict schedule. As such, we grouped the assessments based on the time since initial admission into 6 different timepoints: Baseline, 4-12, 13-22, 23-32, 33-42, & 43-52 weeks after admission. The mean score for each domain is shown in the tables. Timepoint 2 (13-22 weeks) had the highest cognitive performance with an overall MyCQ score 5.93 points above average; while baseline and timepoint 3 (23-32 weeks) showed the lowest cognitive performance, 1.45 and 1.59 points below average, respectively.

To compare the change in the mean scores for each domain over the course of treatment, a paired sample, two-tailed t-test was carried out. As shown in Table 3, four of the five domains showed positive improvement, with executive function having the most substantial increase at 6.05 points (p=0.0001). The mean of the overall score increased by 4.44 points (p=0.005). Of the five domains, attention, executive function, and working memory showed statistically significant positive changes (p=<0.05). Episodic memory was the only domain that had a negative change in mean scores, but it was also had the lowest t-statistic (0.735) and highest p-value (p=0.466). Figure 1 shows a graphical representation of the change in mean scores for each domain.

Figure 2 compares the number of children who were at or above their age standard performance (≥50) at baseline and at final discharge. Episodic memory was the only domain that saw a reduction in the number of children at or above the age standard, with 6 fewer children scoring 50 or above. All other domains saw an increase in the number of children scoring at or above the average for their age; executive function and attention had the largest improvements, with 11 and 10 more children scoring at or above average, respectively.

Discussion

Current research suggests that childhood sexual abuse (CSA), particularly when it leads to post-traumatic stress disorder (PTSD), is a strong predictor of the existence of cognitive deficits [19-24,39]. This may be due, in part, to findings that early-life stress can induce structural and functional changes to important cognitive regions of the brain [40]. Children with histories of childhood maltreatment tend to show less creativity and perform poorer on problem solving tasks than non-abused individuals of similar ages [41,42]. As such, it is essential that any program aimed at treating child sexual abuse survivors include measures of cognitive performance.

The results of this study support three main hypotheses postulated prior to our analysis. First, we theorized that children with a history of sexual abuse would have lower baseline cognitive performance assessments than the age-corrected standard population. While the overall baseline assessment scores were lower than the age-group standard, this difference in the mean scores was not statistically significant. However, three of the five cognitive domains had statistically lower baseline mean scores as compared to the age-group standard. Of interest, baseline scores for attention and executive function were significantly above the age-group standard, which may reflect the positive impact treatment has on the cognitive capacities of a CSA victim.

Second, we postulated that cognitive performance in this population would improve over the course of the multimodal treatment program. This was supported by our findings, with statistically significant improvements being found in both the overall score as well as three of five domains. Interestingly, episodic memory was the only domain that showed a reduction in cognitive performance with treatment. This is potentially noteworthy because current literature suggests that memories of traumatic events tend to be repressed [43,44]. However, as shown by fMRI studies, hippocampal activity, which is the primary region of the brain responsible for episodic memory, tends to be elevated in individuals with histories of trauma [45]. As such, re-experiencing traumatic events in a controlled manner—a hallmark of Trauma-Focused Cognitive Behavioral Therapy (TF-CBT)—can induce a reduction of neural activity in these overstimulated brain regions, effectively dampening episodic memory performance. Furthermore, individuals with PTSD are particularly susceptible to

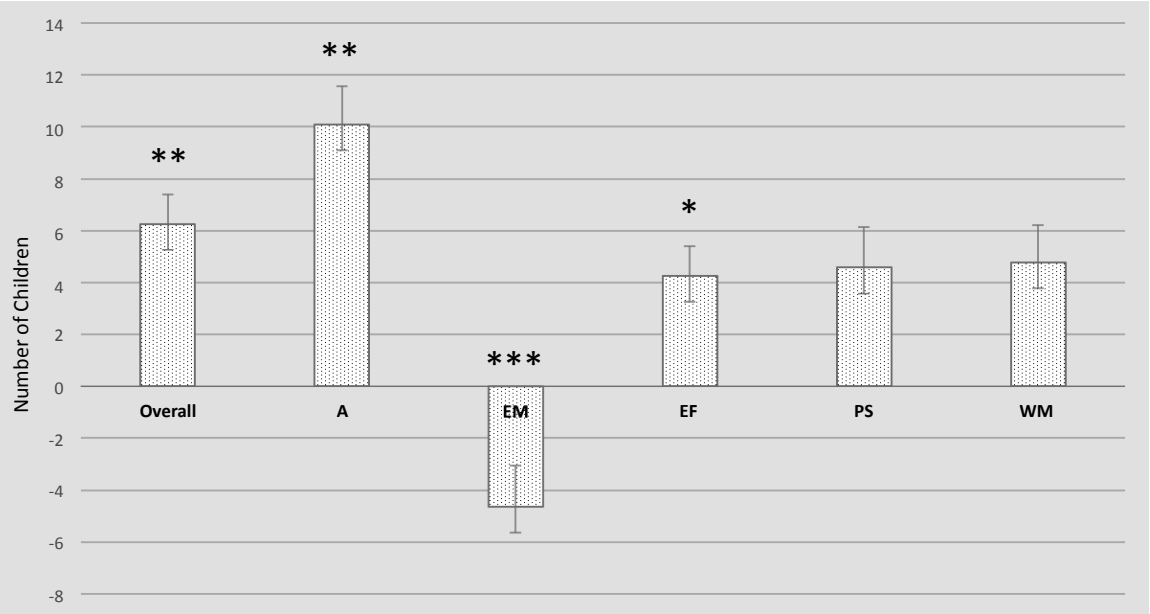

Figure 1: Mean difference in MyCQ scores from baseline to final assessment in five different domains of cognitive performance. This shows the change in cognitive performance following treatment, both in overall level and for specific changes in: attention (A), episodic memory (EM), executive function (EF), processing speed (PS), and working memory (WM). All cognitive assessments were measured by the MyCQ cognitive assessment tool. Statistical significance demonstrated by *p<0.05, **p<0.01, and ***p<0.001.

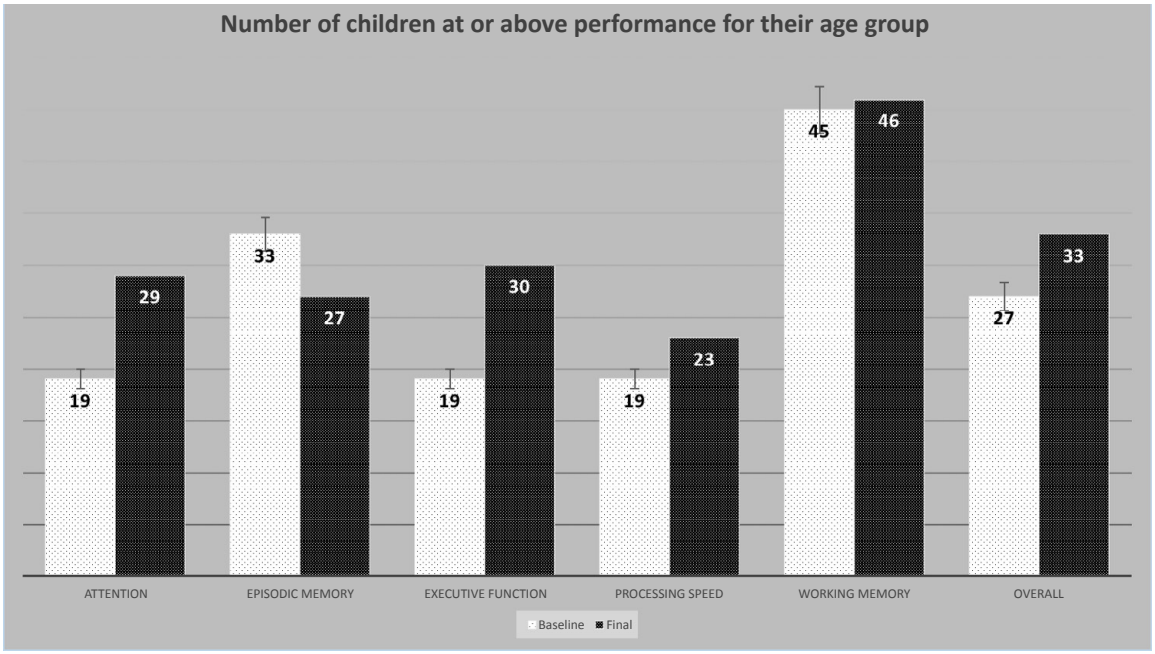

Figure 2: Number of children at or above the average age-group standard cognitive level at initial admission and final discharge. This shows the number of children who scored at or above the age-group MyCQ standard score (≥50) for each of the five domains (attention, episodic memory, executive function, processing speed, working memory) and the overall MyCQ score.

deficits in episodic memory [46], often experiencing spouts of vivid memory, usually activated by trauma-related stimuli [47]. Thus, this reduction of episodic memory could conceivably also represent a positive outcome of the treatment program.

Finally, we hypothesized that the MyCQ assessment application would be a useful and efficacious tool to measure cognitive performance in this population. Given that cognitive deficits are common in CSA victims, it is essential that a useable tool be established in order to properly measure changes in cognitive functioning. Based on our findings, MyCQ appears to be an effective cognitive assessment tool for child sexual abuse victims aged 8-12. Despite this population being statistically more likely to be low-functioning, the children did not appear to have difficulties completing assessments. Furthermore,

Domain	Overall	Attention	Episodic Memory	Executive Function	Processing Speed	Working Memory
Difference in mean (Δμ)	4.44	6.01	-1.95	6.05	4.13	4.55
t-statistic	-2.905	-2.728	0.735	-3.638	-1.524	-2.385
p-value*	**0.005**	**0.009**	0.466	**0.0001**	0.133	**0.021**
*Statistically significant p-values are shown in bold text.						

Table 3: Statistical results from a paired sample, two-tailed t-test. Statistical significance considered at $p \leq 0.05$. Scores range from 0-100 on a normal distribution, with 50 representing the age-group standard. Positive changes represent increased cognitive performance. For each assessment n=53.

MyCQ is particularly useful because scores can be broken down into individual domains of cognitive performance for further investigation.

Nonetheless, it needs to be recognized that this analysis has a few limitations. Firstly, subject data was not controlled for gender, ethnicity, home environment, parental involvement, nature of the sexual abuse, or details regarding the perpetrator. Without this information, more rigorous statistical analysis could not be carried out. Secondly, there was no direct comparison or control group. Although we did compare the group receiving the treatment to an age-matched standard, the absence of a control group means we cannot definitively conclude that the cognitive improvements were directly a result of treatment. Additionally, it would have been useful to have extended our findings past final discharge, to determine whether cognitive improvements held following the end of the treatment program. Finally, because the treatment program was a complex multimodal intervention, it is difficult to determine whether one particular intervention or therapy was responsible for the improvements seen in cognitive performance.

Conclusions and Suggested Future Research

In conclusion, we found that CSA victims have impaired cognitive performance that can be improved with treatments. In terms of measurement, we found that MyCQ is a useful cognitive assessment tool for tracking cognitive performance during treatment in such child-sexual abuse victims. Future research could examine other possible factors including gender, ethnicity, and diagnosis, and this can be helped by the use of control groups in future research. Finally, a number of studies have suggested that a PTSD diagnosis is a better predictor of cognitive deficits than having a history of trauma.
By comparing cognitive performance in CSA victims with and without a diagnosis of PTSD, a more refined understanding of the risk factors involved in cognitive impairment can be developed.

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