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Rates of Reporting Suicidal Ideation and Symptoms of Depression on Children's Depression Inventory in a Paediatric Neurology Sample

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Abstract
Background and Objectives The Children's Depression Inventory (CDI) is frequently used to screen for the symptoms of depression and suicidal thinking during psychological or neuropsychological evaluations. This includes assessment of children with neurological conditions who are at risk of experiencing suicidal thoughts due to general cognitive, psychiatric, and neurological deficits. The purpose of this study was to examine the prevalence and correlates of suicidal thinking and symptoms of depression in youth with neurological disorders, as measured by the CDI. We expected that reporting suicidal ideations would most often occur in children with epilepsy and individuals with low IQ, and positively correlate with impulsivity.
Methods Participants included 313 paediatric neurology patients (mean age=13.1 years, SD=3.1, range=7–17) who underwent neuropsychological assessments, including completion of the CDI.
Results Clinically elevated levels of symptoms of depression were found in 10 % of children, with 18.8 % of the total sample endorsing suicidal ideation on the CDI. Suicidal ideation was most commonly endorsed by youth with epilepsy (22.8 %), children between ages 7 and 10 years (25.8 %), youth with intellectual disabilities (40 % for IQ below the 2nd and 70 % for IQ below 0.2nd percentiles), and girls with attention problems (67 %). Depressive symptoms were significantly correlated with IQ, processing speed, executive functions, attention, parent-reported internalizing behaviours, and gender. Suicidal ideations were best predicted by low verbal intelligence, executive dysfunction, being female, and problems with inattention.
Conclusions Assessments of youth with neurological issues should include a psychological measure, particularly for patients with epilepsy and cognitive disabilities, even at a relatively early age.

Keywords Children's Depression Inventory · Cognition · Executive functions · TBI · Epilepsy · Stroke

Abbreviations

SB	Suicidal behaviours
SI	Suicidal ideation
STI	Suicidal ideation with intent
ST	Suicidal thinking without reported intent

Introduction

Depression and suicidal ideation assessment is a standard practice in a typical neuropsychological assessment. The measures often used for this purpose are the Children's Depression Inventory (CDI; Kovacs 1992) and Children's Depression Inventory, Second Edition (CDI-2; Kovacs 2011). Although

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the measures are considered to be well-established in a variety of clinical and non-clinical settings (Sattler and Hoge 2006), little is known about the rates of endorsing suicidal thoughts and/or elevated symptoms of depression on the CDI/CDI-2 by children who suffer from serious neurological conditions.

Approximately one third of children report thinking of suicide at some point of their life and 9.7 % of adolescents admit to a suicide attempt (Evans et al. 2005). The prevalence of reporting suicidal intentions in the most recent 6 months ranges between 4 and 34 % (mean of 17 %), and the prevalence of suicide attempts ranges from 1 to 17 % (mean of 7 %) (Evans et al. 2005). Variability in these rates is related not only to sociocultural, demographic, cognitive, and other factors but also to the methods used in assessing suicidal intent. Moreover, literature concerning suicidal trends typically highlights that population-specific rates may not apply to other populations of interest (Kokkevi et al. 2012).

Children with neurological conditions may be at particular risk of displaying psychological problems due to two factors: (1) neurophysiological changes in the CNS that are secondary to neurological disease and (2) psychosocial stressors related to the medical condition. These two factors belong to the biopsychosocial model of psychopathology. According to its framework, individuals with neurological issues may display more psychological problems than healthy individuals, regardless of the aetiology of the neurological illness (Lezak et al. 2012; Schoenberg and Scott 2011). Although emotional disturbance has been noted in respect to many areas of the CNS, the brain areas that are typically implicated in the development of cognitive and emotional problems involve the orbital medial frontal and dorsolateral frontal lobe networks. Impairments within these networks may result from a wide range of symptoms such as disinhibition, poor social and emotional control, impulsivity and inappropriate sexual and social behaviours (more related to the orbital medial frontal lobe syndrome) as well as abulia, apathy, emotional restriction, motivation, and lack of initiative (more related to the dorsolateral frontal networks). According to the model, the psychosocial component is related to the process of adjustment to the medical condition, impact of the condition on independence and quality of life, social interactions, family interactions, development of maladaptive coping strategies, functional independence, and other factors that affect both the patient and their environment. Both factors of the biopsychosocial model interact with each other to produce psychological symptoms.

Indeed, physical well-being and the presence of neurological conditions are found to significantly affect suicidal intent and behaviour (Bridge et al. 2006; Kanner 2009b; Simpson and Tate 2007). This primarily involves epilepsy, although other conditions such as traumatic brain injury (TBI) are also known for having high rates of suicidal thoughts and behaviours (Kanner 2009a, b; Kerr et al. 2011; Simpson and Tate 2007). When compared to healthy controls, epilepsy patients are at a threefold higher risk of suicide as a cause of death (Christensen et al. 2007) and at a twofold higher risk of suicidal ideation (Nilsson et al. 2002). For TBI, rates of suicidal intent appear to be positively correlated with the severity of neurological impairment and post-injury psychological distress (Simpson and Tate 2007). These rates appear to be further affected by factors such as psychosis, depression, substance abuse, and weaker cognitive functioning (Simpson and Tate 2007).

Suicidal ideations are frequently reported to relate to cognitive factors including problem solving (Marzuk et al. 2005), impulsivity (Horesh et al. 1999; Hull-Blanks et al. 2004), and overall IQ (Alati et al. 2009). Additionally, girls report higher levels of suicidal intentions and behaviours than boys, but boys display higher rates of suicide completion (Evans et al. 2005); furthermore, the rates of suicidal intentions and behaviours increase as children advance into adolescence (Beautrais 2002; Brent et al. 1999; Groholt et al. 1998; Klonsky and May 2010; Shaffer et al. 1996).

To date, multiple studies have used various reporting measures to examine the correlates and potential predictors of suicidal intention reporting in adults with neurological conditions or neurologically healthy children (Alati et al. 2009; Apter et al. 2003; Beautrais et al. 1998, 1999a, b). However, few studies have focused on the rates of suicidal intentions and/or elevated rates of depression as reported on the CDI/CDI-2 in children with serious neurological conditions. Furthermore, few studies have compared the rates of reported suicidal thoughts and/or elevated symptoms of depression among different neurological groups (Brent 1986; Camfield et al. 2002).

This study aims to report the rates of endorsing suicidal intent on the CDI/CDI-2 for a sample of children with specific neurological disorders and to identify specific neuropsychological and demographic correlates. We expected that children with epilepsy would report the highest prevalence of suicidal intentions as compared to other populations. We also predicted higher rates of suicidal ideation in children with lower intellectual functioning and higher impulsivity. Thus, we sought to enhance direct patient care by elucidating the psychological presentation and needs of paediatric patients who present to tertiary care neurology clinics.

Materials and Methods

Participants and Procedure

Data was extracted from an anonymized neuropsychological database that included consecutively referred patients who underwent an assessment between February 2006 and November 2012 at a tertiary care hospital, Alberta Children's Hospital in Calgary, Alberta, Canada. Participants were included if they had a neurological diagnosis (as determined by the treating neurologist, neurosurgeon, or

paediatrician), completed a neuropsychological assessment, and had answered either the CDI (Kovacs 1992) or CDI-2 (Kovacs 2011). If a patient was assessed several times, only the initial assessment was used. This project was granted ethical approval by the University of Calgary Research Ethics Board (REB 13–0792) and informed consent was acquired from parents/guardians.

Measures

The CDI and CDI-2 (Kovacs 1992, 2011) are two consecutive editions of a self-report measure designed to assess the presence of symptoms associated with depression in individuals 7–17 years of age. The CDI and CDI-2 contain 27 and 28 items, respectively. All items included three statements, and respondents were asked to select the statement that best described their feelings. The total raw scores were converted to age- and gender-adjusted *T* scores. Overall *T* scores of 65 or higher were considered clinically elevated (Kovacs 2003).

CDI/CDI-2 contains one item that addresses the level of suicidal thinking/intent, and includes (1) "I do not think about killing myself"; (2) "I think about killing myself but I would not do it"; and (3) "I want to kill myself". For the purpose of the current analysis, endorsement of option 2 or 3 was coded as overall suicidal ideation. Information regarding the inventories, test reliability, and validity can be found in their respective manuals (Kovacs 1992, 2011).

Participants were also administered measures of neurocognitive functioning, including tests of IQ, processing speed, memory, attention, executive functions, adaptive functioning, and externalizing and internalizing behaviours (for the list of included measures, see Table 1). Note that overall IQ score was used only to report the rates of endorsing suicidal ideation and depressive symptoms among children with specific ranges of cognitive functioning. In subsequent statistical calculations, including correlational as well as classification analysis, non-verbal intelligence and verbal intelligence scores were used instead to gain greater specificity in understanding the relationship between specific neurocognitive variables and endorsing the symptoms of suicidal thinking and depression on the CDI/CDI-2.

Analyses

Initial statistics were completed using the Statistical Package for the Social Sciences (SPSS, IBM Corporation 2010). Kolmogorov–Smirnov tests were performed on overall CDI/CDI-2 *T* scores and all other neurocognitive measures to explore distribution normality. Subsequently, Spearman's rho rank correlation coefficients for non-normally distributed data were conducted between overall CDI/CDI-2 *T* score and selected neurocognitive and demographic variables. A Mann–Whitney *U* test was performed to explore significant differences in the CDI/CDI-2 *T* scores across gender. Variables identified as significantly related to overall CDI/CDI-2 *T* score based on Spearman's rho (at the $p<0.05$ level) were utilized in a subsequent classification and regression tree analysis (CART; Breiman et al. 1984; Lemon et al. 2003).

The CART analysis was chosen over logistic regression or discriminant analysis because it is appropriate for non-normal distributions, is considered robust, is able to handle both categorical and continuous variables (Strobl et al. 2008) and missing data (Therneau and Atkinson 2014). The CART analysis incorporates non-linear effects without requiring additional variables or variable transformations; outliers have limited impact on results, and there is no theoretical constraint concerning the number and type of variables to be considered as potential explanatory variables (Breiman et al. 1984). A CART analysis is therefore particularly useful when there are few a priori expectations as to the relationships between variables. By contrast, logistic regression and discriminant analysis are sensitive to non-normal distributions, outliers, and missing data. Through complete case analysis, both typically exclude participants that do not have a data point for every predictor variable, a limitation that CART does not share.

A CART analysis was conducted using the statistical package R (Core Team 2012) to recursively partition groups of variables into progressively more homogenous subgroups by defining thresholds within the predictor variables. The dependent variable used was the absence versus presence of suicidal ideation. Absence of suicidal ideation was defined as selecting option 1 on the CDI: "I do not think about killing myself". Presence of suicidal ideation was defined as either selecting option 2: "I think about killing myself but I would not do it" *OR* selecting option 3: "I want to kill myself". Seven demographic and neuropsychological variables were assigned as the explanatory variables (gender, verbal intelligence, non-verbal intelligence, processing speed, attention, internalizing behaviours, and executive functioning). Selected explanatory variables were independent so as to avoid violating redundancy assumptions, i.e. overall IQ was not included as an explanatory variable since verbal and non-verbal intelligence were included.

CART determines which variable maximizes the homogeneity (and minimizes the heterogeneity) within a given node for the dependent variable. Subsequent splits increase the model's ability to accurately classify data. In the current study, the CART algorithm determined which variable best differentiated between reporting suicidal ideation or not. This variable was then set aside as

Table 1 Measurements of neurocognitive functioning

Cognitive domain	Measure used
Intellectual abilities	Full Scale IQ from WPPSI-III (Wechsler 2004) WISC-IV (Wechsler 2003) WAIS-III/IV (Wechsler 1997a, 2008)
Processing speed	Processing Speed Index from WPPSI-III (Wechsler 2004) WISC-IV (Wechsler 2003) WAIS-III/IV (Wechsler 1997a, 2008)
Verbal intelligence	Verbal Comprehension Index from WPPSI-III (Wechsler 2004) WISC-IV (Wechsler 2003) WAIS-III/IV (Wechsler 1997a, 2008)
Non-verbal intelligence	Perceptual Reasoning Index from WPPSI-III (Wechsler 2004) WISC-IV (Wechsler 2003) WAIS-III/IV (Wechsler 1997a, 2008)
Recall memory	For words, Long Delay Free Recall from CVLT-C (Delis et al. 1994) CVLT-II (Delis et al. 2000) For faces, Faces Delayed from CMS (Cohen 1997) Faces II from WMS-III (Wechsler 1997b)
Attention skills	ADHD Rating Scale-IV (DuPaul et al. 1998)
Executive functions	Global Executive Composite (GEC) from BRIEF (Gioia et al. 2000)
Adaptive functioning	Adaptive Functioning Index from BASC 2 (Reynolds and Kamphus 2004)
Externalizing behaviours	Externalizing Behaviors Index from BASC 2 (Reynolds and Kamphus 2004)
Internalizing behaviours	Internalizing Behaviours Index from BASC 2 (Reynolds and Kamphus 2004)
Inhibition	Inhibition Total Errors from NEPSY, Second Edition (Korkman et al. 2007)
Cognitive flexibility	Cognitive Flexibility Index from CNS Vital Signs (Moresville, NC)

a *terminal node* and the differentiation of the remaining variables was again examined. This iterative process resulted in a tree structure consisting of branches that illustrate the relative contributions of each variable in explaining the likelihood of reporting suicidal ideation. To avoid *over-fitting*, the analysis was automatically terminated when the addition of any more variables did not add any more significantly explanatory nodes (as determined by a plot of relative error and number of splits). No further pruning methods were used. The nodes and the nature of the splits in the resulting tree structure were examined to interpret which variables could most strongly explain the likelihood of reporting suicidal ideation.

To augment the CART, a random forest (RF) analysis (Breiman 2001) was performed. The RF analysis is an iterative bootstrapping procedure that repeatedly performs classification analysis with data subsamples until it converges on a list of explanatory variables. One thousand trees were *grown* and the mean decrease in Gini (a measure of node impurity) was used as a quantifier for the role a predictor plays in partitioning the data into the defined classes (i.e. higher values indicate a more predictive role in the model).

Results

Details of demographic characteristics of the sample are presented in Table 2. Performance on neurocognitive measures, CDI/CDI-2 scores, and rates of suicidal ideation (SI) and suicidal thinking with intent (STWI) are reported in Tables 3 and 4.

Correlations between CDI/CDI-2 overall scores, demographic, and neuropsychological variables are presented in Table 5. CDI/CDI-2 overall scores were significantly

Table 2 Summary demographics of our paediatric neurology patient sample

Demographics	
Age (years), mean±SD (range)	13.0±3.1 (7.0–17.9)
Duration of the medical condition, mean±SD (range)	5.8±4.5 (0–17.65)
Parent education (years), mean±SD (range)	
-Mother	13.7±2.6 (0–20)
-Father	13.6±3.1 (0–20)
Sex (%)	
-Male	50.2
-Female	49.8
Ethnicity (%)	
-Caucasian	60.1
-Asian	3.8
-Middle Eastern	3.2
-Mixed	3.2
-Hispanic	2.2
-African	1.3
-First nations	1.0
-Other	2.9
-Not reported	22.4
Diagnosis (%)	
-Epilepsy	53.4
-TBI	17.3
-General neurology	15.3
-Stroke	8.9
-Hydrocephalus	5.1

correlated with verbal intelligence, non-verbal intelligence, processing speed, attention, parent-rated internalizing behaviours, parent-rated externalizing behaviours, and executive function. In addition, gender differences in endorsing depressive symptoms were identified as significant ($n=299$, $p<0.01$), with females reporting more symptoms of depression than males. These seven variables were used in the subsequent CART analysis, an illustration of which is displayed in Fig. 1. Five of the seven variables were the most important in explaining the likelihood of suicidal ideation in our sample.

In the CART analysis, verbal intelligence was the most explanatory variable indicating that 70 % of the likelihood of reporting suicidal ideation was explained by a child having a verbal intelligence standard score less than 57.5. Of those children with a verbal intelligence standard score above 57.5, executive dysfunction (i.e., scores on the BRIEF-P higher than $T=50.5$) was predictive of 20.5 % of reports of suicidal ideation. The third explanatory variable was gender and indicated that females had a higher likelihood of reporting SI (28.1 %) compared to males (13.6 %). The final factor in explaining the likelihood of SI was parent rating of attention, indicating that 66.7 % of children endorsing suicidal ideation were rated higher than the 98.5th percentile on the attention rating scale.

RF analysis confirmed the CART results, ranking verbal intelligence (mean decrease in Gini index (MDG)=13.17), executive functioning (MDG=11.88), and attention (MDG=11.76) as the top three variables of importance when classifying predictors of suicidal ideation. Of note, non-verbal intelligence (MDG=10.5) and processing speed (MDG=10.44) were also identified as predictors.

Discussion

The current study provides rates and correlates of suicidal ideation reported by children and adolescents on the CDI/CDI-2 seen in a large Canadian tertiary neurological centre. For our sample, the overall rate of reporting recent suicidal ideation was 18.8 %. This falls within the population estimate of 16 to 26 %, which is the 95 % confidence interval of reporting suicidal thoughts of any kind in a large international review of suicidal trends in children (Evans et al. 2005). Although in general, rates of suicidal ideation reported among children with neurological conditions on the CDI/CDI-2 are similar to these observed in other paediatric groups, a closer look at the population breakdown suggests that these rates differ by the type of neurological diagnosis, overall IQ level, and age. As hypothesized, the highest rates of suicidal ideation were reported by children with extremely low overall IQ, although it is questionable whether these endorsements

Table 3 Rates of endorsing suicidal ideation and depressive symptoms

CDI performance	Number	Mean total *T* score	SD	Range	% clinically elevated	% endorsing suicidal ideation (SI)	% endorsing suicidal thinking with intent (STWI)
CDI in overall sample	313	49.9	11.3	34–89	10.2	18.8	1.9
CDI across diagnostic groups							
Epilepsy patients	167	50.9	11.6	35–89	12.0	22.8	3.0
TBI patients	54	50.6	11.5	34–87	11.1	11.1	1.9
General neurology patients	48	48.1	12.3	36–81	10.4	16.7	0.0
Stroke patients	28	48.0	8.4	37–71	3.6	17.9	0.0
Hydrocephalus patients	16	46.2	5.9	37–56	0.0	12.5	0.0
CDI across intellectual groups							
IQ below 2nd percentile	40	54.8	12.7	37–83	20.0	40.0	7.5
IQ between 2nd and 15th percentile	65	50.4	11.0	36–89	9.2	23.1	1.5
IQ at 16th percentile or above	109	48.9	10.4	34–87	9.2	14.7	0.0
CDI across age groups							
Age 7 to less than 10	66	52.3	11.3	37–88	10.6	25.8	3.0
Age 10 to less than 13	87	49.0	10.9	37–82	8.0	24.1	3.4
Age 13 to less than 16	93	48.1	10.6	34–89	7.5	11.8	1.1
Age 16 to less than 18	67	51.3	13.1	36–89	16.4	14.9	0.0

To be considered clinically elevated, CDI total *T* score had to be 65 or above

CDI Children's Depression Inventory, *SD* standard deviation, *%* percent

reflected the actual suicidal intent and/or were made in full understanding of what suicide is.

Our subsequent, more specific classification analysis indicated that 70 % of children with extremely low verbal IQ endorsed some level of suicidal ideation on the measure. Of the remaining sample, the most at risk were girls with significant attention difficulties, with approximately 67 % of these children reporting recent suicidal ideation. Our findings indicate that significant correlates of elevated symptoms of depression are gender, verbal and non-verbal IQ, executive and attention difficulties, and internalizing behaviours. Surprisingly, age and age of onset were not identified in our study as significant correlates of elevated symptoms of depression.

Type of Neurological Diagnosis

With respect to neurological diagnoses, we hypothesized that children with epilepsy would endorse the highest level of suicidal ideation as compared to other groups. Indeed, almost 23 % of children diagnosed with epilepsy reported thinking of suicide, including 3 % of the sample reporting intent for suicide, suggesting that the incidence of suicidal ideation in these children is strikingly higher than among other neurological populations, such as children with TBI or hydrocephalus. This appears to be supported by the literature that provides evidence of children with epilepsy displaying suicidal ideation more often than any other medical group (Nilsson et al. 2002) as well as active suicidal behaviours (Brent 1986) (Christensen et al. 2007). In our study, children with epilepsy also endorsed symptoms of depression at the highest rate when compared to other neurological groups, supporting the notion that epilepsy is related to symptoms of depression (Camfield et al. 2002). This finding is of particular concern as paediatric epilepsy and depression are considered risk factors for suicide later in life. For example, a Swedish cohort study suggested that patients with symptoms of depression who were diagnosed with epilepsy in adolescence were at the highest risk of suicide, particularly in light of limited neurological follow-up (Camfield et al. 2002).

Children with early epilepsy onset and who display a long-standing history of seizures are at a higher risk of cognitive problems, particularly children with difficult-to-control seizures (Baker et al. 2011; Sarkis et al. 2013). This could partially explain why the current study observes the highest rates of suicidal ideation in this population. It is possible that not only epilepsy as a disorder but also its secondary effects on cognition contribute to the observed differences in suicidal ideation among neurological groups. Taken together, these findings illustrate the necessity of preventive programmes, early screening, and access to psychological interventions for these children and highlight the necessity of including psychological services as integral parts of paediatric epilepsy teams.

Intellectual Functioning

Children with overall IQ impairment were at the highest risk of endorsing suicidal ideation, which is supportive of research

Table 4 Cognitive abilities in paediatric neurology patients administered with the CDI

Cognitive domains	Number	Mean	SD	Range	% impaired
Overall intelligence (index score)	214	83.9	17.5	40–128	20.6
Verbal intelligence (index score)	190	84.7	16.1	45–128	20.5
Non-verbal intelligence (index score)	197	87.0	18.1	45–138	18.3
Processing speed (index score)	282	83.2	15.9	42–135	21.6
Verbal memory, word list (*z* score)	261	−0.5	1.2	−4.0–2.0	24.1
Visual memory, faces (scaled score)	193	8.5	3.6	1–17	15.0
Inhibition (scaled score)	151	7.2	4.0	1–15	29.8
Cognitive flexibility (index score)	126	89.0	18.8	29–133	15.1
Attention, parent rating (percentile)[a]	278	71.1	25.6	5–99	11.9
Externalizing behaviours, parent ratings (*t* score)[a]	65	54.4	14.0	36–95	13.8
Internalizing behaviours, parent ratings (*t* score)[a]	65	57.3	13.9	34–88	16.9
Executive functioning, parent rating (*t* score)[a]	279	60.0	11.9	34–92	23.3
Adaptive functioning, parent rating (*t* score)[a]	65	44.8	11.0	21–67	10.8

Impaired is defined as being at or below the 2nd percentile (e.g. 2 standard deviations below the mean). Index scores have a mean=100 and SD=15. Percentile scores have a mean=50 and range from 1 to 99. *T* scores have a mean=50 and SD=10. *Z* scores have a mean=0 and SD=1. Scaled scores have a mean=10 and SD=3.

CDI Children's Depression Inventory

[a] Higher scores are reflective of lower functioning (or more problems)

showing that lower cognitive abilities are significantly related to reporting suicide-related thoughts and depression (Alati et al. 2009; Fergusson et al. 2005a, b; Gunnell et al. 2005). Previous studies clearly show that children with lower IQs are at higher risk of thinking about suicide regardless of the assessment mode (Alati et al. 2009) and suicidal behaviours (Alati et al. 2009; Fergusson et al. 1999; Gunnell et al. 2005; O'Toole and Cantor 1995), particularly in the presence of childhood conduct problems and complicated family social circumstances (Diaconu and Turecki 2009; Fergusson et al. 2005a, b). Our additional finding that verbal and non-verbal IQ are significant predictors of suicidal ideation adds more specificity to such literature. Subsequent studies could further elucidate the relative contributions of each facet of IQ in this population.

Although it should be acknowledged that children with impaired intellectual functioning may either have some difficulty understanding the content of the CDI/CDI-2 questions or

Table 5 Correlations between cognitive domains and overall score of CDI for paediatric neurology patients

Demographic and cognitive domains	Number	Overall CDI score Spearman's rho
Age (years)	313	−0.074
Duration of the medical condition	186	−0.061
Verbal intelligence (index score)	190	−0.170**
Non-verbal intelligence (index score)	197	−0.207**
Processing speed (index score)	282	−0.118*
Verbal memory, word list (*z* score)	261	−0.075
Visual memory, faces (scaled score)	193	−0.020
Inhibition (scaled score)	151	−0.029
Cognitive flexibility (index score)	126	−0.103
Attention, parent rating (percentile)[a]	278	0.211**
Externalizing behaviours, parent ratings (*t* score)[a]	65	0.229
Internalizing behaviours, parent ratings (*t* score)[a]	65	0.403**
Executive functioning, parent rating (*t* score)[a]	279	0.214**
Adaptive functioning, parent rating (*t* score)[a]	65	−0.174

CDI Children's Depression Inventory

*$p<.05$; **$p<.01$

[a] Higher scores represent more problems

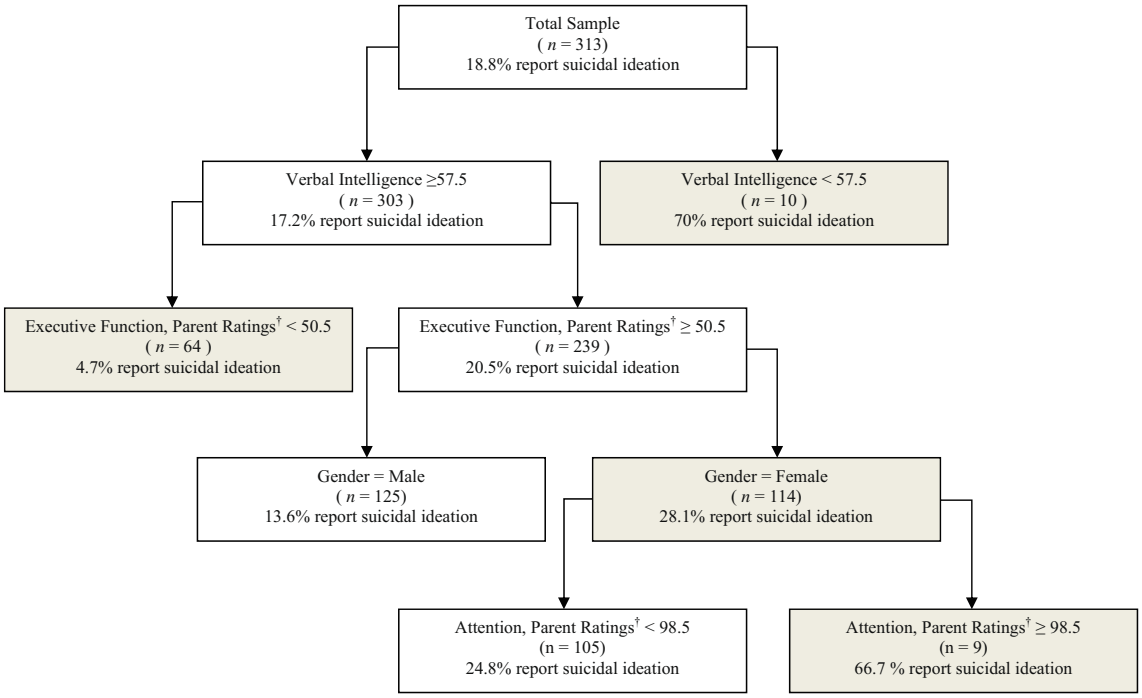

Fig. 1 A simplified classification tree for reported suicidal ideation. *SI* suicidal ideations. *Dagger* indicates that higher scores are reflective of lower functioning (or more problems). *Shaded nodes* indicate nodes of interest

not fully appreciate the meaning of suicide, it does not necessarily mean that these children are not capable of thinking about suicide or engaging in suicidal behaviours. Research shows that this population is vulnerable to developing suicide-related thoughts and engaging in suicidal behaviours, particularly children with severe/profound intellectual deficits (Hardan and Sahl 1999). Previous research shows that approximately 22 % of children with an IQ between 50 and 70 reported thinking about suicide (Pack et al. 1998), and half of the children admitted to inpatient psychiatric units with a dual diagnosis of intellectual disability and psychiatric disorders (ages 6–17; 16 % having severe or profound impairment) displayed concerning levels of suicide-related thoughts and/or suicidal behaviours (Johnson et al. 1995). Rates reported by these studies do not necessary apply to the current population of interest; nevertheless, these studies highlight that regardless of a type of neurological diagnosis, children with intellectual disabilities, including profound and severe disabilities, are at risk of reporting suicide-related thoughts and engaging in suicidal acts.

Age

Depressive symptoms and suicidal ideations did not increase alongside age as suggested by previous research (Beautrais 2002; Brent et al. 1999; Groholt et al. 1998; Klonsky and May 2010; Shaffer et al. 1996). In fact, children between ages 7 and 9 reported more suicidal ideations than the older groups, although age was not significantly correlated with symptoms of depression. Although it is possible that very young children may not be aware of the full meaning behind the concepts of suicide, it is documented that children as young as 7 years old are capable of suicide-related thoughts (Kovacs 2011) and behaviours (Giraud et al. 2013). Within the Canadian population, it has been reported that children as young as 5 years old do attempt suicide (Stewart et al. 2001), suggesting that even if very young children may not have full understanding of the consequences of suicidal behaviour, they do intentionally engage in them. This suggests that any reports of suicide-related thoughts by these children should not be automatically dismissed as invalid. Rather, closer attention should be given to the reasons behind reporting suicidality and full assessment options should be available for these patients.

Correlates of Suicidal Ideation on the CDI/CDI-2 and Symptoms of Depression

In the current analyses, internalizing behaviours observed by a parent did significantly correlate with patient-reported depressive symptoms, but were not sufficiently explanatory according to the CART analysis. This suggests that parents perceive symptoms of internalizing behaviours, including symptoms of depression; however, parental perception of internalizing behaviours does not effectively identify the groups of children who are at risk of reporting suicidal ideation on the CDI/CDI-2. Thus, stand-alone parental ratings of internalizing behaviours may not be a strong predictor of suicidal ideation in youth, and psychological assessments should be conducted

with children regardless of their parents' perception of their symptoms of mood problems.

The current study highlights the risk of endorsing suicidal ideation in females who display significant attention problems. This finding is not surprising, as girls consistently report higher levels of suicide-related thoughts and behaviours than boys (Evans et al. 2005). Although symptoms of attention problems significantly predict suicidal behaviours (Horesh et al. 1999; Hull-Blanks et al. 2004; Renaud et al. 2008), this finding is typically associated with males, and this study suggests that females with attention issues may also be at risk.

Limitations

It is thought that children with low IQ display high rates of psychopathology, placing them at higher risk of depression and suicide, particularly if they present with depressive symptoms, past sexual or physical abuse, presence of oppositional-defiant disorder, recent family loss, sleep problems, social withdrawal, comorbid affective disorders, female gender, and younger age (Hardan and Sahl 1999; Hassiotis et al. 2011; Johnson et al. 1995; Seltzer et al. 2005; Walters et al. 1995). The current project was not able to address all of these factors, and therefore, it is possible that the relatively small correlations observed are attributable to the limited number of variables used. Future projects should strive to create inclusive models by using neurocognitive, social, psychological, and demographic variables as well as additional cognitive domains such as social problem solving or planning abilities. Moreover, past research indicates that thinking about suicide and depression may be moderated by social, family, and economic variables, as well as comorbid psychiatric issues, which was not explored in the current project (Fergusson et al. 2005a, b).

Since this study focused on the CDI/CDI-2, the reported rates of suicidal ideation may not reflect rates of suicide-related thoughts that are measured via anonymous questionnaires or direct interview. Another serious limitation of this project is a lack of a healthy control comparison group. The current study was conducted using a Canadian tertiary neurology sample and may not reflect rates among tertiary neurological populations in other countries (Evans et al. 2005). Finally, the CART analysis is considered an exploratory technique and does not offer predictability statistics (Dietterich 2000). As such, future studies should investigate whether the current findings can be confirmed with predictive analyses such as RF.

Conclusions

The prevalence of reporting suicide-related thoughts on the CDI/CDI-2 in our paediatric neurological population is about 20 %, with 10 % of children reporting clinically elevated symptoms of depression. The results suggest that some personal variables, such as gender, IQ, and attention problems, as well as the presence of specific neurological diagnosis can help predict which children are more likely to report thoughts related to suicide. However, the results also suggest some caution in relying exclusively on parental reports as they may not be effective at identifying children who are at risk. Overall, the results support the notion that children who display neurological impairment should be routinely screened for signs of depression and suicide-related thoughts regardless of age and parental reports.

Compliance with Ethical Statement All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients and their legal guardians for being included in the study. No animal studies were carried out by the authors for this article.

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Conflict of Interest Anya Mazur-Mosiewicz, Helen L. Carlson, Cailey Hartwick, Christianne Laliberte, Emily Tam, Elisabeth M.S. Sherman, and Brian L. Brooks declare that they have no conflict of interest.

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