Original Research Article

Neuropsychological Deficits in Children with Epilepsy in Ghana: A Study At Korle-Bu Teaching Hospital

ABSTRACT

Epilepsy may be associated with a wide range of neuropsychological deficits. The study examined the neuropsychological deficits (language skills, attention skills and executive functioning) associated with epileptic children. The role of medication compliance on the neuropsychological deficits was also assessed. Seventy two participants consisting of 36 epileptic patients visiting the neurological clinic at the Korle Bu Teaching Hospital (children's department) and 36 healthy control group from West African Basic School were selected to complete the Digit Span Tasks, Kilifi Naming Test (KNT), Trail Making Test (TMT) and the Morisky 8-Item Medication Adherence Scale (MMAS-8). Analysis was done using Pearson correlation and the MANOVA. Findings of the study indicated higher deficits in language skills, attention skills and executive functioning among epileptic patients compared to healthy control group. Medication compliance was found to ameliorate the deficits associated with attention, language skills, and executive functions among epileptic patients. Findings suggest that though epilepsy (seizure) is associated with higher neuropsychological deficits, compliance with medication decreases the deficits associated with epilepsy.

Keywords: *epilepsy, seizure, neuropsychological deficits, language skills, attention skills, executive functions, medication compliance*

1. INTRODUCTION

Epilepsy or seizure is one of the most common neurological disorders in childhood (Fastenau, Shen, Dunn, Perkins, Hermann & Austin, 2004). Prevalence estimates suggest that approximately 5% of children will have at least one seizure in their lifetime with approximately 25% of these children subsequently meeting formal diagnostic criteria for epileptic disorder (Sharma, Singh, Goyal, Singla & Kaur, 2011). The prevalence of the deficits associated with epilepsy has attracted a lot of attention with large body of studies conducted on the neuropsychological deficits associated with it (Dunn, Johnson, Perkins, Fastenau, Byars, & Austin, 2010; Reilly & Neville, 2011; Vingerhoets, 2006). Though numerous studies have been carried out on how epilepsy is linked to neuropsychological deficits in the European countries, very little has been done to examine the risk factors that may account for the high deficits among these epileptic children especially in Ghana. In Ghana, because of the low socio-economic status and the belief as to the cause of the disorder, people do not seek adequate care to help control the seizures associated with it. It is therefore important to assess how certain factors such as medication compliance exposes patients to severe neuropsychological deficits in Ghana.

Epilepsy disorder is a neurological condition that affects the nervous system. It is a neurological condition involving the brain (damage to either part or both parts) that makes people more susceptible to having recurrent, unprovoked seizure (Dunn, et al., 2010).

Epilepsy involves a breakdown of the natural electrical activity in the brain (Dunn, et al., 2010). Anyone can have one or more seizures but when a person has two or more unprovoked seizures, he or she is considered to have epilepsy or seizure disorder (Sharma, Singh, Goyal, Singla & Kaur, 2011).

Epileptic disorder is associated with varying brain damage or changes in brain neural network. The changes in brain neural networks affect behaviour causing dysfunctions such as the processing of language (Duke, Tesfaye, Berl, Walker, Ritzl, Fasano, Conry, Pearl, Sato, Theodore & Gaillard, 2012). The deficit in language may range from very limited problems in exact word finding to more pervasive deficits impacting on all language modalities. Yet another cognitive ability affected by epilepsy is executive function (MacAllister, Bender, Whitman, Welsh, Keller, Granader & Sherman, 2012). Epilepsy makes it impossible for the brain to develop connection between the past experiences and the present actions which affect executive function processes (Stuss & Levine, 2002). Repeated seizures also affect attention, particularly in children (Hermann, Jones, Dabbs, Allen, Sheth, Fine, McMillan, & Seidenberg, 2007). Damage to the brain leads to the dysfunction of the central nervous system (CNS). Epileptic patients encounter unusual electrical activity in their brains between seizures because of the CNS dysfunction. This has the propensity of interfering with the ability to focus on stimulus (Hermann, et al., 2007).

The relation between seizures and these deficits may not necessarily be a direct causal relationship but possibly influenced by compliance with treatment (Sharma, et al., 2011). According to Fountain (2000), effective treatment of seizure disorder depends on medication compliance across a lifetime. For individuals with epilepsy, adherence to medication is crucial in preventing or minimizing the seizures associated with it and their cumulative impact on everyday life. Failure to comply with medication may lead to toxicity which may serve as a significant limiting factor in treatment maintenance (Rowland, 2005).

In Ghana, people look for alternative explanations and cure to epilepsy. The traditional belief as to the causes of diseases such as epilepsy in Ghana affects the extent to which epileptic children comply with medication (Dakwa & Mudyahoto, 2013). Patients who believe epilepsy is caused by spiritual factors other than a defect in the brain fail to comply with medications provided by the medical practitioner (Bootsma, et al., 2009).

According to Luria theory of executive function (Luria, 1974), the human brain consists of three basic functional units that are interactively linked and the participation of these three functional units is necessary for any type of mental activity. These three basic functional units are the primary functional unit, the secondary functional unit and the tertiary functional unit. According to Luria theory of executive function (Luria, 1974), each form of conscious activity is always a complex functional system and takes place through the combined working of all three functional units. When the complex functional system is damaged by injury to any of the functional unit or all of the functional units, it disrupts the cohesion of the system resulting in the inability to verify or regulate behavioural outcomes. Consequently, it can lead to the replacement of these complex programmes by more basic behaviour or stereotypical behaviour that is either illogical, irrelevant, or inappropriate.

Studies have indicated that epileptic patients are prone to neuropsychological deficits. Jones, Watson, Sheth, Caplan, Koehn, Seidenberg, and Hermann (2007) found that attention deficit is more prevalent in new onset idiopathic epilepsy children (26.4%) than in healthy controls

(10%). A study by MacAllister, et al. (2012) found higher deficits in executive function among epileptic children. Culhane-Shelburne, Chapieski, Hiscock and Glaze (2002) also indicated that children with epilepsy compared to healthy control group have higher deficits in planning and executive functions. Rejno-Habte, Olsson et al. (2009) indicated that epileptic children have severe language deficits compared to healthy control group.

According to Dunn, et al. (2010), some epileptic children exhibit severe neuropsychological deficits compared to others. If this is the case, then some factors have the potential to influence the neuropsychological deficits of these children. Studies have indicated that medication compliance is one of the major factors that have the potential to influence the neuropsychological deficits of epileptic patients. A study by Nolan, Redoblado, Lah and Sabaz (2003) indicated that medication compliance reduce the deficits associated with epilepsy. Gallassi, Morreale, Lorusso, Procaccianti, Lugaresi and Baruzzi (1990) also revealed that patients who comply with medication had lower neuropsychological deficits than those who do not comply with medication.

Assessing the extant studies, most have been conducted in the European countries. The paucity of studies in Ghana failed to examine the risk factors that may account for the high deficits among the epileptic patients though people do not seek adequate care to help control the seizures due to the belief about the causes of the disorder. It is therefore important to assess how certain factors such as medication compliance exposes patients to severe neuropsychological deficits in Ghana. It is based on this that the present study sought to examine neuropsychological deficits in language skills, attention skills and executive functions of epileptic children. The study also sought to assess whether medication compliance ameliorate the neuropsychological deficits associated with epilepsy. Accordingly, the study sought to test the following predictions:

1. Epileptic patients will exhibit deficits in attention, language and executive function compared to healthy participants
2. Compliance with medication will have a significant relationship with attention, language skills and executive function

2. METHODOLOGY

2.1 Population

The target group consisted of all patients diagnosed with epileptic disorder and healthy individuals without any trace or history of epilepsy. Epileptic patients were obtained from the Korle-Bu Teaching Hospital (children's' department). Korle-Bu Teaching Hospital was selected because it is the biggest hospital in Ghana and it serves as referral centre for patients suffering from epilepsy. Based on the educational background and the age of the selected epileptic patients, participants without epileptic disorders (control group) were also selected using matching. Control participants were selected from West African Basic School at Adenta in the Greater Accra Region of Ghana.

2.2 Participants

Respondents for the study were recruited through purposive sampling technique and matching. The purposive sampling technique was used in selecting the patients with epilepsy. Participants who served the purpose of the study and were willing to participants were selected by the researcher. After selecting the epileptic children, healthy individuals (control participants) with no known history of epilepsy or neurological disorders were also selected using matching. The control was matched on sex, age and educational level.

Seventy two (n=72) participants took part in the study. The seventy two (72) participants consisted of 36 patients with epileptic disorder and 36 healthy individuals. The sample size of 80 was targeted because as proposed by Tabachnick and Fidel (1996), for a sample size to be appropriate for a targeted population, n > 50+8M (n = sample size, M = number of IVs). Since there are 2 IVs (health status and gender) in the present study, the sample size was estimated to be more than 66 (n > 66). The response rate of 72 participants was therefore large enough for the study. The age range of the participants was within 10 – 14 years with a mean age of 12.50 years. Among the 72 participants, 40 were males and 32 were females. The educational level of the respondents ranged from class 4 to Junior Secondary 2. (See Table 1 below for demographic composition of the participants).

Table 1: Demographic Characteristics of Respondents

Variables		**Seizure Patients** (*n* = 36)	**Healthy Control** (*n* = 36)	**Total** (*n* = 72)
Gender	Males	20	20	40
	Females	16	16	32
Education	Class 4	5	5	10
	Class 5	11	11	22
	Class 6	10	10	20
	JHS 1	4	4	8
	JSH 2	6	6	12

2.3 Design

The study adopted the cross-sectional survey assessing the neuropsychological deficits using structured questionnaires. The cross-sectional was appropriate since large amount of data on neuropsychological deficits were collected from among many participants within a relatively short time.

2.4 Measures

Data on neuropsychological deficits (attention skills, executive functions, language) and medication compliance were measured using Digit Span Tasks (DST), Kilifi Naming Test (KNT), Trail Making Test (TMT) and the Morisky 8-Item Medication Adherence Scale (MMAS-8). Comprehensive descriptions of the scales used are presented below:

The Digit Span Tasks (DST) was used to assess attention skills. DST is a sub-scale of the Wechsler Intelligence Scale for Children - Fourth Edition for assessing cognitive ability of children between the ages of 6 years through to 16 years 11 months. The DST requires working memory processes to manipulate orally presented verbal sequences or to simply recall orally presented sequential information. DST contains both forward and backward items (9 forward items and 8 backward items). Each item also consists of two questions making it 18 forward and 16 backward items. To complete the task children need to hold and manipulate (reverse) a series of numbers in their minds. In the digit span, children are told they are going to play a number game. The children are told that they will hear some numbers and they will need first repeat the numbers to the examiner and then later they are asked to repeat the numbers backwards (e.g., If I say ‘1, 3,’ you say ‘3,1’). The DST has been found to be reliable with Cronbach alpha of .86 (Watkins & Smith, 2013). Total scores range from 0 – 18 for the forward series and 0 – 16 for the backward series. Higher scores represent lower deficits in attention.

The Kilifi Naming Test (KNT), a test of confrontation naming, was used to assess language skills (Kitsao-Wekulo et al., 2012). The KNT measures expressive vocabulary in which the child is required to provide names of common pictures as they are presented. In the KNT, the child is asked to spontaneously give one-word responses when presented with a black and white line drawing of a familiar object. If at the first attempt the child provides the correct responses, a score of 2 is encoded. A stimulus cue is provided when no response is given. A score of 1 is given when the child provides correct response after the naming cue is provided. If the child does not provide a correct response after the stimulus cue, the word that is provided is recorded verbatim or the child is given a score of 0. The final score is calculated by summing the number of spontaneously correct items and the number of correct items following a stimulus cue. Cronbach alpha of .88 was reported by Kitsao-Wekulo et al. (2012). Lower score represent higher level of impairment.

The Trail Making Test (TMT; Reitan, 1958) was used to measure executive function. The TMT consists of two parts. Each part consists of 25 circles distributed over a sheet of paper. In Part A, the circles are numbered 1 – 25. Participants are asked to draw lines to connect the numbers in ascending order. In Part B, the circles include both numbers (1 – 13) and letters (A – L). Participants are asked to draws lines to connect the circles in an ascending pattern, but with the added task of alternating between the numbers and letters (i.e., 1-A-2-B-3-C, etc.). Participants are asked to connect the circles as quickly as possible, without lifting the pen or pencil from the paper. Participants are timed as they connect the "trail." If the participant makes an error, it is pointed out immediately and is allowed to correct it and continue. The participant is asked to stop after five minutes if he or she has not completed both parts. Gaudino and Geisler (1995) reported a Cronbach alpha of .84 for the scale. Results for both TMT A and B are reported as the number of seconds required to complete the task with higher scores indicating higher impairment.

The Morisky 8-Item Medication Adherence Scale (MMAS-8; Morisky, Green & Levine, 2008) is a self-report measure use to measure medication compliance. The scale addresses barriers to medication-taking and has an Alpha Reliability of 0.83 (Morisky, Green & Levine, 2008). Among Ghanaian populace, the reliability of the scale was found to be .79 (Beune, van Charante, Beem, Mohrs, & Agyemang, 2014). Participants respond to the scale on a five point Likert scale ranging from Never/rarely (0), Once in a while (1), Sometimes (2), Usually (3) and All the time (4). Scores ranged from 0 – 32 with higher score indicating higher medication compliance.

2.5 Procedure for Data Collection

Ethical clearance was sought from Ethics Committee for Humanities (ECH) at the University of Ghana followed by distribution of introductory letters to the hospital (Korle-Bu Teaching Hospital) and the school (West African Basic School at Adenta). The approvals from the institutions and consent of the participants were sought before administration of the questionnaires. The participants consent was sought from their caregivers. The caregivers signed an informed consent form before the children responded to the measures. Collection of data among the epileptic children took approximately one and half months whilst data from the control group (healthy participants) took approximately one week. Participants took approximately 45 minutes to complete the questionnaire.

3. DATA ANALYSIS

The Statistical Package for Social Science (SPSS, version 20) was used in data analysis. Two hypotheses were tested in the study. The difference in language skills, attention and executive function between epileptic and healthy children as indicated in the first hypothesis was analyzed using the multivariate analysis of variance (MANOVA) (see table 2). This is because the effect of one independent variable (health status) on three dependent variables (language skills, attention and executive function) was investigated.
The Pearson Product Moment Correlation Coefficient was used to establish the relationship between medication compliance and the neuropsychological deficits (language skills, attention skills and executive function as indicated in hypothesis 2 (see table 3). This is because the relationship between medication compliance and neuropsychological deficits was established.

4. RESULTS

Findings obtained from the analysis are summarized in the Tables below.

Table 2: Influence of Health Status (Seizure and Healthy Children) on Neuropsychological Deficits

Variable	**Epileptic Patients** *n*=36	**Healthy Children** *n*=36	***F***	***df***	***p***
	Mean (SD)	*Mean (SD)*			
Attention Skills	9.72 (4.58)	16.47 (5.26)	26.39	(1, 72)	.000**
Language Skills	61.50 (28.25)	90.19 (19.64)	7.39	(1, 72)	.008*
Executive Function	25.00 (18.30)	15.13 (11.78)	33.64	(1, 72)	.000**

** p< 0.01 * p< 0.05

Table 3: Relationship between Medication Compliance and Neuropsychological Deficits

Variable	**1**	**2**	***3***
1. Medication Compliance	-		
2. Attention Skills	.34**	-	
3. Language Skills	.38**	.29**	-
4. Executive Functions	-.23*	-.23*	-.18*

** p< 0.01 * p< 0.05

Table 2 shows a significant impact of health status (epileptic patients and healthy children) on attention skills ($F_{(1, 72)} = 26.39$, $p < .01$), language skills ($F_{(1, 72)} = 7.39$, $p < .05$) and executive function ($F_{(1, 72)} = 33.64$, $p < .01$). This means that epileptic patients had significantly higher deficits in attention (M=9.72, SD=4.58), language (M=61.50, SD=28.25) and executive function (M=25.00, SD=18.30) than the deficits in attention (M=16.47, SD=5.26), language (M=90.19, SD=19.64) and executive function (M=15.13, SD=11.78) of healthy children. The first prediction that "epileptic patients will exhibit higher deficits in attention, language and executive function compared to healthy participants" was supported.

The results in Table 3 also shows that medication compliance had a significant positive correlations with attention skills (r = .34, $p < .05$) and language (r = .38, $p < .01$) but a negative relationship with executive functions (r = -.23, $p < .05$). This means that the second prediction which stated that "compliance with medication will have a significant relationship with attention, language skills and executive function" was also supported.

5. DISCUSSION AND RECOMMENDATIONS

The first aim of the study sought to find out the influence of epilepsy on neuropsychological deficits. The results of the study indicated that epileptic children performed poorly on executive function, attention and language skills compared to healthy children. This means that epilepsy is associated with deficits in executive functions, language, and attention.

The high deficits associated with executive function among epileptic children compared to healthy control group found in the present study is congruent with the study conducted by MacAllister, et al. (2012) which indicated that executive function deficits is more closely related to epilepsy severity. One reason for the deficits in executive function associated with seizure is that executive function is mediated by a healthy functioning frontal lobe, particularly, the prefrontal cortex that regulates inhibition and working memory (Saboya, Franco & Mattos, 2002). Seizures, be it global or focused can affect the frontal lobe because of the primary function of the frontal cortex integrating sensory information from different areas of the brain (Chan, Shum, Toulopoulou, & Chen, 2008). According to the nociferous cortex hypothesis (Hermann, et al., 2007), executive function deficits in epileptic children result from the propagation of the epileptic discharges from the temporal lobe epileptic focus to the frontal lobes. The theory profess that, there are white matter tracts connecting the temporal lobes with the frontal lobes which help in the functioning of the executive function. Epilepsy also releases some discharges. The epileptic discharges may spread through the projections connecting the temporal lobes with the frontal lobes which lead to deficits in the executive function.

There was also a higher deficit in attention among epileptic children compared to the healthy control group. The higher deficit in attention among epileptic patients agrees with the study by Chou, et al. (2013) which indicated that patients with seizure deficit are generally prone to attention disorder. As explained by Hamoda, Guild, Gumlak, Travers and Gonzalez-Heydrich (2008), certain predisposing factors that induce inattention such as frequency of seizure, drugs used etc. can cause higher attentional deficit among epileptic patients. An underlying central nervous system (CNS) dysfunction caused by damage to the brain of epileptic patients could also be a major factor for the low level of attentiveness among the epileptic patients. Because of the central nervous dysfunction, epileptic patients experience unusual electrical activity in their brains in between seizures which interfere with the ability to focus on one's attention. Moreover, the frequencies of seizures experience by epileptic children disrupt their sleep and causes fatigue which has the propensity to induce inattentiveness among epileptic patients.

There was also a deficit in language skills among epileptic children compared to the healthy children. This supports the study by Duke, et al. (2012) which revealed higher deficits in language among epileptic patients. The language deficits among epileptic patients compared to the healthy control group can be due to injury to the Wernicke's and the Broca's areas of the left temporal lobe. The Wernicke's and the Broca's areas of the left temporal lobe are critical for language comprehension and production. Therefore, if there is an injury to these areas, speech production or verbal comprehension becomes a problem (Deonna & Roulet-Perez, 2005).

The significant neuropsychological deficits (language, attention and executive function) associated with epileptic patients can be proffered with the Luria theory of executive function (Luria, 1974). According to this theory, the human brain consists of three basic functional units that are interactively linked and the participation of these three functional units is necessary for any type of mental activity. When this complex functional system is damaged by injury to any of the functional unit or all of the functional units, it disrupts the cohesion of the system resulting in the inability to verify or regulate behavioural outcomes which can lead to neuropsychological deficits (Chan & Chen, 2004). Since epilepsy is associated with varying brain damage or changes in brain neural networks, it will disrupt the cohesion of the functional brain system resulting in cognitive and behavioural dysfunctions in area of thinking including language, memory, attention, planning and behavioural inhibition (Chan & Chen, 2004).

While the effects of epilepsy on neuropsychological deficits were found, the effect was found to be dependent on medication compliance. Effective treatment of epilepsy has been found to depend on medication compliance across a lifetime (Fountain, 2000). Based on this, it was predicted that compliance with medication will have a significant relationship with attention, language skills and executive function. The finding indicated that there was a significant positive relationship between medication compliance and neuropsychological deficits such as attention and language. This means as epileptic children comply with their medication, their level of attention and language skills improve tremendously. Again the findings indicated that medication compliance has significant negative relationship with executive function. With highly scores indicating higher deficits in executive function, the finding implies that as epileptic patients comply with medication, it improve their executive function abilities.

These findings indicate that compliance with medication helps to reduce the neuropsychological deficits associated with epilepsy. The findings agree with the assertion by Nolan, et al. (2003) that the medications prescribed by medical doctors have the potential of reducing the seizure frequency which is associated with the deficits associated with epilepsy. Failure to comply with the medication will reduce the efficacy of the drug in controlling seizure frequency (Nolan, et al., 2003). Complying with the dosage of the medication prescribed has the potential of controlling the frequency of seizure and hence reducing the neuropsychological deficits associated with it. For individuals with epilepsy, adherence to medication is crucial in preventing or minimizing seizures and their cumulative impact on everyday life. Failure to comply with medication may lead to toxicity which will serve as a significant limiting factor in treatment maintenance (Rowland, 2005). Non-adherence to antiepileptic drugs (AEDs) can result in breakthrough seizures many months or years after a previous episode and may lead to varying neuropsychological deficits (Bootsma, et al., 2009).

This study has some limitations that need to be addressed. First, it must be noted that this study is a survey that employed the use of self-report measures. The conclusions drawn in this study therefore are largely correlational and so causal relationships cannot be inferred. Moreover, the study utilized the non-probability sampling and the sample size was also small. This makes it difficult to generalize the findings to the larger population of seizure patients.

Even though the study had some limitations, it invariably yielded reliable results as it supported most of the studies conducted previously on the field of neuropsychological deficits associated with epilepsy. The results of the study indicated that epilepsy is associated with severe neuropsychological deficits in attention, language and executive function compared to healthy children. Complying with medication was found to reduce the deficits associated with it. The implication of the findings is that epileptic patients suffer from various degrees of neuropsychological problems, which if patients comply with medication can reduce the deficits among the epileptic patients and lower the neuropsychological impact of epilepsy in general.

Even though, the study has these unique contributions to the health service, expansion on the present study would allow greater knowledge into the factors that influence the neuropsychological deficits associated with epilepsy. Future investigations should increase the sample size and match the groups in terms of socioeconomic status and type of school attended. To fully pinpoint causality, an ideal study might sample new epileptic children and track their onset of the disorder over a long period (longitudinal design). This will help to know the course of the disorder on neuropsychological deficits.

6. CONCLUSION

The findings of the study have established that epileptic patients experience significantly higher deficits in language skills, attention skills and executive functioning than the healthy control group. Compliance with medication was also found to have a significant relationship with neuropsychological deficits. The findings imply that the inability to comply with medication serves as a risk factor for the development of higher neuropsychological deficits. Physicians and caregivers are therefore urged to encourage patients to comply with medication to help reduce the neuropsychological deficits associated with the disorder. There is the need to educate the patients and the general public on the cause of epilepsy to do away with the belief in the supernatural cause of epilepsy in Ghana.

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