South African Journal of Childhood Education
ISSN: (Online) 2223-7682, (Print) 2223-7674

Investigating the prevalence and comorbidity of attention deficit hyperactivity disorder and developmental dyslexia in learners in a South African practice

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Dates:
Received: 21 Aug. 2021
Accepted: 13 July 2022
Published: 21 Oct. 2022

How to cite this article:
Stark, S., Geertsema, S., Le Roux, M. & Bothma, E., 2022, 'Investigating the prevalence and comorbidity of attention deficit hyperactivity disorder and developmental dyslexia in learners in a South African practice', *South African Journal of Childhood Education* 12(1), a1085. https://doi.org/10.4102/sajce.v12i1.1085

Background: Dyslexia and attention deficit hyperactivity disorder (ADHD) are marked comorbid neurodevelopmental disorders with an estimated bidirectional comorbidity of 25% – 40%. Previous international studies have identified strong hereditary and neurological overlap between these disorders, but the comorbidity of these developmental disorders in a South African practice has not yet been explored.

Methods: This retrospective study aimed to investigate the co-existence of ADHD and the specific learning disorder (SLD) related to reading known as developmental dyslexia (DD). Additionally, the study sought to determine possible correlations between the overlapping diagnostic factors of the two developmental disorders. The study database consisted of 847 learners ranging from 8 to 18 years of age. Study data were obtained through a parent questionnaire regarding scholastic difficulties as well as prior ADHD diagnosis and/or treatment. A comprehensive psychometric assessment of DD was conducted on each participant in the first language of educational instruction, that is English or Afrikaans, to establish a direct dyslexia diagnosis as inclusion criterion.

Results: Of the 847 participants analysed in this study, 38.6% presented with a co-existing diagnosis of both ADHD and DD. However, there was no evidence of statistically significant interdependency between overlapping diagnostic factors of these two disorders.

Conclusions: The zero-correlations in the mentioned areas may indicate an overlap of shared symptoms rather than of distinctive diagnostic approaches.

Keywords: specific learning disorder; developmental dyslexia; ADHD; prevalence; comorbidity.

Introduction

Background

The German ophthalmologist Rudolph Berlin first coined the term dyslexia in 1887 (Ott 2007). Acquired dyslexia in an adult was clinically described in detail by a British ophthalmologist, Hinshelwood, in 1896. Hinshelwood used 'dyslexia' synonymously with 'word-blindness' and defined it as a condition in which with normal vision, which is seeing the letters and words distinctly, an individual is no longer able to interpret written or printed language. This condition is not dependent upon any ocular defect, but upon disorder of the cerebral visual centres (Hinshelwood 1911; Mather & Wendling 2012). Dyslexia was not further defined in detail until 1925, when Orton described the disorder particularly in regard to letter-reversal errors in individuals without obvious neurological problems (Hulme & Snowling 2016). Orton (1925) additionally emphasised that the intelligence test scores of a person with dyslexia do not correlate with their reading ability (Snowling 2005).

Regardless of these historic attempts, a clear-cut definition of dyslexia remained nebulous, as exemplified by Spache in 1976. Diverse meanings and uses of the term *dyslexia* stemmed from the fact that most 'diagnoses' of dyslexia were based on the *exclusionary criteria* that had been proposed by Critchley (in Rudel 1980). The exclusionary definition of dyslexia was stated as 'a disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity' (Critchley 1970:11). Although the exclusionary method as proposed by Critchley (in Rudel 1980) has limitations, it more recently

prompted educators to differentiate between nonspecific and specific reading dysfunction (Vellutino et al. 2004). Authors Carroll, Solity and Shapiro (2016) support this notion by recognising the controversy of dyslexia diagnoses because of a lack of universally recognised set of characteristics. Nonetheless, more informative and reliable diagnoses of dyslexia can be obtained with a direct method rather than the indirect exclusionary method (Friedmann & Coltheart 2018:721–752).

Developmental dyslexia

For centuries, professionals have been querying the phenomenon of a learner who may have normal sensory, perceptual, cognitive and motor abilities yet have marked difficulties decoding (reading) and encoding (writing) the written language (Griffin, Walton & Christenson 2009; Seidenberg 2017). Parents of these children recognise the adequate native intelligence in their child but are puzzled as to why there is a problem with reading, writing and spelling (Seidenberg 2017). This paradoxical phenomenon is known as *developmental dyslexia* (DD) (Frank 2014; Temple et al. 2003).

Dyslexia is a neurologically based, often familial, disorder that interferes with the acquisition and processing of language. Varying in degrees of severity, it manifests in difficulties in receptive and expressive language, including reading, writing, spelling, handwriting and sometimes in arithmetic (IDA 2002). Specific learning disability (SLD) is characterised by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction (DuPaul, Gormley & Laracy 2013).

Note: The *Diagnostic and statistical manual of mental disorders*, 5th edition (DSM-5), changed the classification and recommendations for diagnosis of specific learning disabilities. Developmental dyslexia is one of three specific learning disorders (SLDs) reintroduced in the DSM-5 (Schulte-Körne 2014). For the purpose of this study, the researches refer to this SLD as DD.

Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge (IDA 2019). Despite normal intellectual ability, dyslexic individuals struggle severely with literacy acquisition, thus facing profound barriers to learning throughout life. Developmental dyslexia affects reading and spelling specifically, with subsequent independent performance in other domains such as arts and mathematics (Skeide et al. 2018). Besides detrimental effects on academic achievement, DD may have a considerable negative effect on mental health, including an increased risk of anxiety disorders and depression (Klassen, Tze & Hannok 2013). Haft, Myers and Hoeft (2016) demonstrated in a recent study that children with dyslexia actively avoid reading-related stimuli. This may inadvertently reduce reading practice of dyslexic individuals compared to nonimpaired reading individuals, which subsequently impedes adequate reading comprehension (Snowling 2013). Early identification and assessment of dyslexia is therefore crucial to ensure that maximised educational potential is met and continuing progress monitoring and access to purposive intervention programmes are essential to maintain this potential level (Colenbrander, Ricketts & Breadmore 2018).

Direct types of assessment in reading and writing are used to evaluate characteristic *decoding* (cortical vocalisation of a written word for eidetic decoding and subcortical vocalisation for phonetic decoding), *encoding* and *nemkinesia* (spelling a word upon dictation with correct letters in sequence without reversals) to determine the specific dyslexic type (Aviah & Naama 2016; Zoubrinetzky, Bielle & Valdois 2014). This direct assessment method of diagnosis needs to meet the four criteria stipulated in the DSM-V (American Psychiatric Association 2013), which include the presence of prolonged difficulties during school-age years; standardised tests should be used, difficulties should become apparent in early school years and all exclusionary factors that may cause these difficulties must be ruled out. Consequently, DD is presently viewed as a heterogeneous, specific reading dysfunction, with each subtype within the disorder having its own distinct coding pattern (Elhassan et al. 2015; Stark & Griffin 2010). Developmental dyslexia is recognised as an explicit developmental learning disorder that impacts both learning and the use of adequate grammar. Developmental dyslexia occurs among people of all economic and ethnic backgrounds, regardless of culture, language, gender or age (Shaywitz 2003).

On South African soil, research indicated that the majority of learners who require special educational needs in mainstream schools, presented with either mild or moderate learning difficulties (such as attention deficit hyperactivity disorder [ADHD] and dyslexia) (Nel & Grosser 2016). In 2007, the number of learners with special educational needs in mainstream schools totalled 90 871. Of these, 17% had attention deficit disorder (ADD) or ADHD (as per DSM IV criteria), and 23% had dyslexia (Department of Education [DBE] 2015). In (DBE 2015), 121 461 learners with disabilities were enrolled in mainstream schools (South Africa, DBE 2015). In the same year, learners enrolled in special schools amounted to 119 559. Of these learners, 3116 had ADHD (0.026%), and 13 170 (11.015%) presented with SLD (EMIS 2016). The authors of this study question the accuracy of the latter statistics when compared with global estimations done by Dyslexia International in 2017, which suggest that between 5% and 10% of the worldwide population presents with DD.

Attention deficit hyperactivity disorder

Attention deficit hyperactivity disorder is a disorder marked by an ongoing pattern of inattention and/or hyperactivity–impulsivity that interferes with functioning or development

(NIMH 2019). Attention deficit hyperactivity disorder is a neurodevelopmental disorder that becomes apparent in some children in the preschool and early school years and often lasts into adulthood (Zenglein et al. 2016). It is hard for individuals with ADHD to control their behaviour and/or pay attention, resulting in poor reading development and academic achievement (Rabiner, Carrig & Dodge 2016). Attention deficit hyperactivity disorder in itself is not considered to be an SLD but rather a neurobehavioural disorder (Seidenberg 2017). The principal characteristics of ADHD are inattention, hyperactivity and impulsivity (Boat & Wu 2015). Professionals recognise three subtypes of ADHD. These subtypes are the *predominantly hyperactive–impulsive type* (not characterised by significant inattention), the *predominantly inattentive type* (no significant hyperactive–impulsive behaviour) and the *combined type* (displays both inattentive and hyperactive–impulsive symptoms) (International Dyslexia Association 2020).

International statistics indicate that ADHD is the most common psychiatric disorder in children – affecting 2.0% – 16.0% of the school-age population. The population prevalence for ADHD is estimated as 3.0% – 5.0% (Wittchen et al. 2010). In 2017, Dr Renata Schoeman postulates in her study that 5% of children in South Africa suffer from ADHD. Because of ignorance and lack of knowledge on ADHD in communities, many of these children remain formally undiagnosed and are labelled 'naughty' and 'unintelligent' (Schoeman & Liebenberg 2017). Schoeman conducted the first study on adults with ADHD in South Africa in 2015. She investigated the prevalence and treatment of ADHD in adults. According to her results, the prevalence of adults with ADHD was estimated at 1.09% lower than was previously thought. However, Schoeman attributed this lower prevalence rate to a possible lack of awareness of ADHD, a lack of access to diagnosis and treatment and poor coding habits of health care practitioners (Schoeman & De Klerk 2017).

Comorbidity of attention deficit hyperactivity disorder and developmental dyslexia

Comorbidity refers to the co-occurrence of two or more diagnoses in a single patient (Valderas et al. 2009). The most common comorbid condition with DD is reported to be ADHD (Serrallach et al. 2016). Willcutt and Pennington (2000) estimated that 15% – 40% of children with DD are also diagnosed with ADHD, and similarly 25% – 40% of children with ADHD are diagnosed with DD (Boada, Willcutt & Pennington 2012). In a more recent study, Hendren and colleagues reviewed the prevalence and characteristics of DD's comorbidities in a group of individuals under the age of 18 years (Hendren et al. 2018). They researched relevant articles from 1997 to 2017, and they found that research on comorbidity between DD and ADHD is extensive (Germanò, Gagliano & Curatolo 2010; Sexton et al. 2012; Willcutt et al. 2010). Approximately 20% – 40% of children with inattentive type ADHD have dyslexia (Sciberras et al. 2014; Wadsworth et al. 2015). Yoshimasu et al. (2010) determined that children diagnosed with ADHD were at higher risk for reading disability than children without ADHD. Ebejer et al. (2010) also studied the genetic and environmental influences on the development of early literacy, language and behaviour in children with ADHD and DD and found that the strongest relationship was between reading and inattention. This study showed inattention subsequently undermined reading development. Another research study also indicated that attention problems are especially likely to impair academic achievement when they persist across early grades (Rabiner et al. 2016). According to the International Dyslexia Association, ADHD and dyslexia can both cause people to avoid reading because of dysfluency, resulting in impeded learning (IDA 2019).

Children with ADHD present with problems related to attention, whereas reading is affected in children with DD. Subsequently, both of these conditions may appear alike in terms of focusing on the task at hand (McGrath & Stoodley 2019). Overlapping signs include *distraction, fluency and writing*. Both children diagnosed with either ADHD or DD may appear distracted, although the nature of the *distraction* is different (Quercia, Feiss & Michel 2013). Both children with ADHD as well as DD may appear distracted because of a lack of attention in the case of ADHD and a lack of decoding ability, hence increased effort and attentional input in the case of the child with DD (Jacobson et al. 2013). *Fluency* appears to be affected in both individuals with DD and ADHD (Cohen et al. 1999). Reading accuracy, reading speed and expression in oral reading determine the fluency of readers (Li et al. 2018). Fluent reading is required for good comprehension (Molitor, Langberg & Evans 2016).

A child with ADHD may omit, substitute, reverse and/or transpose words and phrases in text because of a lack of concentration, which ultimately affects their reading fluency and comprehension, whereas the child with DD struggles to read fluently since they need to analyse words phonetically, making the entire decoding process laborious (Sousa 2014). Both ADHD and DD affect the ability of the reader to comprehend what they have read. This is the reason why children with ADHD and/or DD find reading to be an unpleasant activity (Jacobson et al. 2013). The lack of organisational skills, poor fine motor development in writing, pencil grip and control as well as proofreading skills may be prominent in individuals with either ADHD or DD (Michel et al. 2019). Grammar and spelling is also affected in the individual with DD (Alamargot, Morin & Simard-Dupuis 2020). Furthermore, both disorders appear to lead to problems with executive function, memory and processing symbols rapid and efficiently (Moura, Simões & Pereira 2015). The differentiation between these two disorders is evident in the reading, spelling and writing problems of the dyslexic individual and the behavioural symptoms of the ADHD individual (Brown 2013). All of these factors create a challenge for diagnostic criteria, which evidently should be accurate, reliable and trustworthy (Wagner et al. 2020).

DD and ADHD are both considered to be *neurodevelopmental disorders* (Fraga-González, Karipidis & Tijms 2018), and from

the limited statistics available, they seemingly cross-impact each other, leading to even more academic devastation. Ignorance surrounding these two disorders needs to be addressed to better understand and support learners who experience barriers to learning. Similarities in the presentations of ADHD and DD raise concerns for accuracy of unambiguous diagnosis, which necessitates understanding of the prevalence and correlation of ADHD and DD (Manos, Giuliano & Geyer 2017). Understanding the relationship between ADHD and specific subtypes of DD will subsequently provide educators with definite guidelines for the management of learner support programmes per subtype of DD. Such data, as reported earlier, are scarce and outdated. Moreover, no such studies have been conducted in the South African population, making the present investigation both strong in rationale and novelty. The similarities and apparent overlapping between DD and ADHD lead to several points at issue. The following research question is therefore posited: what is the prevalence of comorbid ADHD and DD in learners in a South African practice?

Method

A secondary, retrospective case-control study

This secondary, retrospective study aimed to investigate the prevalence and comorbidity of ADHD in subjects with DD. This study determined frequencies, means and standard deviations and correlation coefficients to achieve the aims. An observational analytic secondary retrospective case-control study design was employed (Ranganathan & Aggarwal 2018). The study compared two types of diagnoses in one group of participants – those with only DD and those with both DD and ADHD. Case-control studies can determine the relative importance of a predictor variable about the presence or absence of the disorder, disease or condition (Kenborg et al. 2015). The design is quantitative, descriptive and comparative in nature: quantitative because of the nature of the collected data; descriptive in that frequencies, means and standard deviations were used to describe the sample's characteristics; and comparative because two specific groups from the overall sample were identified and compared for significant relationships. There has been no experimental manipulation of any of the applicable variables, since data were collected in the same professional environment and evaluated according to standardised norms (Heale & Twycross 2015). Data include background information from a structured questionnaire and the Stark Griffin Dyslexia Diagnostic Assessment (SGDA) (Stark 2020).

Participant sampling method and exclusion criteria

Purposive sampling was used (ed. Lavrakas 2008), a nonrandom sampling method where expert knowledge is applied to select a cross-section from a certain population. School-aged participants who could already read, and who were referred by psychologists, occupational therapists, speech–language therapists, paediatricians, educators or parents for a professional DD diagnosis, were included in the study sample. Participants of all appropriate ages (8–18 years) and with different home languages were included, although the questionnaires were only available in either English or Afrikaans. Exclusionary factors were applied, such as low intelligence, educational and/or sociocultural deprivation, allergies and other comorbidities, where such characteristics were deemed to be primary diagnoses (Delport et al. 2011). Exclusion criteria were therefore met when participants failed the proposed diagnostic criteria for ADD or ADHD and DD as per the DSM-5 (Langer et al. 2019). Because the study is retrospective, a power analysis in terms of sample size would not be of value (O'Keefe 2010). However, according to Field (2018) and Byrne (2012), a sample size of at least 200 is necessary to enable reliable and trustworthy statistical analysis, and this study's final sample consisted of 847 participants, with 327 diagnosed with both ADHD and DD.

Data collection

A comprehensive structured questionnaire, available in English and Afrikaans, was completed by each participant's parent(s) to obtain a thorough individual case history. The following biographical information was collected: gender, age, grade placement, premature birth, delayed developmental milestones, chronic otitis media, speech difficulties, family history of DD, ADHD diagnosis and ADHD medication, hand dominance, pencil grip, referring authority, reported positive and negative characteristics of the child and noted decoding and encoding difficulties in schoolwork as reported by the parents, as well as reported intervention programmes and/or therapy approaches that were followed for remediation. All participants were subsequently professionally assessed and diagnosed with the HPCSA-endorsed Stark Griffin Dyslexia Assessment (HPCSA 2019; Stark 2020; Stark & Griffin 2010). The SGDA contains six subtests to analyse the decoding (reading), encoding (spelling) and nemkinesia (writing) abilities of each participant. Results from the assessments were extracted and evaluated by means of the interpretation table of the Stark Griffin Dyslexia Assessment in order to deliver a direct diagnosis falling in one of eight subcategories (0 = no dyslexia, 1 = dysnemkinesia, 2 = dyseidesia, 3 = dysphonesia, 4 = dysphoneidesia, 5 = dysnemkineidesia, 6 = dysnemkinphonesia, 7 = dysnemkinphoneidesia) with one of five severity levels (0 = no dyslexia to 4 = severe) (Stark 2020; Stark & Griffin 2014). Results obtained for each participant were captured onto spreadsheets. Refer to Figure 1 to view the methodology flow chart of data collection.

Classification of characteristics

The following characteristics were captured for each participant: gender, chronological age, grade placement, premature birth, late developmental milestones, otitis media, speech problems, family history of DD, reported ADHD diagnosis, ADHD medication, type of ADHD medication, hand dominance, pencil grip, referred by, positive characteristics, negative characteristics, therapy and/or intervention and reported motoric, visual and/or auditory signs and symptoms in schoolwork.

Statistical analysis

Frequencies, means and standard deviations were calculated with the use of SPSS 27 (IBM Corporation 2021). A chi-square test was performed to assess the relationship between the categorical variables 'ADHD diagnosis' and 'DD diagnosis'. It is important to note that although there may be a relationship between variables in correlational studies, it ultimately cannot prove cause-and-effect relationships (Carpenter, Goldstein & Kenward 2012).

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of Pretoria Research Ethics Committee (ref. no. 207409073 [HUM014/0121]). The study was conducted in accordance with all ethical practices such as obtaining informed consent from all participants (POPI Act 2013; De Bruyn 2014.).

Results

To our knowledge, this study is the first in South Africa to analyse the comorbidity of and specific relationship between the neurobehavioural disorder ADHD and the learning disorder DD in a South African practice (Fraga-González et al. 2018; Furman 2005). Langer and colleagues refer to the common aetiology model of Willcutt. This model hypothesises that because of shared genetic and/or environmental influences, the likelihood of this comorbidity is increased (Langer et al. 2019). Results from this study, however, indicated no significant correlation between the diagnoses of the neurodevelopmental disorders ADHD and DD.

Characteristics of the participants

Specific demographic characteristics are reported in Table 1. The participant sample (n = 847) was represented by 65.9% boys (n = 558) and 34.1% girls (n = 289) with an age range of 8–18 years (M = 11.04, SD = 2.57), and school grade placement ranging from grades 1 to 12 (M = 5.34, SD = 2.51). Separate frequencies are reported for the four identified groups evaluated. These groups were: (1) participants with neither an ADHD or DD diagnosis (label: NO; n = 40); (2) participants with only an ADHD diagnosis (label: ADHD; n = 31; (3) participants with only a DD diagnosis (label: DD; n = 443); and (4) participants with both an ADHD and DD diagnosis (label: ADHD + DD; n = 327). The six participants not accounted for in any of these groups were excluded because of missing values on diagnosis data.

Descriptive statistics

In Figure 2, the distribution of participants according to ADHD and/or DD diagnosis can be seen.

The prevalence of attention deficit hyperactivity disorder and developmental dyslexia in learners assessed in a South African practice

The number of participants diagnosed with both ADHD and DD amounted to 327 (38.6%). Of these, 239 were male (43.1% of all male participants, 28.2% of total number of participants) and 88 were female (30.8% of all female participants, 10.4% of total number of participants), as seen in Table 2.

The most appropriate statistical evaluation of the strength of a relationship between two categorical variables is a chi-square test (Field 2018). This test assesses the association between two categorical variables by comparing the observed pattern of responses to the pattern that would be expected if the variables were truly independent of each other. The null hypothesis is therefore that no relationship exists between the specified categorical variables in the population and that they are independent (McHugh 2013). The results showed a chi-square (χ^2) value of 0.04 with a significance value (p) of 0.90 (Table 3). In order to make a conclusion about the hypothesis with 95% confidence, the p-value should be less than 0.05. It is therefore concluded that there is not a significant relationship between the two categorical variables diagnosis of ADHD and diagnosis of DD.

Discussion

Comorbidity is very common in neuropsychiatric diseases, including learning disorders (LD) (Margari et al. 2013). Firstly, this study aimed to investigate the comorbidity of ADHD and DD in a typical South African private practice. Secondly, certain correlational factors were also investigated to determine the interdependency of these two disorders.

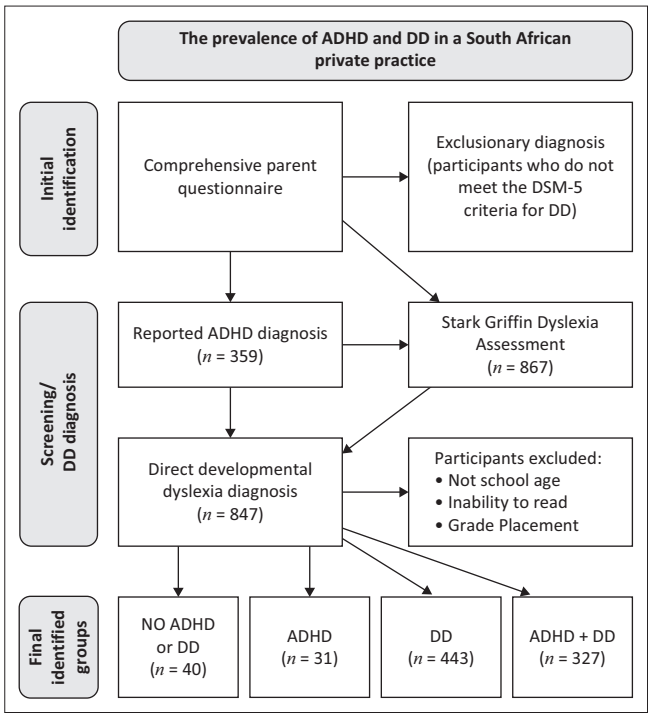
Dykman and Ackerman (1991) indicated that 25% – 40% of persons with ADHD also have symptoms of dyslexia, while 15% – 40% of persons with DD manifest behaviours diagnostic for ADHD. A study by Adams et al. (1999) found that 15.6% of children with dyslexia had a significant problem with attention.

A total of 327 of 847 participants (38.6%) presented with comorbid ADHD and DD in this study. We believe this is a substantial sample size in comparison to other similar studies, for example, by Pauc (2005), who conducted a prospective epidemiological study of 100 children attending a specialist clinic in the United Kingdom. They reported that a clear pattern of comorbidity was demonstrated. Lipowska, Bogdanowicz and Bulin'ski (2008) conducted an interdisciplinary research study on 259 children in Poland to determine whether or not children diagnosed with ADHD and DD differ in the level of linguistic functioning from their peers who are only hyperactive or have isolated DD. A study done by Shaywitz et al. (2017) investigated 209 children aged 10–16 years in terms of the effect of atomoxetine treatment on their reading and phonological skills. A larger sample of 1269 children and adolescents were recruited through 18 ADHD centres in Italy, where 56% ADHD and DD comorbidity was reported (Reale et al. 2017). In Pakistan, 48 children were examined by means of an exploratory study by investigating the neuropsychological differences in ADHD and DD comorbidity (Naz & Najam 2019). Other recent comorbidity study sample sizes include the study done in Ecuador on 140 children in third and fifth grades, (Fernández-Andrés et al.

TABLE 1: Specific and demographic characteristics of the participants (n = 847).

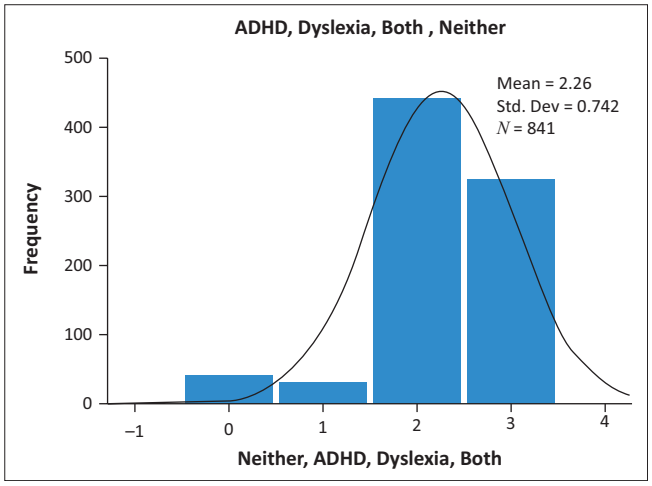
Item	Category	Neither ADHD nor dyslexia diagnosis (NO)		ADHD diagnosis (ADHD)		Dyslexia diagnosis (DD)		Both ADHD and dyslexia diagnosis (ADHD + DD)	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Gender	Male	22	4.0	19	3.4	275	49.5	239	43.1
	Female	18	6.3	12	4.2	168	58.7	88	30.8
Age (years)	8 years	3	2.9	3	2.9	61	59.2	36	35.0
	9 years	14	6.8	3	1.4	107	51.7	83	40.1
	10 years	5	3.5	9	6.3	78	54.9	50	35.2
	11 years	9	9.1	6	6.1	45	45.5	39	39.4
	12 years	2	3.0	4	6.1	33	50.0	27	40.9
	13 years	2	3.6	1	1.8	34	61.8	18	32.7
	14 years	1	1.8	3	5.3	26	45.6	27	47.4
	15 years	2	4.5	2	4.5	23	52.3	17	38.6
	16 years	2	5.3	0	0.0	18	47.4	18	47.4
	17 years	0	0.0	0	0.0	13	65.0	7	35.0
	18 years	0	0.0	0	0.0	5	50.0	5	50.0
Grade	1	0	0.0	0	0.0	2	50.0	2	50.0
	2	1	3.4	2	6.9	13	44.8	13	44.8
	3	10	4.8	4	1.9	114	54.8	80	38.5
	4	9	5.3	4	2.4	95	56.2	61	36.1
	5	10	8.5	9	7.6	54	45.8	45	38.1
	6	3	4.1	5	6.8	36	49.3	29	39.7
	7	1	1.7	3	5.2	36	62.1	18	31.0
	8	2	3.0	4	6.0	31	46.3	30	44.8
	9	3	8.8	0	0.0	18	52.9	13	38.2
	10	0	0.0	0	0.0	20	48.8	21	51.2
	11	1	3.6	0	0.0	14	50.0	13	46.4
	12	0	0.0	0	0.0	10	83.3	2	16.7
Premature birth	No	37	4.9	27	3.6	404	53.6	286	37.9
	Yes	3	3.5	4	4.7	37	43.5	41	48.2
Late development	No	16	3.4	16	3.4	251	53.7	184	39.4
	Yes	24	6.5	15	4.1	187	50.7	143	38.8
Otitis media	No	36	4.8	25	3.3	407	54.0	286	37.9
	Yes	4	4.7	4	7.0	35	40.7	41	47.7
Speech problems	No	38	5.7	27	4.1	350	52.9	247	37.3
	Yes	2	1.1	4	2.3	88	50.6	80	46.0
Dyslexia family history	No	30	9.0	19	5.7	172	51.3	114	34.0
	Yes	10	2.0	12	2.4	271	53.6	213	42.1
Using medication	No	40	8.0	0	0.0	439	88.0	20	4.0
	Yes	0	0.0	31	9.1	3	0.9	306	90.0
Type of medication	No medication	11	3.8	0	0.0	260	89.3	20	6.9
	Ritalin	0	0.0	7	9.5	0	0.0	67	90.5
	Concerta	0	0.0	11	9.4	0	0.0	106	90.6
	Strattera	0	0.0	0	0.0	0	0.0	10	100.0
	Contramyl	0	0.0	0	0.0	0	0.0	1	100.0
	Cypramil	0	0.0	1	100.0	0	0.0	0	0.0
	Neucon	0	0.0	1	9.1	0	0.0	10	90.9
	Zoxadan	0	0.0	0	0.0	0	0.0	1	100.0
	Ritalin + Concerta	0	0.0	1	25.0	0	0.0	3	75.0
	Ritalin + other	0	0.0	0	0.0	0	0.0	3	100.0
	Concerta + other	0	0.0	1	25.0	0	0.0	3	75.0
	Cilift + other	0	0.0	0	0.0	0	0.0	1	100.0
	Herbal + vitamins	0	0.0	0	0.0	4	22.2	14	77.8
	Other	0	0.0	0	0.0	0	0.0	19	100.0
Dominant side	Right side	32	4.3	28	3.8	394	53.4	284	38.5
	Left side	8	8.5	3	3.2	44	46.8	39	41.5
Pencil grip	Correct pencil grip	27	4.8	24	4.3	293	52.0	220	39.0
	Incorrect pencil grip	12	4.7	7	2.8	135	53.1	100	39.4
Referred by	No referral	1	2.6	0	0.0	24	61.5	14	35.9
	Professional referral	16	5.8	9	3.3	137	49.6	114	41.3
	Parents, family or friends	15	6.0	13	5.2	132	52.0	93	36.8
	School	6	3.0	9	4.5	109	54.8	75	37.7
	Media	1	3.6	0	0.0	14	50.0	13	46.4

ADHD, attention deficit hyperactivity disorder; DD, developmental dyslexia.



ADHD, attention deficit hyperactivity disorder; DD, developmental dyslexia; DSM-5, Diagnostic and statistical manual of mental disorders, 5th edition.

FIGURE 1: Methodology flow chart of data collected for 4 groups related to attention deficit hyperactivity disorder and/or developmental dyslexia diagnosis for the study of prevalence of these disorders in a South African practice.



ADHD, attention deficit hyperactivity disorder.

FIGURE 2: Distribution: Participants grouped according to attention deficit hyperactivity disorder and/or developmental dyslexia diagnosis.

2021), as well as the research study done on 100 children in Egypt, where 18% ADHD and DD comorbidity was reported (Darweesh et al. 2020).

Results from the current study concur with key results from international studies done by DuPaul et al. (2013) and Langer et al. (2019). These researchers reported a prevalence of 5% – 10% of dyslexia (also known as DSM-5 SLD with impairment in reading) and ADHD. They also reported a bidirectional comorbidity rate of 25% – 40% (DuPaul et al. 2013). Du Paul and his colleagues' studies done in the United States of America (USA) revealed a mean comorbidity rate of 45.1%, which was higher than had been obtained in studies

TABLE 2: The prevalence of comorbid attention deficit hyperactivity disorder and developmental dyslexia (n = 327).

Participants by gender	Frequency	Valid per cent (number of comorbid ADHD + DD participants)	Valid per cent (total number of participants)
Male	239	73.1	28.2
Female	88	26.9	10.4

ADHD, attention deficit hyperactivity disorder; DD, developmental dyslexia.

TABLE 3: Relationship between attention deficit hyperactivity disorder and developmental dyslexia diagnoses.

Variable	χ^2-test value	*p
ADHD diagnosis and dyslexia diagnosis	0.04	0.90

*p < 0.05.

ADHD, Attention deficit hyperactivity disorder.

done by Italian researchers Margari and colleagues in the same year. Margari and colleagues found the comorbidity rate of ADHD and DD to be 33% in the 240 participants they investigated. The comorbidity rate obtained in the present retrospective study was 38.6%. These figures substantiate previous co-occurrence rates of 25% – 40% in comorbidity studies done by Boada and his colleagues in 2012, as well as the comorbidity rate of 20% – 40% found in a Colorado longitudinal study done in the USA on twins in 2015 by Wadworth and his colleagues.

Co-occurrence of the neurodevelopmental disorders ADHD and DD is thus confirmed in this South African study. Although research has been done on the prevalence of ADHD in South Africa (De Milander et al. 2020; Schellack & Meyer 2012, 2016), and although national and international researchers do not dispute the co-occurrence of ADHD and DD (Danielson et al. 2018), to our knowledge it is the first time in South African history that the relationship and interdependency of these two developmental disorders were investigated.

Reading disabilities overlap with ADHD and inattentive traits (Mascheretti et al. 2017). Attention deficit hyperactivity disorder and DD are highly comorbid disorders with shared neurophysiological and genetic factors (Pham & Riviere 2015). In a study of children with dyslexia and ADHD, Snowling (2001) suggested that one condition could occur as a consequence of the other. The common aetiology model of Willcutt, however, hypothesises that the comorbidity occurs as a result of shared genetic and/or environmental influences that increase the likelihood for both disorders. This model assumes that the disorders are differentiated by other aetiological factors that are distinct to each disorder (Willcutt 2018). Correlation does not imply causation, and therefore the researchers of this study do not conclude causality from our correlational studies (Lau 2017).

Statistical research findings ascertain no significant relationship between ADHD and DD, thus indicating that one disorder does not cause the other disorder (Langer et al. 2019), but rather showing that the prevalence of comorbidity is independent of the order of diagnosis. The *correlation* between ADHD and DD in this study proved to be insignificant, which indicated that although these two

disorders could be comorbid, the presence of one does not indicate nor influence the presence of the other. Both ADHD and DD are differentiated by aetiological factors that are distinct to each disorder, and the comorbid occurrence thereof is unrelated (Langer et al. 2019).

The authors of this study speculate that statistics revealed the need for further investigation into the possible existence of comorbid neurodevelopmental disorders. In this study, DD diagnosis was sought after ADHD examinations and diagnoses were concluded. The authors therefore suggest that *misdiagnosis* and lack of direct diagnosis hypothesises the concerning number of learners in South African schools who continue to experience barriers to learning despite an original unilateral diagnosis of *a* neurodevelopmental disorder (Phillips 2010). Diagnosis of only one disorder may be suboptimal, which could explain why children still struggle at school and experience barriers to learning (Snowling 2013).

Conclusion

To our knowledge, the current study is the first in South Africa to analyse the co-occurrence of ADHD and DD as well as the correlation between these disorders. Our goal was to investigate this comorbidity and its correlation in order to contribute to a multilevel understanding of the importance of a comprehensive approach to diagnosing *neurodevelopmental disorders* (Fraga-González et al. 2018; Scandurra et al. 2019). One theoretical advancement that is guiding the study of comorbidity is the shift from unilateral and indirect diagnoses to a multidisciplinary approach in comprehensive diagnoses of both neurobehavioural as well as SLDs in leaners who fail to succeed academically. This study sets the framework not only for future dyslexia–ADHD comorbidity investigation, but it also anchors the necessity for direct and broader diagnostic approaches to neurodevelopmental disorders, especially when signs and symptoms of these disorders appear to be vague and/or overlapping (Schuchardt et al. 2015). Direct diagnoses of developmental disorders are also essential for intervention and therapy strategies to be purposive and have favourable outcomes (Snowling 2013).

Limitations and suggestions of this study

The authors of this study speculate that statistics reveal the need for further investigation into the possible existence of comorbid neurodevelopmental disorders. Participants in a retrospective study such as this study, are often recruited by convenience sampling. For this study subjects were sampled from a secure professional environment, and they are thus not representative of the general population. Future studies could possibly include population samples from wider geographical areas and communities in rural areas. Although the data retrieved in this study met the criteria for exclusionary factors that may play a role in diagnosis, it is possible that other risk factors may be present that were not measured. Another limitation to this particular study is that causation cannot be determined, only correlation, (Price & Murnan 2004). Future additional research studies should clearly delineate the neuropsychological profile of comorbid ADHD and DD, drawing participants with direct diagnoses for both these disorders. Investigative research into the early diagnosis and/or screening of predictive factors and patterns pertaining to possible diagnosis of ADHD and DD in younger participants (aged 5–7 years) may replicate the key results from this study. The favourable sample size and large number of characteristics analysed in this study lends itself to explore various avenues of discovery in the field of DD (Stein 2018).

Acknowledgements

The authors acknowledge the Stark Griffin Dyslexia Academy practice for permitting the use of the research data collected over a period of 10 years (2010–2020).

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

S.S. designed the study, collected the data and compiled the article. E.B. analysed the data. S.G. and M.l.R. provided critical feedback and assisted in writing this article.

Funding information

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data availability

The data that support the findings of his study are available on request from the corresponding author, S.S. The data are not publicly available because of privacy restrictions.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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