Early Psychosocial and Executive Functioning Outcomes in Pediatric Brain Tumor Survivors After Proton Radiation

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Abstract

Background: Pediatric brain tumor survivors can experience detrimental effects from radiation treatment. Proton radiation therapy (PRT), which enables better targeting of radiation to tumors, may result in fewer sequelae. This follow-up cross-sectional study examined psychosocial and executive functioning in children and young adults treated with PRT. *Procedure:* Psychosocial and executive functioning was assessed by standardized parent rating scales for 187 patients. The sample was divided by age at baseline (<6 years [35.8%] and [?]6 years [64.2%]) and PRT field (craniospinal irradiation (CSI [36.9%]) and focal [63.1%]). Rates of impairment were calculated. *Results:* Mean age was 8.49 years at baseline; mean follow-up interval was 3.84 years. All mean scores were within the normal range and within normative expectation. Younger CSI group had significantly more problem behaviors and lower adaptive skills compared to older CSI or focal groups; however, no significant differences were found between younger PRT groups. There were no significant differences in executive functioning between the four age-by-PRT-field groups. Rates of impairment exceeded expected rates in social withdrawal, somatic concerns, activities of daily living, and metacognitive executive functioning. Age group was not significantly related to impairment rates, although the younger group had more problems with withdrawal, anxiety, activities of daily living, and executive functioning with relatively higher anxiety and withdrawal in the younger CSI group. *Conclusions:* Psychosocial and executive functioning was within the normal range at follow-up. Younger patients, particularly those treated with CSI, appeared more vulnerable. Screening and proactive intervention are needed to support psychosocial well-being and executive functions.

Introduction

Brain tumors are the most common type of solid tumor in children.[1] Radiation treatment is a life-saving intervention that can be associated with neurocognitive, emotional, and behavioral sequalae,[2-7] although the use of proton radiation treatment (PRT) has yielded more favorable outcomes due to its dose-sparing properties.[8-10] Initial studies examining the outcomes of PRT revealed cognitive and adaptive functioning in the normal range more than 3 years post-treatment;[11-13]however, psychosocial and executive functioning outcomes have not been comprehensively described.

Psychological functioning following conventional radiation has revealed higher rates of internalizing emotional problems characterized by depression and anxiety.[14-16] Rates of externalizing behavior problems (e.g., conduct problems, aggression, defiance) have not been reported at elevated levels,[17,18] and, in some cases, rates are lower than the normative mean.[19]Greater attention problems (an internally experienced symptom) have been reported on parent questionnaires, whereas greater hyperactivity (externally observed behavior) has generally not been reported in this population.[17,20] As a whole, pediatric patients treated with radiation tend to experience higher rates of symptoms that are experienced inside one's mind (internalizing) rather than symptoms that are more readily observed and directed towards other people (externalizing).

Social functioning is also impacted at higher rates following conventional radiation treatment. The most consistent findings are higher rates of social isolation[6,21,22] as well as reduced social acceptance[2,23] and withdrawal.[14] Reduced leadership skills have also been described.[2,21] Studies have collectively demonstrated weaknesses in social responsiveness and engagement levels, rather than deficits in social skills themselves.

Executive functions are a group of higher ordered cognitive skills that represent a constellation of behaviors required for task completion and goal-directed behavior.[24] Executive functions are mediated by frontal-subcortical-cerebellar white matter circuits which are highly susceptible to injury from radiation treatment,[25,26] and disruption of white matter integrity can impact the long-term developmental trajectory of pediatric survivors.

Executive functioning is affected at higher rates following radiation compared to the general population.[17,19,22,27,28,29]Ecological assessment using parent-report is a valuable method to capture executive functioning abilities in daily contexts.[30] The Behavior Rating Inventory of Executive Function (BRIEF) is a widely used, standardized measure that is sensitive to executive functioning difficulty in daily life.[31,32] Parent report using the BRIEF has revealed greater levels of executive dysfunction in pediatric brain tumor survivors, particularly in the domain of metacognitive executive skills including working memory, planning/organization, and initiation.[16,33,34] Reports of difficulty with behavioral dysregulation are mixed, with some studies citing significantly more difficulty[33,35] and others reporting lower rates of behavioral dysregulation.[34]Reduced problems with inhibition, even relative to healthy controls, have been reported.[16,34]

Executive dysfunction is associated with reduced quality of life,[36,37] greater social deficits,[38] and symptoms of depression,[16] suggesting a multidirectional effect of cognitive, psychosocial, and behavioral status impacting overall well-being among pediatric patients treated with conventional radiation therapy. Similarly, greater attention problems can have an adverse impact on social functioning[39] resulting from an inability to attend to simultaneous stimuli, particularly when there are competing external demands (e.g., group conversations; excess/extraneous noise). The inter-relatedness of cognitive, psychosocial, and behavioral functioning requires comprehensive assessment as each domain directly impacts others. As such, improved cognitive outcomes associated with PRT may contribute to reduced psychosocial and executive functioning sequalae.

Several specific risk factors may lead to adverse outcomes for pediatric brain tumor survivors. Younger age at diagnosis and treatment is a risk factor for greater neurocognitive,[12,13,19] emotional, and behavioral[19,40] sequalae. The extent of radiation (e.g., craniospinal radiation (CSI) vs. focal) has also been shown to impact cognitive outcomes,[12,13,41] including executive functioning.[42] Socioeconomic status (SES) can adversely impact functional outcomes in pediatric oncological conditions,[43] including pediatric patients diagnosed with brain tumors.[44,45] Examination of risk factors is important to determine if these impact outcomes of pediatric survivors treated with PRT.

The goal of the current study was to examine whether pediatric brain tumor survivors treated with PRT had difficulties with psychosocial and executive functioning at follow-up. The study examined demographic, diagnostic (e.g., tumor location), and treatment-related variables to identify those patients at highest risk for adverse outcome. It was anticipated that: 1) psychosocial and executive functioning for the total sample would be within the normal range; 2) problems with behavioral dysregulation and externalizing behaviors (e.g., conduct) would not be seen; 3) patients treated with PRT prior to age 6 years would have greater impairment compared to patients treated after that age; 4) a longer time interval between PRT and follow-up would be associated with greater problems; 5) demographic factors, such as SES, would impact outcomes, and 6) outcomes after PRT would be favorable compared to published outcomes with conventional radiation therapy.

Methods

Participants and Procedures

This follow-up cross-sectional study consisted of 187 patients treated with PRT at the Massachusetts General Hospital (MGH) Francis H. Burr Proton Center for a primary brain tumor. Patients were [?] 20 years at initiation of PRT (baseline), had no prior diagnosis of brain or CNS tumor, and had follow-up assessment conducted by MGH that included measures of psychosocial and executive functioning at least one year after completion of PRT.

Patients were treated with PRT, surgery, and chemotherapy appropriate for the diagnosis and according to the current standard of care. Surgical resection, when performed, was prior to PRT. Chemotherapy as part of treatment was always completed before follow-up testing. All radiation was delivered with standard fraction sizes of 1.8 Gy (RBE) per fraction (1.5 Gy per fraction for germinomas) in accordance with the national standard set by Children's Oncology Group protocols for target coverage. MGH and Dana-Farber Cancer Institute Institutional Review Board approvals were obtained for this study.

Measures

Psychosocial functioning was assessed using the Behavior Assessment System for Children- 2nd or 3rdeditions (BASC)- Parent form.[46,47] The BASC is a standardized written measure with age-based norms that assesses adaptive and problem behaviors. There are three forms: preschool (ages 2 through 5), child (ages 6 through 11), and adolescent (ages 12 through 21). The BASC produces several specific clinical scales, a Behavioral Symptoms Index that assesses the degree of overall problem behaviors, and an Adaptive Skills score that assesses skills such as activities of daily living and social skills. Not all clinical scales are produced for the three forms of the test. All scores are T-scores (Mean = 50; standard deviation [S.D.] = 10), where higher scores indicate greater problems. All results are presented in the same direction; the results of the Adaptive Skills scales, where a lower score typically indicates greater problems, were transformed for the present analyses to be consistent across measures.

Executive functioning was assessed using the BRIEF- 1st or 2nd editions, a standardized written parent report measure with age-based norms.[31,32] The BRIEF assesses executive functions or self-regulation in everyday life. There are three forms: preschool (ages 2 through 5), child and adolescent (ages 5 through 18), and adult (ages 18+). The BRIEF produces several specific clinical scales as well as two Index scores: Behavioral Regulation and Metacognition that together yield the Global Executive Composite. The BRIEF produces T-scores (Mean = 50; S.D. = 10), where higher T-scores reflect greater problems. Not all clinical scales are produced for the three forms of the test.

Statistical Analyses

Descriptive statistics were used to characterize the sample at baseline and follow-up. Patients were divided by age at baseline into younger (age $<$ 6 years) and older (age [?] 6 years) age groups, with 6 years set as the cutoff to match the age-appropriateness criteria for the measures used (e.g., BASC and BRIEF Preschool versions $<$6 years), to assess the vulnerability of this young age group to the detrimental effects of radiation, and to be consistent with previously published results from our group.[13] The two age groups were divided by radiation field (CSI or focal). For the present study, the BASC Behavioral Symptoms Index and Adaptive Skills and the BRIEF Global Executive Composite, Behavioral Regulation, and Metacognition indices were used as primary outcome measures. One-way analysis of variance (ANOVA) was conducted to determine the differential impact of demographic, diagnostic, and treatment-related characteristics on these primary outcome measures. Pearson correlation was used to investigate the relationship between the primary outcome measures and the time interval between baseline and follow-up. A one-way ANOVA was conducted to compare mean differences in the primary outcome measures at follow-up across the four age-by-radiation-field groups. When the one-way ANOVA resulted in a significant group difference, a least significant difference post hoc analysis was performed.

One-sample t-tests were used to compare mean scores with published normative means. Rates of impairment were calculated and defined as the frequency of scores $>$ 1.5 S.D. above the mean of 50 (T-score $>$ 65). Chi-square analysis was conducted to evaluate the differences in rates of impairment by age groups. Pearson correlation was used to examine the relationships between those scales where rates of impairment exceeded expectations in the general population.

Analyses were performed using SPSS version 24 (IBM 2016, Chicago, IL). Two-tailed analyses were used in all comparisons; statistical significance was defined as $p < 0.05$.

Results

Participants

As shown in Table 1, the mean age at baseline was 8.49 years (range, 1.05 to 20.41 years), with 67 (35.8%) in the younger age group. The mean length of follow-up was 3.84 years (range, 1.00 to 14.39 years). There was no significant difference for mean length of follow-up between the younger and older groups ($p = 0.12$). All patients received PRT; 69 (36.9%) received CSI of which 19 were in the younger group. More than half (64.7%) received both PRT and chemotherapy. Most (85.0%) underwent gross or near/subtotal surgical resection prior to PRT. Medulloblastoma was the most common histology group (29.4%). Histology was significantly related to age at baseline ($p< 0.001$); the ependymoma group was younger (Mean = 5.78 years, SD = 4.34) than the other histology groups while the germ cell tumor group (Mean = 13.82 years, SD = 2.70) was older. The majority of patients were white (92.5%); the median household income in the community of residence[48] (a proxy indicator for SES) was $83,664 (range, $34,118 to $213,750).

Psychosocial Functioning

All BASC mean T-scores were in the normal range at follow-up (Table 2), although scores were variable ranging from within the normal range to the impaired range across most scales. No significant relationship (p [?] 0.10) was found between mean T-scores for the Behavioral Symptoms Index or the Adaptive Skills score and the following factors: gender, hydrocephalus at diagnosis, history of surgical resection, tumor location, radiation field, treatment with chemotherapy, or SES. Younger age at baseline was significantly related to a higher Behavioral Symptoms Index mean score($p = 0.016$) and the Adaptive Skills mean score ($p = 0.001$), although both mean scores were within the normal range. Histology was significantly related to the Behavioral Symptoms Index mean score ($p = 0.038$); the ependymoma group had a higher mean score than the other histology groups. No significant relationship was found between the Adaptive Skills mean score and histology. The time interval between baseline and follow-up was not significantly correlated with the Behavioral Symptoms Index or Adaptive Skills mean scores (both$p$ values [?] 0.10).

There was a significant difference in the mean Behavioral Symptoms Index for the age by radiation field groups ($p = 0.038$); younger patients who received CSI had significantly more problem behaviors compared to older patients who received either CSI ($p = 0.014$) or focal PRT ($p = 0.007$). However, there was no significant difference ($p = 0.10$) in problem behaviors (Behavioral Symptoms Index) between younger patients who received CSI or focal PRT. Likewise, there was a significant difference in the Adaptive Skills mean score for the age by radiation field groups ($p= 0.008$); younger patients who received CSI had significantly lower adaptive skills compared to older patients who received either CSI ($p = 0.012$) or focal PRT ($p = 0.022$). However, no significant difference ($p = 0.24$) was seen between younger patients who received CSI or focal PRT.

Compared to the normative mean, a significantly elevated mean score was found for the total sample on Withdrawal ($p < 0.001$) while mean scores were significantly lower (indicating less problems) than expectation on Hyperactivity ($p = 0.001$), Aggression ($p < 0.001$), Conduct Problems ($p < 0.001$), Adaptability ($p = 0.013$), Social Skills ($p < 0.001$), and the Behavioral Symptoms Index ($p = 0.032$). Scores were at or near the normative mean on the remaining BASC scales (p values [?] 0.063), including Anxiety, Depression, Somatization, Attention Problems, and Adaptive Skills.

Rates of impairment for the Behavioral Symptoms Index and Adaptive Skills scale for the total sample were similar to expected rates in the general population as were the scores on Hyperactivity, Aggression, Conduct Problems, Depression, Anxiety, Atypicality, Attention Problems, Adaptability, Social Skills, Leadership, and Functional Communication. In contrast, rates of impairment on Somatization, Withdrawal, and Activities of Daily Living exceeded expectations. There was no significant difference between the rates of impairment and the younger and older age groups on any scale ($p > 0.10$), although there was a relatively greater rate of impairment for the younger group in Anxiety, Withdrawal, and Activities of Daily Living. Rates of impairment were generally higher in the younger group treated with CSI compared to focal PRT for Withdrawal (8/19, 42.1% vs. 7/43, 16.2%) and Anxiety (4/19, 21.1% vs. 5/42, 11.9%), but not for Activities of Daily Living (3/19, 15.8% vs. 10/44, 22.7%).

Executive Functioning

All BRIEF mean T-scores were in the normal range (Table 2), although scores ranged from within the normal range to the impaired range across most scales. No significant relationship (p [?] 0.10) was found between the Global Executive Composite, Behavioral Regulation or Metacognition indices and the following variables: age at baseline, gender, histology, hydrocephalus at diagnosis, history of surgical resection, location of tumor, radiation field, treatment with chemotherapy, SES, or the time interval between baseline and follow-up.

There were no significant differences between age by radiation field groups and the Global Executive Composite ($p = 0.39$), Behavioral Regulation Index ($p = 0.59$) or Metacognition ($p = 0.40$) mean T-scores. That is, younger and older age groups who received CSI or focal PRT did not significantly differ in executive functioning skills at follow-up.

Compared to the normative mean, significantly elevated mean scores were found on the Metacognition ($p = 0.003$), Initiate ($p = 0.001$), Working Memory ($p < 0.001$), and Plan/Organize ($p = 0.007$) scales. In contrast, mean scores were significantly better than expectation on the Inhibit scale ($p = 0.001$) and Behavioral Regulation Index ($p = 0.019$). Mean scores were at or near the normative mean on the remaining clinical scales.

Rate of impairment on the Behavioral Regulation Index for the total sample was similar to expected rates in the general population. In contrast, scales assessing metacognitive skills, namely Metacognition, Initiate, Working Memory, and Plan/ Organize, exceeded expectations. There was no significant difference ($p > 0.10$) between the rates of impairment and the two age groups on any BRIEF scale, although the younger group had a slightly greater percentage of overall executive functioning difficulties than the older group (Global Executive Composite 17.9% vs. 13.3%). Rates of impairment were slightly higher in the younger age group treated with CSI compared to focal PRT for Global Executive Composite (4/19, 21.1% vs. 8/48, 16.7%).

Relationship between Psychosocial and Executive Functioning

Correlations were conducted for those BASC and BRIEF scales where rates of impairment for the total sample exceeded expectations in the general population. Higher scores on the BASC Withdrawal, Somatization, and Activities of Daily Living scales were positively correlated ($p< 0.05$) with greater problems with the BRIEF Metacognition, Initiate, Working Memory, and Plan/ Organize scales.

Discussion

The present study examined early psychosocial and executive functioning outcomes in a large cohort of pediatric brain tumor survivors at an average of 3.8 years post-PRT. The total sample was not significantly different than the population norms for psychosocial and executive functioning at follow-up. Behavior problems, including a lower level of hyperactivity, aggressive behavior, and conduct problems, were in fact significantly below normative expectations. This was reflected in the low rates of impairment for these behaviors. These findings are consistent with previously reported research.[17-19] In contrast, significantly elevated symptoms of social withdrawal were observed. These differences were more marked in the younger than in the older group, although the differences were not statistically significant. Younger children had significantly more behavior problems and lower adaptive or "everyday" living skills at follow-up regardless of treatment with CSI or focal PRT. Prior research has noted greater neurocognitive difficulty associated with younger age at treatment[12,13,19] as well as greater emotional and behavioral difficulty.[19,40] In this context, the ependymoma group in this study had more problem behaviors at follow-up, but this is likely related to age as the ependymoma group was younger than the other histology groups.

Executive functioning was not significantly different from population norms, but the total sample did show a higher rate of impairment in metacognitive executive skills, namely the ability to take initiative, sustain working memory (e.g., capacity to hold and "work on" information in mind to complete an activity), and plan and organize tasks. In contrast, the rate of impairment with behavioral dysregulation was similar to expected rates and consistent with the lower level of acting-out behavior that was observed with the BASC. Neither age nor radiation field were significantly related to executive functioning. In addition, the time interval between baseline and follow-up was not significantly related to psychosocial or executive functioning.

Although the total sample had more difficulty with social withdrawal (e.g., the tendency to evade others to avoid social contact), the patients' social skills were within the normal range with a low rate of impairment, suggesting patients have the skills necessary for interacting successfully with peers and adults. This finding is consistent with prior literature on conventional post-radiation outcomes reflecting greater social withdrawal,[14]isolation,[2,6,21,22] and lower acceptance,[2,23] but the absence of deficits in social skills as a more primary mechanism of impairment. Social withdrawal was significantly related to greater problems with metacognitive skills, namely the ability to take initiative, multi-task, and plan and organize activities. Prior research has demonstrated a bidirectional relationship between greater executive dysfunction and greater social vulnerability[38] and reduced quality of life[36,37] reflecting the functional impact of neurocognitive vulnerability on aspects of social competence. This relationship between executive dysfunction and social vulnerability is consistent with a hypothesis that successful social engagement requires participants to initiate and participate in complex social interactions involving metacognitive skills. The interrelatedness of aspects of neurocognitive development and functional social proficiency warrants a comprehensive approach to intervention.

These findings highlight both the importance of routine screening (e.g., rating scales/questionnaires) of pediatric brain tumor survivors for emerging psychosocial and executive functioning challenges, as well as the need for targeted proactive interventions, particularly for patients treated with PRT prior to age 6 years. Such interventions could target the development of social initiative and participation, independence in activities of daily living, and metacognitive executive functioning skills. For example, interventions that provide increased opportunities for positive social interactions with peers in the context of adult-facilitated support may minimize social withdrawal and maximize social initiation and engagement, particularly in younger patients. Older patients may benefit from explicit instruction or coaching in executive functioning that teaches them strategies to plan, organize, set goals, prioritize, multi-task, and be a self-starter and independently problem solve. Cognitive remediation,[49,50,51] cognitive-behavioral therapy,[52] social skill programming,[53,54] and psychopharmacology[55,56] each have been shown to be effective for pediatric brain tumor survivors. Methylphenidate may be beneficial for some patients following PRT as long-term improvements in both social functioning and internalizing symptoms (e.g., symptoms of withdrawal, somatic, anxiety/depression) have been reported.[55]

While these results contribute to the growing knowledge of psychosocial and executive functioning outcomes of pediatric brain tumor survivors treated with PRT, some limitations of the present study should be noted. One is the relatively short mean time interval to follow-up. Late effects of radiation therapy have been well established[26] and psychosocial and executive functioning challenges may emerge later than the mean time interval of the present study. However, time since PRT was not correlated with outcome in the present study. Second, the sample was predominantly white and of relatively high SES, with an estimated median income higher than that of the United States. Patients represented a diverse mix of SES, and no relationship was found between estimated household income and psychosocial and executive functioning outcomes. Finally, the findings are based only on parent rating scales, which are subject to rater bias and can reflect parents' impressions; self-report rating scales were not included in the analyses for comparison.

In summary, the present study examined psychosocial and executive functioning outcomes in a large cohort of pediatric brain tumor survivors treated with PRT. Psychosocial and executive functioning were within the normal range at follow-up. Younger patients, particularly those treated with CSI, appeared more vulnerable. These early findings are encouraging. Future research will examine a longer follow-up interval to better determine the risk of late effects of PRT, optimally in a more diverse sample.

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TABLE 1. Patient characteristics of the total sample (N = 187)

	Mean (± SD) or N (%)
Mean Age at Baseline Testing (year) < 6 years of age [?] 6 years of age	8.49 (±4.57), range 1.05–20.41 67 (35.8) 120 (64.2
Mean Age at Follow-up (year)	12.33 (±4.89), range 2.60 – 21.61
Mean Follow-Up Interval (year)	3.84 (±2.68), range 1.00 – 14.39
Male / Female	99 (52.9) / 88 (47.1)
Race	
White	173 (92.5)
Black or African-American	7 (3.7)
Other	7 (3.7)
Median household income in community of residence	$83,664, range $34,118–$213,750
Histology	
Medulloblastoma	55 (29.4)
Ependymoma	42 (22.5)
Craniopharyngioma	29 (15.5)
Glial (astrocytoma; glioma)	27 (14.4)
Germ cell	16 (8.6)
Other	18 (9.6)
Primary Tumor Location	
Infratentorial	95 (50.8)
Supratentorial	92 (49.2)
Hydrocephalus at diagnosis	
Yes	83 (44.4)
No	104 (55.6)
Radiation Field	
Craniospinal irradiation	69 (36.9)
Focal radiation	118 (63.1)
Surgery (before proton radiation)*	
Gross total resection	105 (56.1)
Near/subtotal resection	54 (28.9)
Biopsy	16 (8.6)
None	12 (6.4)
Chemotherapy treatment (yes) **	121 (64.7)

* No surgical biopsies or resections were performed during or after proton radiation.

** Concurrent or subsequent to proton radiation.

TABLE 2. Psychosocial and executive functioning data (N = 187).

Measure	Mean T-score (S.D.)	% Rate of Impairment+	% Rate of In
			Age group <6 years
BASC-Parent Report	BASC-Parent Report		
Behavioral Symptoms Index (N = 187)	Behavioral Symptoms Index (N = 187)	48.57 (9.01)*	1.5
Hyperactivity (N = 173)	Hyperactivity (N = 173)	47.30 (10.04)**	8.1
Aggression (N =170)	Aggression (N =170)	45.87 (6.97)**	0.0
Conduct problems (N = 150)	Conduct problems (N = 150)	44.86 (7.94)**	4.9
Depression (N = 172)	Depression (N = 172)	50.28 (10.32)	4.9
Anxiety (N = 173)	Anxiety (N = 173)	50.64 (9.78)	14.8
Somatization (N = 176)	Somatization (N = 176)	51.65 (11.76)	12.5
Atypicality (N = 172)	Atypicality (N = 172)	48.95 (9.94)	4.8
Withdrawal (N = 173)	Withdrawal (N = 173)	53.69 (12.48)**	24.2
Attention problems (N = 172)	Attention problems (N = 172)	48.48 (10.78)	4.8
Adaptive Skills (N = 187)	Adaptive Skills (N = 187)	48.47 (11.21)	9.0
Adaptability (N = 171)	Adaptability (N = 171)	48.02 (10.30)*	8.1
Social Skills (N = 172)	Social Skills (N = 172)	46.34 (10.06)**	3.2
Activities of Daily Living (N = 173)	Activities of Daily Living (N = 173)	50.81 (12.20)	20.6
Leadership (N = 153)	Leadership (N = 153)	49.70 (11.66)	11.9
Functional Communication (N =173)	Functional Communication (N =173)	50.24 (11.76)	8.1
BRIEF - Parent Report	BRIEF - Parent Report		
Global Executive Composite (N = 187)	Global Executive Composite (N = 187)	51.21 (11.68)	17.9
Behavioral Regulation Index (N = 187)	Behavioral Regulation Index (N = 187)	48.26 (10.08)*	7.5
Inhibit (N = 187)	Inhibit (N = 187)	47.78 (9.24)**	9.0
Shift (N = 187)	Shift (N = 187)	50.37 (11.49)	13.4
Emotional Control (N = 187)	Emotional Control (N = 187)	48.65 (10.57)	7.5
Self-Monitor (N = 160)	Self-Monitor (N = 160)	49.17 (11.26)	9.3
Metacognition Index (N = 187)	Metacognition Index (N = 187)	52.78 (12.62)**	19.4
Initiate (N = 164)	Initiate (N = 164)	53.26 (12.31)**	17.8
Working Memory (N = 187)	Working Memory (N = 187)	55.52 (13.70)**	23.9
Plan/ Organize (N = 186)	Plan/ Organize (N = 186)	52.48 (12.42)**	16.7
Organization of Materials (N = 165)	Organization of Materials (N = 165)	49.75 (10.91)	15.6

Note: BASC = Behavior Assessment System for Children; BRIEF = Behavior Rating Inventory of Executive Function; S.D. = standard deviation

* $p < 0.05$ compared to normative means

** $p < 0.01$ compared to normative means

+ Impairment defined as > 1.5 S.D. above the published normative mean.

BASC and BRIEF normative mean = 50, S.D. = 10, where higher scores indicate greater problems.