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The effects of fluoxetine in improving the neurocognitive functioning of children with attention deficit hyperactivity disorder attending the psychiatric clinic of the University Teaching Hospital, Lusaka, Zambia

Perpetual Mushivi, Anatolii Tsarkov *, Petro Petlovanyi and Ravi Paul

Department of Psychiatry, School of Medicine, University of Zambia (UNZA), Zambia.

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Abstract

Introduction: Stimulants are medicines approved to treat attention deficit hyperactivity disorder (ADHD) in children and adolescents and are considered the first-line pharmacological agents in ADHD management. These medicines are highly controlled and are usually unavailable in Zambia. Therefore, it is important to seek some supplementary therapy that may substitute stimulants. Fluoxetine has been used for its purpose in Zambia.

Objective: The main aim of this study was to find out the effects of fluoxetine in improving the neurocognitive functioning of children with ADHD attending our local psychiatric clinic. Two specific objectives guided the study: to identify the effects of fluoxetine in improving attention and executive functioning in children with ADHD and to find out the effects of fluoxetine in improving memory in children with ADHD.

Methodology: The study used a causal-comparative study design and a purposive sampling method. 10 patients (aged 7-11) meeting DSM-5 criteria for ADHD were required in this study. The participants were assessed before they started their treatment with fluoxetine and 4 weeks after the therapy started. The research participants' memory, attention, and executive functioning were specifically considered in this study.

Results: The analysis of the results for test 2 using ANOVA were as follows; $\alpha = 0.05$, the critical value for an F with d. f. (4, 40) being 2.61, the F ratio is 9.96 and total mean square is 272.18, and the total sum of squares is 13337. Since $\alpha = .05$ and d. f. = 4, 40, (we reject H0 since $F_{4,40} \leq 2.61$). The computed value of the F statistic is 9.96. The null hypothesis was rejected in the second assessment, and the alternative hypothesis was accepted.

Conclusion: There was a significant difference in the neurocognitive functioning performance of children with ADHD before and after taking fluoxetine. The results of this study indicated that the executive functioning, attention, and memory of ADHD children showed improvement after commencing 4-week fluoxetine therapy.

Keywords: ADHD; Fluoxetine; Neuropsychology; Neurocognitive functions

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a disorder commonly diagnosed in children during the developmental years that impedes their abilities to pay attention and stay still, which could be detrimental in a school setting [1]-[3]. Even though ADHD is a disorder that mainly affects children, in some cases, it affects adults as well [4]. ADHD is often comorbid with other psychiatric disorders such as anxiety, autism, bipolar disorder, child schizophrenia,

* Corresponding author: Anatolii Tsarkov
Department of Psychiatry, School of Medicine, University of Zambia (UNZA), Zambia.

depression, and antisocial behaviors [4]-[7]. Signs of this disorder are inability to sit still, being fidgety, interrupting those who are talking, inability to stay on task, and being distracted easily [1]-[3], [8]. About 7% of the school-age population is being diagnosed with ADHD [2]. ADHD affects school achievement, and relationships with peers, teachers, and parents leading to anxiety and depression [9]. The diagnosis of ADHD requires persistent and impairing symptoms of either hyperactivity/impulsivity or inattention that cause impairment in at least two different settings [2], [4]. Studies have shown that brain damage can cause ADHD. The hypothesized brain damage may potentially be associated with a circulatory, toxic, metabolic, mechanical, or physical insult to the brain during early infancy caused by infection, inflammation, and trauma [2].

Neurocognitive deficits may be associated with many functional (e.g., psychosis, delirium, depression, etc.), and organic (e.g., head injury, sequelae of stroke, Parkinson's disease, dementia, etc.) disorders [2], [7], [10]-[16]. Even such a common disease in Zambia as sickle disease may cause neurocognitive deficits and impair social, physical, and psychological well-being as well as learning performance [17]. ADHD is not an exception. ADHD is associated with substantial deficits across a variety of neurocognitive domains [18]. Such children have deficits in higher-level cognitive functions necessary for mature adult goal-directed behaviors (executive functions) that are mediated by late developing fronto-striato-parietal and fronto-cerebellar networks [19].

Stimulants are approved medication for ADHD treatment in children and adolescents and are considered first-line therapy [1]-[3]. However, these medicines are highly controlled and are usually imported to Zambia. On the Zambian market, stimulants like methylphenidate and methamphetamine are not affordable to most Zambians. In addition, these medicines are mostly out of stock or not stocked at all in most places on the Zambian market making it difficult for patients to access them any time they need them. Non-stimulant medications like atomoxetine and clonidine have been tried and approved for the treatment of ADHD symptoms. Even these medications are hard to find in a local market.

Another relevant problem to the Zambian population in relation to the use of stimulants among HIV-infected patients. It adversely affects sustained attention [20]. It was also discovered that stimulants used in conjunction with antiretroviral therapy in patients with HIV can have a profoundly negative impact on disease progression. Therefore, this indicates the need for more research on the alternative treatment and management approaches for HIV-positive ADHD patients. The literature has reviewed that Zambia is among the countries experiencing a high prevalence rate of HIV and AIDS [21]. Studies have shown that stimulant use may exacerbate the deleterious cognitive effects of HIV. Studies have also shown that despite the high rate of psychiatric conditions such as ADHD among HIV-positive children, there is little literature on the patterns and efficacy of psychiatric medications which they are given [22].

Furthermore, when ADHD occurs along with mood disorders such as depression and anxiety, a stimulant is given to treat the ADHD symptoms and an ant-depressant is given to treat the mood disorder [23]-[24]. Antidepressants are used for the treatment of clinical symptoms of depression [25]-[26]. Many clinicians opt for fluoxetine because of its long effect duration in the body which makes it an ideal drug for patients who forget to take it. Fluoxetine is a selective serotonin reuptake inhibitor and has been approved for children with depression [2]. Studies have shown that fluoxetine is an effective antidepressant in the context of HIV [27]. Some studies done out of Africa have also shown that fluoxetine may be helpful to children with ADHD [28]. In Zambia and Africa, studies establishing the effects of fluoxetine on children with ADHD have not been found.

Research in Africa on ADHD is scanty, and evidence of the research activities in South Africa, Congo D.R, Nigeria, Kenya, and Zambia only focused on prevalence rates and not treatment and management approaches. The prevalence of ADHD among school children, according to studies conducted in Africa ranges between 5.4% and 8.7% [29]. The studies coming from South Africa documented a prevalence of about 5%, which concurred with the finding of a prevalence of about 5% in the meta-analysis study of the worldwide prevalence of ADHD [30]. The epidemiological study among school children coming from the Democratic Republic of Congo documented a prevalence of 6.0%, while the epidemiological study coming from Nigeria among school children revealed a prevalence of 8.7%. These prevalence rates call for more research to focus on possible and favorable treatment and management options.

Methylphenidate is a short-acting medication that is generally used to be effective during school hours so that children with the disorder can attend to tasks and remain in the classroom. The drug's most common adverse effects include headaches, nausea, and insomnia. Some children experience a rebound effect, in which they become mildly irritable and appear to be slightly hyperactive for a brief period when the medication wears off. In children with a history of motor tics, some caution must be used; in some cases, methylphenidate can exacerbate the tic disorder [1]-[3]. Furthermore, even though Atomoxetine has been shown to be effective for inattention as well as impulsivity in children and in adults with ADHD, it has a short half-life (approximately 5 hours) and it is usually administered twice daily. Most common side

effects include diminished appetite, abdominal discomfort, dizziness and irritability. In some cases, increases in blood pressure and heart rate have been reported [1], [3].

Few data confirm the efficacy of selective serotonin reuptake inhibitors (SSRIs) such as fluoxetine in the treatment of ADHD. Because ADHD is a comorbid disorder, these drugs are considered in combination therapy or even as monotherapy [2], [28]. They are relatively safe and cause fewer side effects. If a person has ADHD and depression, for example, an antidepressant is given to treat depression and a stimulant can be given to treat ADHD symptoms. Many clinicians opt for fluoxetine because of its long duration in the body which makes it an ideal drug for patients who forget to take it [2], [31].

A study which was done by Barrickman, and their colleagues discovered that fluoxetine may prove to be an alternative treatment for some ADHD patients [28]. At the completion of their study, nearly 60% were judged to be at least moderately improved with no side effects on appetite or weight and side effects were minimal.

Another study which was done by Campbell and their colleagues suggested that after fluoxetine was initiated, there was a significant improvement in sleep and responsiveness after a week [32]. After a 6-week follow-up, the patients were sleeping well and behaving in an acceptable manner at school and at home. There was an improvement in their attention span and their social interactions. Blood pressure, pulse, and weight remained normal and no significant side effects were noted.

Furthermore, a study which was done by Mowla and their colleagues discovered that fluoxetine enhanced memory and cognition [33]. However, this study was not done on children with ADHD.

Another study that was done by Carlisi and colleagues discovered that a serotonin agonist up-regulates activation in typical ADHD dysfunctional areas in right inferior frontal cortex, insula, and striatum as well as down-regulating default mode network regions in the context of impulsivity, temporal discounting, and potentially improves cognitive functioning of ADHD patients.

In Zambia, studies on the effects of fluoxetine in improving the neurocognitive functioning of children with ADHD have not been found. Zambia and other Sub-Saharan countries do not have permanent guidelines for the treatment of children and adolescents with ADHD [1], [35]-[36].

Medication alone is often not sufficient to satisfy the comprehensive therapeutic needs of children with the disorder and is usually but one facet of a multimodality regimen. Social skills groups, training for parents of children with ADHD, and behavioral interventions at school and at home are often efficacious in the overall management of children with ADHD [1]-[2].

The neurocognitive domains affected in ADHD patients are memory, attention, and executive functioning. A deficit in the executive function can disrupt the normal function of an individual especially in demanding situations that require rapid and flexible adjustment of behavior to changing demands of the environment. Memory is a crucial part of our lives, without it, people cannot function. It is involved in the processing of a significant amount of the received information, for example, images, sounds, meanings, facts, etc. Attention is the ability to choose and concentrate on relevant stimuli. It is a cognitive process that makes it possible to position oneself towards relevant stimuli and consequently respond to them. There is a growing consensus that the fundamental problems in ADHD are self-regulated, and that ADHD is better conceptualized as an impairment of higher order cognitive processing, known as executive functioning. Patients with ADHD tend to show specific impairment in frontal lobe tasks associated with executive functioning, therefore, the deficits in ADHD appear to be relatively specific to executive functioning rather than reflecting generalized cognitive functioning [37]. Cognitive deficits, particularly impairments in focused attention and executive functions are hypothesized to be core components of ADHD and are thought to play a major role in the adaptive functioning of children with ADHD. Children with ADHD exhibit subaverage or relatively weak performance on various tasks of vigilance, sustained attention, motoric inhibition, and executive functioning [38].

The purpose of the study was to find out the effects of fluoxetine in improving the neurocognitive functioning of children with ADHD. The study was undertaken mainly to investigate the effects of fluoxetine in improving the neurocognitive functioning of children with ADHD in Zambia. Specific objectives were to identify the effects of fluoxetine in improving attention, executive functioning, and memory in children with ADHD. The study was done to fill the knowledge gap regarding the treatment and management of ADHD in Zambia. ADHD is poorly recognized and treated in most countries especially those with limited resource settings like Zambia. This study was a viable proposition because it has generated knowledge on the effects of fluoxetine in improving the neurocognitive functioning of children with ADHD in Zambia.

More important is the implication of fluoxetine on the central nervous system of children with ADHD, specifically the neuropsychological domain of executive functioning, attention, and memory. Since there is not much research done on the treatment and management of ADHD in Zambia, the results of the present study may open research prospects, particularly on the treatment and management of ADHD. This study has also added to the relevant literature on the treatment and management of ADHD in Zambia and Africa. Our study has the potential to provide an additional alternative treatment that can improve the neurocognitive functioning of children with ADHD which is easily available to parents, caregivers, and the community in Zambia. The findings from this study can increase awareness of ADHD and how it can negatively affect children. The results from the present study will as well contribute to the understanding of what policymakers and other stakeholders need to do to help children with ADHD achieve their potential in life.

2. Material and methods

This was a quantitative research study that utilized a causal-comparative study design also known as a quasi-experimental study design. This study design allows the researcher to control the treatment condition. In this study, the researcher assessed the patients before and 4 weeks after taking fluoxetine.

This study was conducted at the psychiatric clinic of the University Teaching Hospital (UTH) in Lusaka Zambia. This study site was chosen as UTH is the largest hospital and main referral health institution in Zambia. Patients come from all over the country. The hospital has a well-established clinic that deals with various neuropsychological disorders, including child and adolescent problems.

The target population was the patients with ADHD who met the inclusion criteria. The target population consisted of both male and female children with ADHD who were not on any medications such as stimulants which might have affected the results of the study. A total number of 10 participants were recruited in the study, comprising of individuals aged 7 to 11 who attended a psychiatric clinic at UTH. However, the sample size was limited according to the number of participants that were available during the period of data collection (referrals of children with ADHD to clinic 6 were few). The researcher assessed the participants before and 4 weeks after the patients started taking fluoxetine.

The study sample excluded children with ADHD who were on other medications such as children with ADHD who were on stimulants. Apart from this, children with ADHD whose parents were unable to give assent equally were excluded from the study.

A purposive sampling technique was used. This is because the researcher was focusing on characteristics of a population that were of interest and which best answered the research question.

This study used a developmental neuropsychological assessment tool, second edition (NEPSY- II) which has various subtests to assess domains of cognition. This assessment tool has been used in Zambia and across similar clinical settings before. The domains that were considered in this study were those which affect a child with ADHD (memory, attention, and executive functioning). To assess attention and executive functioning, the animal sorting test, design fluency test, and clocks test were used. To assess memory, the list memory test and narrative memory test were used.

The child psychiatrists at the psychiatric clinic ascertained the diagnosis of ADHD using the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5). Child psychiatrists also rely on several things and ways in order to diagnose ADHD such as having interviews with parents, personally assessing the child, use of psychological tests, and also using rating scales such as the Vanderbilt ADHD Diagnostic Rating Scale (VADRS). The recruited participants were referred to the researcher by the psychiatrists who ascertained the diagnosis of ADHD. Both the researcher and the medical staff obtained assent from the participants. Those patients who were diagnosed with ADHD and whose parents were not willing to allow them to take part in the study were not recruited. The researcher assessed the participants to determine their neurocognitive functioning before referring them to a psychiatrist for a prescription. The medical staff also assisted the researcher with the relevant information about the patients such as whether the patient was on any other medication or not and whether the patient was having any other illness or disorder apart from ADHD so that only those who met the inclusion criteria were recruited.

The main independent variable in the present study is ADHD. The dependent variables in the present study are memory, attention, and executive functioning. Data collected in this study were statistically analyzed using the statistical package for social sciences (SPSS) version 21. The version was well-suited to this study because it is one of the latest versions and could, therefore, perform various data analyses and functions. Analysis of variance (one-way ANOVA) was used to determine the effects of fluoxetine on children with ADHD.

The participants were informed of the study objectives so that they could make an informed decision regarding their participation. They did not materially or financially benefit from it, but there were long-term benefits mainly because the study findings will be used to inform policymakers on how to improve patient care.

Participants were also informed that they were free to withdraw at any time and that no punitive action was to be taken against them such as withdrawal of medical services and that, they were not coerced into participating in the study. Participants were informed that confidentiality would be maintained regarding the data collected to avoid stigma which would consequently lead to emotional stress. The names and codes used during the study were kept separately from the data to avoid them being linked to the participants. All the collected data was kept securely and safely.

3. Results

The main characteristics considered were age, sex, educational level, and employment status of parents. They are shown in table 1 below. The participants in the age range of 7-9 were 7 (70%) while those in the age range of 9-11 were 3 (30%). Apart from this, 7 (70%) of the participants were males while 3 (30%) of the participants were female. The participants who were in grades 1-3 were 7 (70%) while participants who were in grades 3-6 were 3 (30%). Finally, 6 (60%) participants had employed parents, while 4 (40%) participants had unemployed parents.

Table 1 Demographic characteristics of participants

Variable	Category	N	%
Age	7-9	7	70
	9-11	3	30
Sex	Male	7	70
	Female	3	30
Education Level	1-3	7	70
	3-6	3	30
Parents employment status	Employed	6	60
	Unemployed	4	40

Table 2 The first assessment of the baseline measurement

S/N	Animal sorting test	Design fluency test	Clocks test	List memory test	Narrative memory test
1	4	12	21	20	14
2	6	16	22	26	10
3	8	24	20	28	12
4	10	15	24	26	16
5	10	10	25	30	10
6	12	25	27	35	12
7	4	14	20	25	18
8	7	13	15	28	10
9	10	25	30	40	20
10	8	20	13	22	15

In the first assessment, under the Animal sorting test, the lowest score was 4 and the highest score was 12. For the Design fluency test, the lowest score was 10 and the highest score was 25. Under the Clocks test, the lowest score was

13 and the highest score was 30. Under the List memory test, the lowest score was 20 and the highest score was 40. For the Narrative memory test, the lowest score was 10 and the highest score was 20. The summary of the findings is presented in table 2.

An analysis of the Animal sorting test reviled that, 3 participants scored below average, which is 30% while 7 scored average which is 70%. Under the Design fluency test, 7 participants scored below average, which is 70% while 3 scored average which is 30%. An analysis of the Clocks test reviewed that, 8 participants scored below average which is 80% while 2 scored average making 20%. Under the List memory test, 7 participants scored below average which is 70% while 3 scored average which is 30%. Findings after analyzing the Narrative memory test reviled that, 4 participants scored below average which is 40% while 6 scored average which is 60%. Table 3 below illustrates the summary of the statistical analysis of the first assessment.

Table 3 The results of the statistical analysis of the first assessment

Tests	**Category**	**N**	**%**
Animal sorting test	0.-6.6	3	30
	6.6-13.6	7	70
Design fluency test	0-23.3	7	70
	23.3-46.6	3	30
Clocks test	0-26	8	80
	26-52	2	20
List memory test	0-30	7	70
	30-60	3	30
Narrative memory test	0-11.3	4	40
	11.3-22.6	6	60

The analysis of the results for test 1 using ANOVA concluded with $\alpha = 0.05$, the critical value for an F with d.f. (4, 40) being 2.61, the F ratio is 2.5 and total mean square is 68.6, and the total sum of squares is 3361.2. Since $\alpha = .05$ and d.f. = 4, 40, accept H_0 since $F_{4,40} \leq 2.61$. The computed value of the F statistic is 2.58. Table 4 depicted below illustrates the summary of the analysis of the first 1 using ANOVA.

Table 4 The summary of the test 1 analysis using ANOVA

Source	**Sum of squares**	**Degree of freedom (d. f)**	**Mean square**	**F**
A (assessment results)	342	4	585.53	2.5
Error (or residual)	1019.5	40	25.5	
Total	3361.62	49	68.6	

In the second assessment, under the Animal sorting test, the lowest score was 8 and the highest score was 17. For the Design fluency test, the lowest score was 15 and the highest score was 30. Under the Clocks test, the lowest score was 20 and the highest score was 36. Under the List memory test, the lowest score was 24 and the highest score was 61. For the Narrative memory test, the lowest score was 15 and the highest score was 26. Table 5 shows the summary of the second assessment for all conducted tests.

Table 5 The second (end-line) assessment of the baseline measurement

S/N	Animal sorting test	Design fluency test	Clocks test	List memory Test	Narrative memory test
1	8	25	25	50	16
2	10	18	20	38	20
3	10	18	30	51	20
4	12	20	28	50	25
5	15	20	36	53	24
6	13	28	31	52	25
7	14	24	26	45	20
8	17	15	26	35	15
9	15	30	35	61	26
10	14	25	20	24	20

An analysis of the Animal sorting test reviewed that, 6 participants scored average which is 60% while 4 scored above average which is 40% (mean=2.4 and sd=0.52). An analysis of the Design fluency test reviewed that, 5 participants scored below average which is 50% while the other 5 participants scored average which is 50% (mean=1.5 and sd=0.53). Findings after analyzing the Clocks test reviewed that, 5 participants scored below average which is 50% while the other 5 participants scored average which is 50% (mean=1.5 and sd=0.53). An analysis of the List memory test reviewed that, 1 participant scored below average which is 10%, 8 participants scored average which is 80%, and 1 participant scored above average which is 10% (mean=2.0 and sd=0.47), and for the Narrative memory test, 6 participants scored average which is 60% while 4 scored above average which is 40% (mean=2.4 and sd=0,52). Table 6 demonstrates the results of the statistical analysis of the second (end-line) assessment.

Table 6 The results of the statistical analysis of the second (end-line) assessment

Tests	Category	N	%
Animal sorting test	6.6-13.6	6	60
	13.6-20	4	40
Design fluency test	0-23.3	5	50
	23.3-46.6	5	50
Clocks test	0-26	5	50
	26-52	5	50
List memory test	0-30	1	10
	30-60	8	80
	60-90	1	10
Narrative memory test	11.3-22.6	6	60
	22.6-34	4	40

The analysis of the results for test 2 using ANOVA concluded with $\alpha = 0.05$, the critical value for an F with d.f. (4, 40) being 2.61, the F ratio is 9.96 and total mean square is 272.18, and the total sum of squares is 13337. Since $\alpha = .05$ and d.f. = 4, 40, we reject H_0 since $F_{4,40} \leq 2.61$. The computed value of the F statistic is 9.96. The summary of the discussed analysis is presented in table 7.

Table 7 The summary of the test 2 analysis using ANOVA

Source	Sum of squares	Degree of freedom (d.f)	Mean square	F
A (assessment results)	6266	4	1566.5	9.96
Error (or residual)	7071	40	176.78	
Total	13337	49	272.18	

Figure 1 depicted below shows the number of respondents in their respective categories according to the NEPSY II classification. 6 respondents were in the expected level, 2 respondents were in the below-expected level and 2 were in the above-expected level. No one was in the well below expected level and the borderline category. There was an 80% improvement.

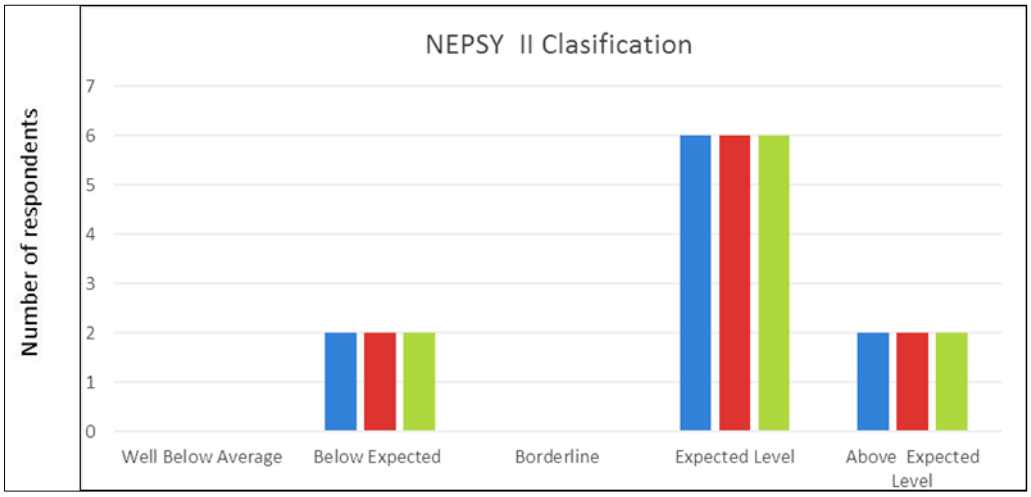

Figure 1 Classification of the research participants based on the NEPSY II results

4. Discussion

In the present study, ten (10) ADHD children who attended psychiatric clinics at UTH were assessed before they started taking fluoxetine and 4 weeks after fluoxetine was administered. The children were assessed using the NEPSY II which consists of various subtests. The subtests used in this study were the Animal sorting test, the Design fluency test, the Clocks test, the List memory test, and the Narrative memory test. Executive functioning, attention, and memory are major areas of deficits in ADHD patients [37]-[39].

The first objective of this study was to identify the effects of fluoxetine in improving attention and executive functioning in children with ADHD. The effects of fluoxetine in improving attention and executive functioning were determined in the second assessment done 4 weeks after fluoxetine was administered to our patients.

The null hypothesis was rejected in the second assessment, and the alternative hypothesis was accepted. This means that there was a significant difference in the neurocognitive functioning performance of children with ADHD before and after taking fluoxetine. The assessment results indicated that children with ADHD performed better after fluoxetine therapy was commenced. Therefore, the results of this study indicated that the executive functioning, attention, and memory of children with ADHD showed improvement after 4 weeks of fluoxetine therapy. The results from all tests in the second assessment were higher than the results of the first assessment; the details are discussed below.

Findings after analyzing the Animal sorting test indicated that, in the first assessment, most participants scored average (70%), few scored below average (30%), and no one scored above average while in the second assessment, most of the participants scored average (60%), few scored above average (40%), and no one scored below average. Under the Design fluency test, in the first assessment, most participants scored below average (70%), few scored average (30%), and no one scored above average while in the second assessment, half of the participants scored below average (50%),

the other half scored average (50%), and none scored above average. The analysis of the Clocks test indicated that, in the first assessment, many of the participants scored below average (80%), few scored average (20%), and no one scored above average while in the second assessment half scored below average (50%), the other half scored average (50%), and none scored above average. Findings after analyzing the List memory test, in the first assessment, most of the participants scored below average (70%), few scored average (30%), and no one scored above average while in the second assessment few scored below average (10%), majority scored average (80%), and few scored above average (10%). The analysis of the Narrative memory test revealed that in the first assessment few participants scored below average (40%), the majority scored average (60%), and no one scored above average while in the second assessment, the majority scored average (60%), few scored above average (40%), and no one scored below average.

In the first assessment, an analysis of the Animal sorting test indicated that 3 participants scored below average, which is 30% while 7 scored average which is 70%. The findings after analyzing the Design fluency test indicated that 7 participants scored below average, which is 70% while 3 scored average which is 30%. For the Clocks Test, 8 participants scored below average which is 80% while 2 scored average which is 20%. In the second assessment, an analysis of the Animal sorting test indicated that 6 participants scored average which is 60% while 4 scored above average which is 40% (mean=2.4 and sd=0.52). Under the Design fluency test, 5 participants scored below average 50% while 5 scored average which is 50% (mean=1.5 and sd=0.53). For the Clocks test, 5 participants scored below average which is 50% while 5 scored average which is 50% (mean=1.5 and sd=0.53). The results clearly show that patients with ADHD performed better in the second assessment than in the first assessment.

The findings of the present study are in line with some of the previous studies carried out in different parts of the world. A case study done by Campbell and their colleagues on a young child with ADHD suggested that after fluoxetine was initiated, there was a significant improvement in sleep and responsiveness after a week [32]. Like in our study, there was an improvement in attention span. Additionally, our study represents a Zambia ADHD population and may be interesting for other African countries, or for the health care settings with similar challenges.

Furthermore, a study which was done by Barrickman, and their colleagues discovered that fluoxetine may prove to be an alternative treatment for some ADHD patients. At the completion of the study, nearly 60% were judged to be at least moderately improved [28]. The findings are relevant to the current study because they provide some evidence that fluoxetine may be helpful to children with ADHD and correspond with our findings in relation to the improvement of neurocognitive deficits and psychiatric symptomatology.

The second objective of this study was to find out the effects of fluoxetine in improving memory in children with ADHD. The effects of fluoxetine in improving memory were determined in the second assessment done 4 weeks after fluoxetine was administered.

The following were the results obtained from each of the above tests in both the first and the second assessments. In the first assessment, findings after analyzing the List memory test reviewed that, 7 participants scored below average which is 70% while 3 scored average which is 30%. Analysis of the Narrative memory test indicated that 4 participants scored below average which is 40% while 6 scored average which is 60%. In the second assessment, findings after analyzing the List memory test indicated that 1 participant scored below average which is 10%, 8 participants scored average which is 80%, and 1 scored above average which is 10% (mean=2.0 and sd=0.47). For the Narrative memory test, 6 participants scored average which is 60% while 4 scored above average which is 40% (mean=2.4 and sd=0,52).

These assessment results indicated that there was a significant improvement in the patient's memory. These findings are in line with the findings done by Mowla and their colleagues, which discovered that fluoxetine enhanced memory and cognition in ADHD patients [33]. The main gap in this study was that it was not done on children with ADHD. It provides evidence that fluoxetine can improve memory in the general population as well as may be useful for ADHD patients.

5. Conclusion

This study investigated the effects of fluoxetine in improving the neurocognitive functioning of children with ADHD. The results of this study indicated that there was a significant difference in the neurocognitive functioning performance of children with ADHD before and after taking fluoxetine. The overall assessment results indicated an 80% improvement. The data collected and analyzed in this study indicate that fluoxetine provides a new light and alternative option in the treatment of Zambia population affected ADHD. Our research findings may open research prospects for the treatment and management of ADHD and may also disseminate information on the effects of fluoxetine in improving the

neurocognitive functioning of children with ADHD. Our research indicates that fluoxetine may improve attention, executive functioning, and memory in ADHD patients, but further studies with a larger sample size are required.

Limitations

The study was limited to children with ADHD who attended a psychiatric clinic at UTH, Lusaka, Zambia. Additionally, the sample size was small. However, the results obtained were generalizable to the target population.

Recommendations

Firstly, there is a need for further research by universities and individuals on the effects of fluoxetine in improving the neurocognitive functioning of children with ADHD especially using the longitudinal study design. Secondly, there is also a need for the government, universities, and individuals in Zambia to carry out studies on the improvement of the diagnosis and management of ADHD. Lastly, there is also a need for responsible stakeholders in African countries to carry out studies on the management of ADHD so that there can be more optimal options for management strategies suitable for individuals in any group of the society (especially from the underserved population). It would also be advisable for the government to facilitate sensitization on both the symptoms and management of ADHD at the community level in order to enable parents and caregivers to have sufficient knowledge and be able to bring children early for treatment.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

Statement of ethical approval

This research was approved by biomedical research ethics committee, the "Excellence in Research and Science Converge Institution" (ERES Converge) (ref. # 2019-May-004). The permission to conduct this research was also granted by the administration (the Head Clinical Care) of the University Teaching Hospital (UTH) on the 26th July 2019.

Statement of informed consent

Only the participants who met eligibility criteria, expressed willingness to participate, and provide written informed consent were enrolled in the study. The consent processes were done in English since the researcher only chose participants whose parents were able to read and write. The potential participants were given a chance to answer all questions. A copy of the information sheet and consent form was offered to the study participants' parents or legal guardians who were required to read and sign which the researcher countersigned. Appropriate informed consent was obtained from all individual participants included in the study.

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