Academic achievement in children with sickle cell disease: a meta-analysis

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Objective: To assess the impact of sickle cell disease (SCD) on academic achievement measures via a meta-analysis of published studies.
Methods: Six published studies were identified that assessed reading decoding and mathematical computation skills in children with SCD and no history of stroke as compared to demographically-matched children without SCD. Data were pooled based on a grand total of 210 children with SCD and 141 comparison children.
Results: Children with SCD showed lower achievement for reading decoding, but not mathematical computation ability. Reading decoding scores were on average approximately 6 standard score points below the comparison group, whereas math scores were less than 2 standard score points below the comparison group.
Conclusions: Children with SCD as a group have specific difficulties with developing reading skills. Recent reports indicating poor development of vocabulary and auditory processing skills in children with SCD are consistent with this finding. Preschool interventions should be developed to screen pre-reading skills in children with SCD and to intervene when warranted.

Key words: academic achievement, sickle cell disease

Cognitive functioning has become an important outcome variable for studying the functional impact of SCD on the brain (e.g., Armstrong et al., 1996; Bernaudin et al., 2000; Brown et al., 1993, 2000; DeBaun et al., 1998; Hariman et al., 1991; Steen et al., 1999, 2003; Wang et al., 2001). Decrements in cognitive functioning have been associated with several aspects of the disease, including occurrence of overt stroke (Armstrong et al., 1996; Bernaudin et al., 2000; Brown et al., 2000; Hariman et al., 1991), the presence of silent cerebral infarcts (Armstrong et al., 1996; Bernaudin et al., 2000; Brown et al., 2000; DeBaun et al., 1998), or lower hematocrit levels (Bernaudin et al., 2000, Brown et al., 1993; Steen et al., 1999, 2003).

Psychometric tests of academic skills are also frequently used as a functional outcome measure to determine if disease effects are impacting learning in school. Individually administered academic skills tests have been used most often (Armstrong et al., 1996; Brown et al., 1993, 2000; Devine et al., 1998; Fowler et al., 1988; Wang et al., 2001), although group administered tests have also been used (Fowler et al., 1985; Richards & Burlew, 1997). Studies comparing children with SCD and no history of stroke to peers without SCD have generally had small sample sizes and have come to inconsistent conclusions about group differences. Therefore, I conducted the following meta-analysis to determine if meta-analytic procedures might aid in interpreting these data.

Method

Identification of studies

PsychLit and Medline databases as of January 2003 were reviewed with the key words "sickle cell" combined with each of the following: "academic", "achievement", "cognitive", "neuropsychologic", and "school". Thirteen studies were identified that included data on academic achievement scores for children with SCD (Armstrong et al., 1996; Brown et al., 1993, 2000; Devine et al., 1998; Fowler et al., 1985, 1988; Nabors & Freymuth, 2002; Nettles, 1994; Noll et al., 2001; Swift et al., 1989; Richards & Burlew, 1997; Wang et al., 2001; Wasserman et al., 1991). Among these studies six had either a demographically-matched sample of siblings or a demographically-matched sample of peers (see Table 1).

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Mean scores for reading decoding measures and mathematical calculation were available from all six studies. Grand means and pooled standard deviations were computed for each academic skills measure in each group with the scores weighted according to the number of participants in the study. Grand means and pooled standard deviations were compared via *t*-tests.

Table 1. Data from six previous studies examining individually-administered academic achievement tests of reading and mathematics in children with sickle cell disease (SCD) compared to demographically matched comparison children (Ctrl).

Study	Test	N SCD, Ctrl	Reading score - SCD	Reading score - Ctrl	Difference Reading	Math score - SCD	Math score - Ctrl	Difference Math
Fowler et al., 1988	WRAT	28, 28	91.6 (16.5)	104.3 (17.1)	-12.7*	83.9 (14.8)	84.3 (18.4)	-0.4
Swift et al., 1989	WJ	24, 21	81.5 (12.3)	91.8 (14.8)	-10.3*	78.4 (11.0)	92.6 (7.8)	-14.2*
Wasserman et al., 1991	WRAT	43, 30	90.3 (14.7)	94.3 (17.7)	-4.0	82.5 (13.3)	86.2 (16.0)	-3.7
Brown et al., 1993	K-ABC	70, 18	95.0 (14.4)	109.5 (24.6)	-14.5*	94.1 (13.3)	91.6 (13.5)	+2.5
Noll et al., 2001	WRAT-R	31, 31	87.5 (16.9)	90.4 (17.9)	-2.9	80.9 (14.5)	85.5 (15.0)	-4.6*
Nabors & Freymuth, 2002	WRAT-R	14, 13	81.3 (13.3)	85.1 (14.1)	-3.8	82.0 (11.1)	89.0 (20.0)	-7.0
Total	- - -	210, 141	90.0 (14.9)	96.2 (18.0)	-6.2[a]	85.8 (13.3)	87.6 (15.5)	-1.8[b]

Notes: WRAT = Wide Range Achievement Test, WJ = Woodcock-Johnson Tests of Achievement, K-ABC = Kaufman Assessment Battery for Children; Comparison groups were siblings except for Fowler, 1988 and Noll, 2001, who used demographically similar classmates.
*Differences between groups were reported in individual study results. [a] $p < .001$; [b] n.s.

Results and Discussion

Mean scores for reading were lower for children with SCD than for comparison children, $t(350) = -3.49$, $p < .001$. Mean scores for mathematics did not differ, $t(350) = -1.13$, n.s. The average effect size for reading was $d = .382$, which was approximately three times larger than the effect size for mathematics ($d = .127$). An effect size of .382 corresponds to approximately 25% non-overlap between the two distributions (Cohen, 1988).

The specific difficulty with reading is a different outcome than one might expect based on studies within subgroups of children with SCD. For example, children with silent cerebral infarcts appear to have lower performance in mathematics relative to children with SCD without infarcts on structural neuroimaging (Armstrong et al., 1996; Wang et al., 2001). This suggests that factors other than focal cerebral vascular injury may be responsible for the effect of SCD on reading achievement. Studies of specific cognitive functions in SCD have identified difficulties relative to peers in areas such as vocabulary (Noll et al., 2001; Wang et al., 2001; Schatz et al., in press) and auditory discrimination (Steen et al., 2002; Swift et al., 1989) that are key skills for acquiring reading proficiency (Lundberg, 2002). It is possible that these cognitive deficits may be related to more diffuse effects of SCD on the brain (Steen et al., 1998, 1999, 2003), rather than focal cerebral vascular injury. Alternately, there may be interactions of the disease with social or environmental factors that are responsible for difficulties with reading. Future studies are needed to evaluate these possibilities.

Cognitive ability (Thompson et al., 2002) and pre-reading skills (Steen et al., 2002) may be affected by SCD during the preschool period. These data along with the current study indicating subsequent reading deficits suggest that children with SCD should be screened during the preschool years for signs of delays in school readiness skills. Cost effective early intervention programs have been shown to have a significant impact on reading development (Nicolson et al., 1999), and could be offered to ameliorate this effect on academic achievement.

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