Review article

The impact of epilepsy on academic achievement in children with normal intelligence and without major comorbidities: A systematic review

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ABSTRACT

Purpose: To systematically examine published literature which assessed the prevalence of academic difficulties in children with epilepsy (CWE) of normal intelligence, and its associating factors.

Methods: A search was conducted on five databases for articles published in English from 1980 till March 2015. Included were studies who recruited children (aged 5–18 years), with a diagnosis or newly/recurrent epilepsy, an intelligent quotient (IQ) of ≥70 or attending regular school, with or without a control group, which measured academic achievement using a standardised objective measure, and published in English. Excluded were children with learning difficulties, intellectual disabilities (IQ < 70) and other comorbidities such as attention deficit hyperactive disorder or autism. Two pairs of reviewers extracted the data, and met to resolve any differences from the data extraction process.

Results: Twenty studies were included. The majority of the studies assessed “low achievement” whilst only two studies used the IQ-achievement discrepancy definition of “underachievement”. Fourteen studies (70%) reported that CWE had significantly lower academic achievement scores compared to healthy controls, children with asthma or reported norms. The remaining six studies (30%) did not report any differences. CWE had stable academic achievement scores over time (2–4 years), even among those whose seizure frequency improved. Higher parental education and children with higher IQ, and had better attention or had a positive attitude towards epilepsy, were associated with higher academic achievement score. Older children were found to have lower academic achievement scores.

Conclusions: In CWE of normal intelligence, the majority of published literature found that academic achievement was lower than controls or reported norms. The high percentages of low achievement in CWE, especially in the older age group, and the stability of scores even as seizure frequency improved, highlights the need for early screening of learning problems, and continued surveillance.

Keywords:
Academic achievement
Low achievement
Underachievement
Epilepsy
Normal intelligence

ARTICLE INFO

1. Introduction

Academic difficulty has been reported among children with epilepsy (CWE), even when these children have normal intelligence (i.e. an IQ ≥ 70) (Fastenau et al., 2008; McNelis et al., 2005; Mitchell et al., 1991), particularly in mathematics and reading (Fastenau et al., 2008; Jackson et al., 2013; Puka et al., 2015). However, studies on academic achievement in childhood epilepsy have relied on subjects recruited from clinical settings which tend to include CWE who have below average intelligence (an IQ < 70) (Fastenau et al., 2008; McNelis et al., 2005; Reilly et al., 2014). Therefore, the true prevalence of academic difficulties in CWE of normal intelligence is not known. In a community based study conducted in the United States, CWE were found to have a high rate of school difficulties and grade repetition (Russ et al., 2012). If CWE are unable to progress as well as their peers in school, and tend to drop out of school earlier, it may impact on their social outcomes as they progress into adulthood (Sillanpaa et al., 1998).

A study in the United Kingdom found that 31% of adults who had childhood epilepsy pursued higher education, compared to 48% of normal population (Chin et al., 2011). The same study showed the unemployment rate among adults with childhood epilepsy was 23% as compared with only 9% of the normal population (Chin et al., 2011). Due to the nature of epilepsy as a disease, and the side effects of its treatment, CWE may have specific learning problems such as inattention and working memory that influence on classroom learning and academic achievement (Reilly and Neville, 2011), Although seizure
variables (e.g. age of seizure onset, effects of antiepileptic drug) may affect academic achievement, study findings are conflicting (Aldenkamp et al., 2005; Williams et al., 2001).

Family factors may also contribute to academic difficulties in CWE (Chambers et al., 2014; McNelis et al., 2005; Mitchell et al., 1991). Negative parenting such as harsh or inconsistent methods on how a parent disciplines a child, may deter a child from learning (Oostrom et al., 2003). A parent’s mental health may also affect the child. Greater parent’s anxiety may cause a child with epilepsy to withdraw from society and learning, as CWE usually internalize their anxiety and depression, thus making learning more difficult (Dunn et al., 2010). Mitchell et al. (1991) reported that encouragement from parents, as well as family participation in promoting positive emotional and physical growth in CWE, may promote better academic achievement.

Child psychosocial and school factors may also have a significant impact on academic achievement. CWE who have negative attitudes toward their illness, have a low self-esteem, and poor motivation have poorer academic achievement (Austin et al., 1998). These children will feel less positive about school as they are worried about how they will perform in examinations, are anxious when their teacher calls on them to answer questions (Austin et al., 1998). McNelis et al. (2005) suggested that teacher’s involvement in assessing and monitoring CWE who are at risk for academic difficulties is important to help CWE success in academic achievement (McNelis et al., 2005).

A search of published literature revealed that to date, no systematic review has been performed on the impact of epilepsy on academic achievement in children with epilepsy and normal intelligence (IQ ≥ 70). A literature review by Reilly et al. in 2011 included studies which utilized both subjective (such as teacher’s reports) and objective measures of academic achievement, and recruited mixed population of children that attended normal as well as special education schools (Reilly and Neville, 2011).

The objective of this review is to systematically examine published literature which focused on the academic achievement in CWE with normal intelligence (IQ ≥ 70) and without comorbidities, with respect to the prevalence of academic difficulties, and the possible factors associated with academic achievement.

2. Methods

2.1. Type of outcome

The types of patient outcome assessed were the scores of academic achievement based on standardized objective instruments in CWE.

2.2. Type of study

The type of study included were cross sectional and longitudinal studies.

2.3. Search strategies

The PRISMA guideline was used to guide our search strategy (Moher et al., 2009). A search was conducted on 5 databases: ERIC, PubMed, CINAHL, WoS, and PsycINFO for all studies assessing academic achievement in CWE, until March 2015. Medical Subject Headings (MESH) definitions of ["epilep*", "seizure"] and ["child*", "school-child*", "school age*", "preschool*", "kid*", "adoles*", "teen*", "boy*", "girl*", "paediatric*", "school", "primary school*", "secondary school*", "elementary school*", "high school*"] was used to define the study population. In addition, specific MESH definitions to describe outcomes such as ["academic", "education", "cognition", "achievement", "underachievement", "assessment", "low achievement"].

2.4. Inclusion and exclusion criteria

Published articles which met the following criteria were considered for inclusion: cross sectional and longitudinal studies, in English, conducted in children with a diagnosis or newly or recurrent epilepsy, aged 5–18 years, with an IQ ≥ 70 and attending regular school, with or without a control group, and which measured academic achievement using a standardised objective instrument (A child was considered to have epilepsy when diagnosed by a paediatric neurologist). Only studies published as full text article were included. Entire papers were read before they were included. Excluded were children with learning difficulties, intellectual disabilities (IQ < 70) and other comorbidities such as autism. In addition, studies which reported on academic achievement measurement using unstandardized subjective instrument and article published only in abstract were excluded.

2.5. Data extraction

Two forms were used to extract data: the “Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies” (NIH, 2004) and a self-developed data extraction form.

These forms were pilot-tested on five randomly-selected studies. Two pairs of reviewers (SW/WYL and LCO/PSML) extracted data from each study. The two pairs then met to resolve any differences from the data extraction process. Due to substantial heterogeneity in the study design and outcomes measure of the articles reviewed, no attempt was made to summarize the data using meta-analysis.

3. Results

The number of studies which met the review inclusion criteria is shown in Fig. 1.

3.1. Study characteristics of included studies

Out of 20 studies, 13 studies were conducted in the United States (Austin et al., 1998, 1999; Bailet and Turk, 2000; Caplan et al., 2006; Drewel et al., 2009; Hermann et al., 2008; Jackson et al., 2013; Jones et al., 2010; Mitchell et al., 1991; Schoenfeld et al., 1999; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996), three in the Netherlands (Aldenkamp et al., 2005; Braakman et al., 2012; Overvliet et al., 2011), two in Brazil (Miziara et al., 2012; Tedrus et al., 2009), one in Jamaica (Chambers et al., 2014), and one in Turkey (Gulgonen et al., 2000).

Fifteen studies were conducted at a single site (a public hospital) (Aldenkamp et al., 2005; Bailet and Turk, 2000; Braakman et al., 2012; Chambers et al., 2014; Gulgonen et al., 2000; Hermann et al., 2008; Jackson et al., 2013; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Seidenberg et al., 1986; Tedrus et al., 2009; Williams et al., 2001; Williams et al., 1996). The remaining 5 studies were conducted in more than one site: two were conducted in both a public and private hospital (Austin et al., 1998, 1999), one was conducted in a public hospital, private hospital and the community (Caplan et al., 2006; Jones et al., 2010), whilst one was conducted in a public hospital, private hospital and school (Drewel et al., 2009).

Sixteen were cross sectional studies (Aldenkamp et al., 2005; Austin et al., 1998; Braakman et al., 2012; Caplan et al., 2006; Chambers et al., 2014; Drewel et al., 2009; Gulgonen et al., 2000; Jackson et al., 2013; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Seidenberg et al., 1986; Tedrus et al., 2009; Williams et al., 2001; Williams et al., 1996), and four were longitudinal studies (Austin et al., 1999; Bailet and Turk, 2000; Hermann et al., 2008; Jones et al., 2010) (Tables 1 and 2, respectively).

Twelve out of 20 studies had a control group (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Bailet and Turk, 2000; Chambers et al., 2014; Caplan et al., 2006; Drewel et al., 2009; Hermann et al., 2008; Jackson et al., 2013; Jones et al., 2010; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Seidenberg et al., 1986; Tedrus et al., 2009; Williams et al., 2001; Williams et al., 1996), two were conducted in both a public and private hospital (Austin et al., 1998, 1999), one was conducted in a public hospital, private hospital and the community (Caplan et al., 2006; Jones et al., 2010), whilst one was conducted in a public hospital, private hospital and school (Drewel et al., 2009).
2014; Gulgonen et al., 2000; Hermann et al., 2008; Jackson et al., 2013; Jones et al., 2010; Miziara et al., 2012; Schoenfeld et al., 1999; Tedrus et al., 2009), whilst the remaining eight studies which did not have a control group, compared their academic achievement scores with normal means (Braakman et al., 2012; Caplan et al., 2006; Drewel et al., 2009; Mitchell et al., 1991; Overvliet et al., 2011; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996). Of the 12 studies that had a control group, nine studies used healthy children as controls (Aldenkamp et al., 2005; Chambers et al., 2014; Gulgonen et al., 2000; Hermann et al., 2008; Jackson et al., 2013; Jones et al., 2010; Miziara et al., 2012; Schoenfeld et al., 1999; Tedrus et al., 2009), whilst three studies used children with asthma or migraine as controls (Austin et al., 1998, 1999; Bailey and Turk, 2000).

Five out of 20 studies reported the response rates of their participants upon recruitment (range: 50.1%–97.0%) (Chambers et al., 2014; Drewel et al., 2009; Jackson et al., 2013; Mitchell et al., 1991; Miziara et al., 2012). However, only two studies performed a sample size calculation (range: 42–220) (Aldenkamp et al., 2005; Chambers et al., 2014). Participants were followed up for two (Hermann et al., 2008; Jones et al., 2010), three (Bailey and Turk, 2000), and four years (Austin et al., 1999), respectively in the longitudinal studies.

3.2. Low achievement and underachievement in children with epilepsy

Out of 20 studies, only 18 studies assessed low achievement in CWE: 11 and four studies compared the expected mean score of CWE with controls (Austin et al., 1998, 1999; Bailey and Turk, 2000; Chambers et al., 2014; Gulgonen et al., 2000; Hermann et al., 2008; Jackson et al., 2013; Jones et al., 2010; Miziara et al., 2012; Schoenfeld et al., 1999; Tedrus et al., 2009), and reported norms (Caplan et al., 2006; Drewel et al., 2009; Williams et al., 2001; Williams et al., 1996), respectively, whilst three assessed educational delay (Aldenkamp et al., 2005; Braakman et al., 2012; Overvliet et al., 2011).

Two studies assessed underachievement by using the IQ-achievement discrepancy definition cutoff score of 0.5 standard deviation (Mitchell et al., 1991) and 1.0 standard deviation (Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996).
Table 1
Cross sectional studies (n = 16) which assessed the academic achievements of children with epilepsy.

<table>
<thead>
<tr>
<th>Author(s) year</th>
<th>Setting</th>
<th>Population (sample size)</th>
<th>Control group</th>
<th>Instrument(s) used</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldenkamp et al. (2005)</td>
<td>Public hospital, The Netherlands</td>
<td>Children aged 6–12 years (n = 176): PE (n = 121); IGE (n = 30); SGE (n = 25)</td>
<td>Healthy controls (n = 113)</td>
<td>Tempotest</td>
<td>Low achievement in CWE in comparison with healthy controls: Difference of 12 months in educational delay (mathematics and reading subscales) between the 2 groups. Children with PE had 14 months educational delay; whilst children with SGE had 26 months educational delay, compared to healthy controls. No educational delay was found in children with IGE.</td>
</tr>
<tr>
<td>Austin et al. (1998)</td>
<td>Public and private clinics, USA</td>
<td>Children aged 6–12 years (n = 225): CWE (n = 117) Children with asthma (n = 108)</td>
<td>Children with asthma (n = 108)</td>
<td>CAT and ITBS</td>
<td>CWE had significantly lower achievement scores in reading and mathematics subscales than children with asthma.</td>
</tr>
<tr>
<td>Braakman et al. (2012)</td>
<td>Public hospital, the Netherlands</td>
<td>Children aged 6–16 years (n = 50): children with FLE (n = 50)</td>
<td>None</td>
<td>Tempotest</td>
<td>Low achievement in CWE in comparison of reference value, score &lt; 80 indicates delay of academic achievement Children with FLE performed worse in reading and mathematics, which was significantly lower than the reference values on all subtests. Scores were lowest in participants with the highest seizure activity. CWE demonstrated academic achievement within average range.</td>
</tr>
<tr>
<td>Caplan et al. (2006)</td>
<td>Public hospital, community services and private practices, USA</td>
<td>Children aged 5.1–16.3 years (n = 149): children with CPS (n = 93)&amp; PGE (n = 56)</td>
<td>None</td>
<td>WIAT Screener</td>
<td>There was no significant difference in academic achievement (reading, spelling, and mathematics) between children with CPS and PGE. CWE did not score significant lower in mathematics compared to healthy controls. Low achievement was defined as lower than expected mean (SD): 100(50)</td>
</tr>
<tr>
<td>Chambers et al. (2014)</td>
<td>Public hospital, Jamaica</td>
<td>Children aged 7–12 years (n = 66): children with GE and children with PE (n = 33) Children aged 8.5–15.1 years (n = 173): children with GTCS, myoclonic or atonic (n = 26), CPS or SPS (n = 107) and AS (n = 40)</td>
<td>Healthy controls (n = 33)</td>
<td>WRAT-3 math expanded WJR</td>
<td>CWE scored lower than expected mean (SD) in reading [92.7(17.5)], mathematics [92.9(20.6)], and written language [84.0(16.4)] subtests.</td>
</tr>
<tr>
<td>Drewel et al. (2009)</td>
<td>Public clinics, private practices, and schools, USA</td>
<td>Children aged 8.5–15.1 years (n = 173): children with GTCS, myoclonic or atonic (n = 26), CPS or SPS (n = 107) and AS (n = 40)</td>
<td>None</td>
<td>WRAT-3, mathematics subscale only</td>
<td>There was no significant difference in mathematics score between CWE and healthy controls. However, the performance in CWE was significantly inferior to healthy controls in the mental mathematics but not written mathematics.</td>
</tr>
<tr>
<td>Gulgonen et al. (2000)</td>
<td>Public hospital, Turkey</td>
<td>Children aged 6–14 years (n = 42): children with IOLE (n = 21)</td>
<td>Healthy controls (n = 21)</td>
<td>WRAT-3, mathematics subscale only</td>
<td>Low achievement was defined as 0.5 SD below the expected score based on IQ level. The percentage of CWE who were underachieving were greatest in general knowledge (50%), followed by reading comprehension (38%), mathematics (31%), spelling (32%) and reading (16%)</td>
</tr>
<tr>
<td>Jackson et al. (2013)</td>
<td>Public hospital in USA</td>
<td>Children aged 8–18 years (n = 166) Children with IGE: JME (n = 26) and CAE (n = 11) and children with ILRE BECTS (n = 22) and PE (n = 31)</td>
<td>Healthy controls (n = 72)</td>
<td>WRAT-3</td>
<td>Children with IGE performed significantly worse than healthy controls in spelling and mathematics, where mathematics showed the greatest discrepancies from healthy controls. Participants with ILRE scored significantly worse than healthy controls in mathematics. Participants with IGE scored significantly lower than ILRE participants only in the mathematics subtest. Further analysis showed that all the sub-syndromes of IGE &amp; ILRE (CAE, BECT, JME &amp; FE) scored significantly lower in mathematics compared to healthy controls. Children with CAE had significant lower score in spelling compared to healthy controls.</td>
</tr>
<tr>
<td>Mitchell et al. (1991)</td>
<td>Public hospital in USA</td>
<td>Children aged 5–13 years (n = 78) with CWE (n = 78)</td>
<td>None</td>
<td>PIAT</td>
<td>Academic underachievement was defined as 0.5 SD below the expected score based on IQ level. The percentage of CWE who were underachieving were greatest in general knowledge (50%), followed by reading comprehension (38%), mathematics (31%), spelling (32%) and reading (16%)</td>
</tr>
<tr>
<td>Miziara et al. (2012)</td>
<td>Public hospital, Brazil</td>
<td>Children aged 7–13 years (n = 71): children with BECTS (n = 30)</td>
<td>Healthy controls (n = 41)</td>
<td>SPT</td>
<td>The BECTS group had a significantly lower mean SPT score (composite of reading, mathematics, and writing subscales) than that of the healthy controls group. Low achievement in CWE with scores of &lt; 100 was considered</td>
</tr>
<tr>
<td>Overvliet et al. (2011)</td>
<td>Public hospital, the Netherlands</td>
<td>Children aged 6.5–13 years (n = 48) with children with RE</td>
<td>None</td>
<td>Tempotest</td>
<td></td>
</tr>
<tr>
<td>Author(s) year</td>
<td>Setting</td>
<td>Population (sample size)</td>
<td>Control group</td>
<td>Instrument(s) used</td>
<td>Outcome</td>
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<td>(2011)</td>
<td>Netherlands</td>
<td>(n = 48)</td>
<td></td>
<td></td>
<td>have an educational delay, &lt; 50 indicates reading or mathematic deficits. Children with RE has significant impairment in reading (delay mean of 8.6 months in reading sentences and delay mean of 6 months in reading words) compared to mathematics (delay mean of 4.1 months). The finding indicated that RE is a language-related learning disorder but not a general learning disorder.</td>
</tr>
<tr>
<td>Schoenfeld et al. (1999)</td>
<td>Public hospital, USA</td>
<td>Children aged 7–16 years (n = 84): children with CPS (n = 57) and children with PS (n = 27)</td>
<td>Healthy controls (n = 27)</td>
<td>WRAT-3</td>
<td>When IQ was used as covariance, children with CPS performed significantly worse than the healthy controls in academic achievement (reading, spelling and mathematics subscales). Academic underachievement was defined as a cutoff of 1 SD below the expected score based on IQ level of CWE. CWE were making less academic progress than expected for their age and IQ level.</td>
</tr>
<tr>
<td>Seidenberg et al. (1986)</td>
<td>Public hospital, USA</td>
<td>Children aged 7–15 years (n = 122): children with GS (n = 72) and children with PS (n = 50)</td>
<td>None</td>
<td>WRAT and PIAT</td>
<td>Academic deficiencies were greatest in mathematics, followed by spelling, reading, comprehension and word recognitions. Low achievement in CWE in comparison with healthy control, using two categories: best 75% (superior or average) and lowest 25% (inferior). There was no significant differences in the mathematics subtest in children with BECTS compared to healthy controls. However, performance in reading and writing were frequently inferior for children with BECTS. Low achievement was defined as lower than expected mean (SD): 100(50). CWE demonstrated academic achievement within average range which was comparable to national norms.</td>
</tr>
<tr>
<td>Tedrus et al. (2009)</td>
<td>Public hospital, Brazil</td>
<td>Children aged 8–11 years (n = 69), children with BECTS without educational problem (n = 31)</td>
<td>Healthy controls (n = 30)</td>
<td>SPT</td>
<td>Low achievement in CWE in comparison with healthy control, using two categories: best 75% (superior or average) and lowest 25% (inferior). There was no significant differences in the mathematics subtest in children with BECTS compared to healthy controls. However, performance in reading and writing were frequently inferior for children with BECTS. Low achievement was defined as lower than expected mean (SD): 100(50). CWE demonstrated academic achievement within average range which was comparable to national norms.</td>
</tr>
<tr>
<td>Williams et al. (2001)</td>
<td>Public hospital, USA</td>
<td>Children aged 8–13 years (n = 65): children with CPS (n = 44) and GS (n = 21)</td>
<td>None</td>
<td>WJR</td>
<td>Low achievement in CWE in comparison with national norms. Overall achievement scores for the sample were in average range for reading (45%), mathematics (46%), language (50%), spelling (49%) and the basic battery (46%). However, children with poorly controlled seizures had significantly lower scores in reading compared to children with adequate seizure control.</td>
</tr>
<tr>
<td>Williams et al. (1996)</td>
<td>Public hospital, USA</td>
<td>Children aged 5.11–16.2 years (n = 84): children with CPS or AS disorders: controlled CPS (n = 22), controlled AS (n = 22), uncontrolled CPS (n = 21), and uncontrolled AS (n = 19).</td>
<td>None</td>
<td>ITBS, Stanford 8, MAT 7, and CTBS 4</td>
<td>Low achievement in CWE in comparison with national norms. Overall achievement scores for the sample were in average range for reading (45%), mathematics (46%), language (50%), spelling (49%) and the basic battery (46%). However, children with poorly controlled seizures had significantly lower scores in reading compared to children with adequate seizure control.</td>
</tr>
</tbody>
</table>

Note: PE, Partial epilepsy; IGE, Idiopathic generalized epilepsy; SGE, Symptomatic generalized epilepsy; USA, United States of America; CWE, Children with epilepsy; CAT, California Achievement Test; ITBS, Iowa Tests of Basic Skills; PLE, Frontal lobe epilepsy; CPS, Complex partial seizure; PGE, Primary generalized epilepsy with absence; WIAT, Wechsler Individual Achievement Test; WRAT-3, Wide Range Achievement Test-3; GE, Generalized epilepsy; SD, Standard deviation; GTCS, Generalised tonic clonic seizures; SPS, Simple partial seizure; AS, Absence seizure; WJR, Woodcock-Johnson Test of Achievement- Revised; IOLE, Idiopathic occipital lobe epilepsy; JME, Juvenile myoclonic epilepsy; CAE, childhood absence epilepsy; ILIE, Idiopathic localized related epilepsy; BECTS, Benign epilepsy with centro-temporal spikes; FE, Focal epilepsy; PIAT, Peabody Individual Achievement Test; SPT, School Performance Test; RE, Rolandic epilepsy; PS, Partial seizure; WRAT, Wide Range Achievement Test; Stanford 8, Stanford Achievement Test 8th edition; MAT 7, Metropolitan Achievement Test 7th edition; CTBS 4, Comprehensive Tests of Basic Skills 4th edition.
Table 2
Longitudinal studies (n = 4) on academic achievement in children with epilepsy.

<table>
<thead>
<tr>
<th>Author(s) year</th>
<th>Study design, setting</th>
<th>Duration, number of times followed up</th>
<th>Population (sample size)</th>
<th>Instrument(s) used</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austin et al. (1999)</td>
<td>Public and private clinics, USA</td>
<td>4 years, at baseline and after 4 years</td>
<td>Children aged 12-17 years (n = 194): CWE (n = 98); controls: Children with asthma (n = 96)</td>
<td>CAT, ITBS, and ISTEP</td>
<td>Twice as many CWE (44%) repeated at least one grade at school, as compared to children with asthma (22.5%). 4 years later, CWE continued to perform significantly worse in all five achievement areas: composite, reading, mathematics, language and vocabulary) compared to children with asthma. Overall, children with either inactive or low-severity epilepsy had mean scores comparable to national norms. Those with high seizure severity had mean scores ranging from 3–5 points below national norms. No changes were found in academic achievement over time for both samples, even among those whose conditions improved. Although boys with high-severity epilepsy continued to have the lowest achievement scores, there was no trend for them to decline in achievement over time.</td>
</tr>
<tr>
<td>Bailet and Turk (2000)</td>
<td>Public clinics, USA</td>
<td>3 years, at baseline, after 1 year and 2 years</td>
<td>Children aged 8-13 years (n = 113): children with IGE (n = 77); controls: Children with migraine (n = 13), and healthy controls (n = 23)</td>
<td>WRAT-R</td>
<td>CWE had higher rates of grade retention (34%) and placement in special education (19%) compared with healthy controls. 4 years later, CWE scored significantly worse than healthy controls in all three academic subscales: reading, mathematics and spelling. CWE without comorbidity were no different from healthy controls.</td>
</tr>
<tr>
<td>Hermann et al. (2008)</td>
<td>Public hospital, USA</td>
<td>2 years, at baseline and after 2 years</td>
<td>Children aged 8-18 years (n = 62): children with newly onset epilepsy, without comorbidity: LRE (n = 11) and IGE (n = 13); controls: Healthy controls (n = 30)</td>
<td>WRAT-3</td>
<td>They were comparable and equivalent to healthy controls in all tested areas of academic achievement (reading, mathematics and spelling). Academic achievement (reading, mathematical and spelling) was remarkably stable over the 2-year interval in all three groups. Among the CWE average IQ group with decreased seizure frequency at follow-up had a decline in mathematical score.</td>
</tr>
<tr>
<td>Jones et al. (2010)</td>
<td>Public hospital, private hospital and community, USA</td>
<td>2 years, at baseline and after 2 years at the 2nd year (lost to follow up: CWE (32%) and healthy controls (56%))</td>
<td>Children aged 7-16.1 years (n = 82): children with CPS (n = 31), CAE (n = 25), and it was grouped into two groups: IQ below average (n = 23) and average IQ (n = 41); controls: Healthy controls (n = 27)</td>
<td>WIAT screener</td>
<td>CWE had no different from controls.</td>
</tr>
</tbody>
</table>

Note: USA, United States of America; CWE, children with epilepsy; CAT, California Achievement Test; ITBS, Iowa Tests of Basic Skills; ISTEP, Indiana Statewide Test of Educational Progress; IGE, Idiopathic generalized epilepsy; WRAT-R, Wide Range Achievement Test Revised; LRE, Localized related epilepsy; WRAT-3, Wide Range Achievement Test 3; CPS, Complex partial seizure; CAE; childhood absence epilepsy; WIAT, Wechsler Individual Achievement Test.
1986), below the expected IQ score. Underachievement in CWE ranged from 10 to 50% (Mitchell et al., 1991; Seidenberg et al., 1986).

3.3. Academic difficulties in children with epilepsy

Fourteen out of 20 studies reported that CWE had academic difficulties compared to controls or reported norms (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Bailet and Turk, 2000; Braakman et al., 2012; Drewel et al., 2009; Gulgonen et al., 2000; Jackson et al., 2013; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Seidenberg et al., 1986; Tedrus et al., 2009), 12 studies reported low achievement in CWE (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Bailet and Turk, 2000; Braakman et al., 2012; Drewel et al., 2009; Gulgonen et al., 2000; Jackson et al., 2013; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Tedrus et al., 2009), whilst two studies reported underachievement in CWE (Mitchell et al., 1991; Seidenberg et al., 1986). The remaining six studies did not report any difference (Caplan et al., 2006; Chambers et al., 2014; Hermann et al., 2008; Jones et al., 2010; Williams et al., 2001; Williams et al., 1996).

Overall, the longitudinal studies found that CWE had stable academic achievement scores over time (Austin et al., 1999; Bailet and Turk, 2000; Hermann et al., 2008; Jones et al., 2010) [Table 2]. However, Austin and colleagues did not find an increase in scores among those children whose seizure control had improved over time (Austin et al., 1999). Another study found a subgroup of children who showed a decline in their mathematics scores despite a decrease in seizure frequency on follow-up (Jones et al., 2010).

3.4. Academic domains measured in children with epilepsy

All the included studies assessed mathematics. Twelve studies showed CWE had significantly lower mathematics scores compared to controls or reported norm (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Bailet and Turk, 2000; Braakman et al., 2012; Drewel et al., 2009; Gulgonen et al., 2000; Jackson et al., 2013; Mitchell et al., 1991; Miziara et al., 2012; Schoenfeld et al., 1999; Seidenberg et al., 1986), whilst the remaining 8 studies did not find any significant differences (Caplan et al., 2006; Chambers et al., 2014; Hermann et al., 2008; Jones et al., 2010; Overvliet et al., 2011; Tedrus et al., 2009; Williams et al., 2001; Williams et al., 1996).

Of the 19 studies that assessed reading, 14 studies showed that CWE had significantly lower reading scores compared to controls or reported norm (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Bailet and Turk, 2000; Braakman et al., 2012; Drewel et al., 2009; Gulgonen et al., 2000; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Seidenberg et al., 1986; Tedrus et al., 2009; Williams et al., 1996), whilst the remaining five studies did not find any significant difference (Caplan et al., 2006; Hermann et al., 2008; Jackson et al., 2013; Jones et al., 2010; Williams et al., 2001). Of the 11 studies that assessed spelling, six studies showed that CWE had significantly lower spelling scores compared to control or reported norm (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Bailet and Turk, 2000; Braakman et al., 2012; Drewel et al., 2009; Gulgonen et al., 2000; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996). Studies that measured other domains such as writing (Drewel et al., 2009; Miziara et al., 2012; Seidenberg et al., 1986; Williams et al., 1996), reading comprehension (Mitchell et al., 1991; Seidenberg et al., 1986), and general knowledge (Mitchell et al., 1991), found that CWE showed significantly lower scores compared to controls or reported norms.

3.5. Factors associated with academic achievement

Factors associated with academic achievement in CWE are shown in Table 3.

3.5.1. Demographic factors

The older the child, the lower the academic achievement score of the child (Mitchell et al., 1991; Seidenberg et al., 1986). There was no association found for gender (Austin et al., 1998, 1999; Miziara et al., 2012; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996) and socioeconomic status (Chambers et al., 2014; Williams et al., 2001) with academic achievement scores. However, a higher parental education was associated with a higher academic achievement score (Mitchell et al., 1991; Miziara et al., 2012).

3.5.2. Epilepsy/seizure related factors

Duration of epilepsy (Jones et al., 2010; Schoenfeld et al., 1999; Williams et al., 2001) and timing of seizure (Miziara et al., 2012) did not show any significant association with academic achievement. Studies that looked at the type of epilepsy (Aldenkamp et al., 2005; Bailet and Turk, 2000; Braakman et al., 2012; Chambers et al., 2014; Gulgonen et al., 2000; Hermann et al., 2008; Jackson et al., 2013; Miziara et al., 2012; Overvliet et al., 2011; Tedrus et al., 2009), epilepsy severity (Austin et al., 1998, 1999; Mitchell et al., 1991), age at seizure onset (Bailet and Turk, 2000; Jones et al., 2010; Miziara et al., 2012; Seidenberg et al., 1986; Williams et al., 1996), seizure type (Caplan et al., 2006; Drewel et al., 2009; Jones et al., 2010; Schoenfeld et al., 1999; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996), seizure control (Jones et al., 2010; Williams et al., 1996), seizure frequency (Bailet and Turk, 2000; Jones et al., 2010; Miziara et al., 2012; Schoenfeld et al., 1999; Seidenberg et al., 1986; Williams et al., 1996), EEG discharges (Aldenkamp et al., 2005; Bailet and Turk, 2000; Miziara et al., 2012), and the location of discharge (Aldenkamp et al., 2005; Bailet and Turk, 2000; Miziara et al., 2012) had mixed findings.

3.5.3. Medication related factors

The number of antiepileptic drugs (Jones et al., 2010; Seidenberg et al., 1986), and type of treatment (no treatment, monotherapy or polytherapy) (Aldenkamp et al., 2005) were not found to be associated with academic achievement. However, the type of antiepileptic drug showed mixed results (Bailet and Turk, 2000; Miziara et al., 2012; Williams et al., 2001).

3.5.4. Cognitive related factors

The higher the IQ of the child (Chambers et al., 2014; Drewel et al., 2009; Mitchell et al., 1991; Williams et al., 2001) and if the child had better attention in school (Williams et al., 2001) were significantly associated with better academic achievement. However, thought disorders showed mixed results (Caplan et al., 2006).

3.5.5. Child/family psychosocial related factors

The child’s positive attitude toward epilepsy was significantly associated with better academic achievement (Austin et al., 1998). No association was found between self-esteem (Williams et al., 2001) and peer difficulty (Drewel et al., 2009), with academic achievement. A “caring environment” showed mixed results (Chambers et al., 2014; Mitchell et al., 1991).

3.5.6. School related factors

No association was found between school self-concept or school adaptive functioning, with academic achievement (Austin et al., 1998).

4. Discussion

The aim of our study was to systematically examine published literature which focused on the academic achievement in CWE with normal intelligence, with respect to the prevalence of academic difficulties, and its associating factors. Our systematic review showed that the majority of the studies (70%) showed that CWE had significantly lower academic achievement scores than healthy controls or reported norms, whilst 30% reported no
Table 3
Factors associated with academic achievement in children with epilepsy.

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of studies (references)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic factors</td>
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</tr>
</tbody>
</table>
| Gender                                 | 6 (Austin et al., 1998, 1999; Miziara et al., 2012; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996) | No association was found between gender and academic achievement in four studies (Miziara et al., 2012; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996)
Two studies reported that boys had significantly poorer academic achievement than girls (Austin et al., 1998, 1999)
However, it was found that boys in the sample have more severe epilepsy than girls. The significant differences were only found between boys with “high severity” epilepsy and girls with “low severity” epilepsy. Therefore, gender was not a risk factor for academic achievement in CWE (Austin et al., 1999)

| Age                                    | 2 (Mitchell et al., 1991; Seidenberg et al., 1986) | Older children had significant poorer academic achievement (Mitchell et al., 1991; Seidenberg et al., 1986)

| Parents’ educational level             | 2 (Mitchell et al., 1991; Miziara et al., 2012) | Children whose parents had higher educational level had better academic achievement (Mitchell et al., 1991; Miziara et al., 2012)

| SES                                    | 2 (Chambers et al., 2014; Williams et al., 2001) | No association was seen between socioeconomic status and academic achievement (Chambers et al., 2014; Williams et al., 2001)

| Epilepsy/seizure related factors       |                               |                                                                                                                                                                                                                                                                                                                                                                   |
| Epilepsy severity                      | 3 (Austin et al., 1998, 1999; Mitchell et al., 1991) | Children who had more severe epilepsy had significantly lower academic achievement scores (Austin et al., 1998, 1999)
No association was found between epilepsy severity and academic achievement (Mitchell et al., 1991)

| Type of epilepsy                       | 10 (Aldenkamp et al., 2005; Bailet and Turk, 2000; Braakman et al., 2012; Chambers et al., 2014; Gulgonen et al., 2000; Hermann et al., 2008; Jackson et al., 2013; Miziara et al., 2012; Overvliet et al., 2011; Tedrus et al., 2009) | Children with SGE (Aldenkamp et al., 2005), FLE (Braakman et al., 2012), BECT or RE (Miziara et al., 2012; Overvliet et al., 2011; Tedrus et al., 2009), IOLE (Gulgonen et al., 2000), and ILRE (Hermann et al., 2008; Jackson et al., 2013) had lower academic achievement score compared to healthy controls or norms
Children with IGE/GE and PE showed mixed results. Two studies showed that children with IGE scored significantly worse than controls in academic achievement (Bailet and Turk, 2000; Jackson et al., 2013)
However, two studies showed that children with IGE did not show educational delay compared to controls (Aldenkamp et al., 2005), and had academic achievement scores comparable to controls (Chambers et al., 2014).
One study showed that children with PE had academic achievement scores comparable to controls (Chambers et al., 2014). On the other hand, one study showed that children with PE scored significantly lower academic achievement than controls (Aldenkamp et al., 2005)

| Duration of epilepsy                   | 4 (Jones et al., 2010; Mitchell et al., 1991; Schoenfeld et al., 1999; Williams et al., 2001) | No association was found between duration of epilepsy and academic achievement (Jones et al., 2010; Mitchell et al., 1991; Schoenfeld et al., 1999; Williams et al., 2001) |

| Age at seizure onset                  | 6 (Bailet and Turk, 2000; Jones et al., 2010; Miziara et al., 2012; Schoenfeld et al., 1999; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996) | An earlier age of seizure onset was associated with poorer academic achievement in two studies (Schoenfeld et al., 1999; Seidenberg et al., 1986)
However, no association was found between age of seizure onset and academic achievement in four studies (Bailet and Turk, 2000; Jones et al., 2010; Miziara et al., 2012; Williams et al., 1996)

| Seizure type                           | 7 (Caplan et al., 2006; Drewel et al., 2009; Jones et al., 2010; Schoenfeld et al., 1999; Seidenberg et al., 1986; Williams et al., 2001; Williams et al., 1996) | There was no significant difference in academic achievement of children with PGE compared to the norms (Caplan et al., 2006)
Children with PE (Seidenberg et al., 1986), GS (Drewel et al., 2009; Seidenberg et al., 1986), and CS (Drewel et al., 2000) had significantly lower academic achievement compared to the norms.
Children with CPS and AS showed mixed results. Four studies showed that children with CPS demonstrated academic achievement within average range compared to the norms (Caplan et al., 2006; Jones et al., 2010; Williams et al., 2001; Williams et al., 1996)
However, one study showed that children with CPS performed significantly worse than controls in academic achievement (Schoenfeld et al., 1999).
Two studies showed that children with AS demonstrated average academic achievement compared to the norms (Jones et al., 2010; Williams et al., 1996).
However, one study showed that children with AS had significantly lower academic achievement compared to the norms (Drewel et al., 2009)

| Seizure control                        | 2 (Jones et al., 2010; Williams et al., 1996) | No association was found between seizure control and academic achievement in one study (Jones et al., 2010)
However, one study showed that CWE with good seizure control have significant higher score in reading compared to CWE with poorly controlled seizure (Williams et al., 1996)

| Seizure frequency                      | 6 (Bailet and Turk, 2000; Jones et al., 2010; Mitchell et al., 1991; Schoenfeld et al., 1999; Seidenberg et al., 1986; Williams et al., 1996) | No association was found between seizure frequency and academic achievement in four studies (Bailet and Turk, 2000;Jones et al., 2010; (continued on next page)
### Table 3 (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of studies (references)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing of seizure occurrence</td>
<td>1 (Miziara et al., 2012)</td>
<td>Not association was found between timing of seizure occurrence and academic achievement in one study (Miziara et al., 2012)</td>
</tr>
<tr>
<td>EEG discharges and the location of discharge</td>
<td>3 (Aldenkamp et al., 2005; Bailey and Turk, 2000; Miziara et al., 2012)</td>
<td>No association was found between EEG discharges and academic achievement in two studies (Aldenkamp et al., 2005; Bailey and Turk, 2000; Miziara et al., 2012). However, one study found CWE with normal EEGs performed significantly better than CWE with abnormal EEGs (Bailey and Turk, 2000)</td>
</tr>
<tr>
<td>Medication related factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of antiepileptic drug</td>
<td>3 (Bailey and Turk, 2000; Miziara et al., 2012; Williams et al., 2001)</td>
<td>No association was found between type of antiepileptic drug and academic achievement in two studies (Miziara et al., 2012; Williams et al., 2001)</td>
</tr>
<tr>
<td>Number of antiepileptic drug</td>
<td>1 (Jones et al., 2010; Seidenberg et al., 1986)</td>
<td>One study found that CWE taking CBZ had better spelling score than CWE taking VPA (Bailey and Turk, 2000)</td>
</tr>
<tr>
<td>Type of treatment (no treatment/monotherapy/polytherapy)</td>
<td>1 (Aldenkamp et al., 2005)</td>
<td>No association was found between type of treatment and academic achievement in one study (Aldenkamp et al., 2005)</td>
</tr>
<tr>
<td>Cognitive related factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>5 (Aldenkamp et al., 2005; Chambers et al., 2014; Drewel et al., 2009; Mitchell et al., 1991; Williams et al., 2001)</td>
<td>A lower IQ level was associated educational underachievement (Aldenkamp et al., 2005; Chambers et al., 2014; Drewel et al., 2009; Mitchell et al., 1991; Williams et al., 2001). Thought disorder was significantly associated with lower academic achievement with children with PGE (Caplan et al., 2006). However, there was no association between thought disorder and academic achievement in children with PGE (Caplan et al., 2006). Higher ability to pay attention to recall combinations of number/letters of increasing length immediately was significantly associated with better academic achievement in CWE (Williams et al., 2001)</td>
</tr>
<tr>
<td>Thought disorder</td>
<td>1 (Caplan et al., 2006)</td>
<td>Thought disorder was significantly related to lower academic achievement with children with PGE (Caplan et al., 2006). However, there was no association between thought disorder and academic achievement in children with PGE (Caplan et al., 2006). Higher ability to pay attention to recall combinations of number/letters of increasing length immediately was significantly associated with better academic achievement in CWE (Williams et al., 2001)</td>
</tr>
<tr>
<td>Attention</td>
<td>1 (Williams et al., 2001)</td>
<td>No association was found between self-esteem and academic achievement in one study (Williams et al., 2001)</td>
</tr>
<tr>
<td>Child/family psychosocial related factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-esteem</td>
<td>1 (Williams et al., 2001)</td>
<td>No association was found between self-esteem and academic achievement in one study (Williams et al., 2001)</td>
</tr>
<tr>
<td>Peer difficulty</td>
<td>1 (Drewel et al., 2009)</td>
<td>No association was found between peer difficulty and academic achievement in one study (Drewel et al., 2009)</td>
</tr>
<tr>
<td>Attitude towards epilepsy</td>
<td>1 (Austin et al., 1998)</td>
<td>The child's attitude toward epilepsy was significantly associated with academic achievement (Austin et al., 1998)</td>
</tr>
<tr>
<td>Caring environment</td>
<td>2 (Chambers et al., 2014; Mitchell et al., 1991)</td>
<td>No association was found between caring environment and academic achievement in one study (Chambers et al., 2014). However, a caring environment was significantly associated with better academic achievement in one study (Mitchell et al., 1991)</td>
</tr>
<tr>
<td>School related factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School self-concept</td>
<td>1 (Austin et al., 1998)</td>
<td>No association was found between school self-concept and academic achievement in one study (Austin et al., 1998)</td>
</tr>
<tr>
<td>School adaptive functioning</td>
<td>1 (Austin et al., 1998)</td>
<td>No association was found between school adaptive functioning and academic achievement in one study (Austin et al., 1998)</td>
</tr>
</tbody>
</table>

Note: CWE = Children with epilepsy; SES = Socioeconomic status; SGE = Symptomatic generalized epilepsy; FLE = Frontal lobe epilepsy; BECTS = Benign epilepsy with centro-temporal spikes; RE = Rolandic epilepsy; IOLE = Idiopathic occipital lobe epilepsy; ILRE = Idiopathic localized related epilepsy; IGE = Idiopathic generalized epilepsy; GE = Generalized epilepsy; PE = Partial epilepsy; PGE = Primary generalized epilepsy with absence; PS = Partial seizure; GS = Generalized seizure; CS = Complex seizure; CPS = Complex partial seizure; AS = Absence seizure; EEG = epileptiform; IQ = Intelligence quotient; CBZ = carbamazepine; VPA = valproate.

difference; which was similar to a previous review (Reilly and Neville, 2011). The previous review included a total of 15 studies (Reilly and Neville, 2011), whilst 20 studies were included in our present review. Although there were only eight studies (Aldenkamp et al., 2005; Austin et al., 1999; Bailey and Turk, 2000; Mitchell et al., 1991; Schoenfeld et al., 1999; Tedrus et al., 2009; Williams et al., 2001; Williams et al., 1996) that were included in both reviews, similar findings were obtained.

While one third of the studies reviewed (35%) (Bailey and Turk, 2000; Chambers et al., 2014; Gulgonen et al., 2000; Hermann et al., 2008; Jackson et al., 2013; Schoenfeld et al., 1999; Seidenberg et al., 1986) used the WRAT to assess academic achievement, while others (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Braakman et al., 2012; Caplan et al., 2006; Drewel et al., 2009; Jones et al., 2010; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Tedrus et al., 2009; Williams et al., 2001; Williams et al., 1996) utilized a variety of other instruments, making direct comparison was difficult as each instrument has different outcome measures (e.g., educational delay, expected mean). Some studies measured academic achievement at or close to the time when epilepsy was diagnosed (Hermann et al., 2008; Jackson et al., 2013); whilst others assessed academic achievement in children who have been diagnosed with epilepsy for at least 6
months (Aldenkamp et al., 2005; Austin et al., 1998, 1999; Bailey and Turk, 2000; Braakman et al., 2012; Caplan et al., 2006; Chambers et al., 2014; Drewel et al., 2009; Gulgonen et al., 2000; Jones et al., 2010; Mitchell et al., 1991; Miziara et al., 2012; Overvliet et al., 2011; Schoenfeld et al., 1999; Seidenberg et al., 1986; Tedrus et al., 2009; Williams et al., 2001; Williams et al., 1996). Lastly, academic difficulty can be caused by other specific underlying impairment such as cognitive impairment (e.g., poor executive function), psychomotor impairment (e.g. lack of fine motor skill), or impairment of affective domains (e.g. attitudes towards epilepsy), which are important to promote learning (Woolfolk, 2007).

Most of the studies in our systematic review assessed “low achievement” rather than “underachievement”. This may be because low achievement may be less time consuming to evaluate than underachievement (Fletcher et al., 2004). To assess underachievement, researchers would have to determine an appropriate cut off score (e.g., 1 or 1.5 standard deviation below the expected scores using the IQ-achievement discrepancy model), which may be difficult to perform as there are statistical limitations of psychometric cut offs (Fastenau et al., 2008; Fletcher et al., 2004). Therefore, assessing “low achievement” in CWE is more practical and pragmatic for future research. Children (regardless of type of disease) who are classified with underachievement or low achievement are eligible to be provided with special education services or educational support (Education, 2011). It is important to raise their performance with educational support so that they are not below average, but on par with their academic ability and potential (Ford and Moore, 2013).

Our systematic review found that children with higher IQ (Aldenkamp et al., 2005; Chambers et al., 2014; Drewel et al., 2009; Mitchell et al., 1991; Williams et al., 2001), who had better attention (Williams et al., 2001), and had a positive attitude towards epilepsy (Austin et al., 1998), as well as higher parental education (Mitchell et al., 1991; Miziara et al., 2012), were associated with higher academic achievement score. Older children were also found to have lower academic achievement score (Mitchell et al., 1991; Seidenberg et al., 1986). However, the number of studies that showed these positive associations was small. Seizure characteristic have been studied but have yielded mixed results. Comparisons between studies was difficult partly due to the variability in definition of seizure types and indices of seizure severity For example, some studies measured seizure frequency using a lifetime seizure frequency (Miziara et al., 2012; Seidenberg et al., 1986), whilst others measured seizure frequency for the past one year (Jones et al., 2010). Lastly, most of the studies included did not investigate factors associated with academic achievement in a more holistic approach and using a structural equation model.

The high percentage of low achievement in CWE suggests that early screening of specific learning and behavioural problems, as well as early interventions should be developed and applied (Fastenau et al., 2008). The assessment of possible neuropsychological correlates of academic difficulties may help identify factors contributing to academic difficulties, and help with the development of individualized educational program and other educational plans, independent living needs and skills (Fastenau et al., 2009). Screening by an educational psychologist is important to identify CWE who require further assessment to determine their learning difficulties, which is often missed in school examinations or through a teacher’s observation in school. Screening may occur as early as at the time of epilepsy onset, or at the different stages of life, as children have different needs at the different stages of their life (Ronen et al., 2003). Given that older children showed poorer school achievement scores, screening for learning and behavioural problems are also important in adolescents as they transition to post-high school education and enter the workforce (Ronen et al., 2003). Through appropriate assessment, recommendation of interventions or educational supports will then lessen the impact of such difficulties among CWE (Reilly and Fenton, 2013).

Attitudes of teachers and other education providers toward epilepsy can significantly influence’s school performance in CWE (Austin et al., 1998). CWE can be at an increased risk for academic problems if their teachers or parents do not understand their needs (Dantas et al., 2001). Therefore, it is important that interventions to enhance a teacher’s awareness about epilepsy be developed. Although not all CWE require special education services, these students should be given opportunities to reach their full potential. It is also important for policy makers to ensure that schools are able to identify, evaluate, and reevaluate CWE who require special education and related services, to provide CWE a less restrictive and more interactive environment with other student. A discrimination-free environment where CWE should be encouraged to participate non-academic activities such as sports and special interest clubs, should be promoted.

In the present study, several research gaps were identified. Firstly, there are no published literature on interventions to improve academic achievement in CWE. Secondly, there is a lack of population based studies with an adequate sample size to comment accurately on the true prevalence of low achievement and underachievement in CWE. Thirdly, there is a paucity of studies particularly in Asia, as there is a lack of validated academic achievement instruments in Asian countries. Therefore, future studies on academic achievement in CWE should address these issues to better understand academic achievement in children with epilepsy.

One of the limitations of our study was that we were not able to perform a meta-analysis. This was because the outcomes measured between studies were different and comparisons between studies were difficult. However, the strength of our study was that we performed this systematic review according to the PRISMA guidelines, and that our search was conducted on five databases.

5. Conclusions

The majority of published literature found that academic achievement among CWE was lower than controls or reported norms. The high percentages of low achievement in CWE with normal intelligent and without any comorbidities, especially in the older age group, and the stability of scores even as seizure frequency improved, highlights the need for early screening of learning problems, and continued surveillance.

Conflict of interest

All authors declare that they have no conflict of interest.

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