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Anne-Lise Juul Haugan

Group Cognitive Behavioural Therapy and Functional Impairment in Adolescents with ADHD

Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Medicine and Health Sciences
Department of Mental Health

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Norwegian University of
Science and Technology

Anne-Lise Juul Haugan

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Trondheim, February 2023

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Norsk sammendrag

Kognitiv atferdsterapi i gruppe og funksjonsvansker hos ungdom med ADHD

Ungdom med ADHD har kroniske og funksjonsnedsettende oppmerksomhetsvansker og/eller hyperaktivitet som hemmer dem i hverdagen. I tillegg er de ekstra sårbare for å ha samtidige emosjonelle vansker, lærevansker, atferdsvansker og økt risikoatferd. Medikamentell behandling kan dempe kjernesymptomene ved ADHD, men medisin er ikke for alle og mange avslutter behandlingen etter kort tid. Ungdom med ADHD mangler ofte ferdigheter for å mestre egne funksjonsvansker i hverdagen, og mange tar med seg vanskene over i voksenlivet. Behovet for ikke-medikamentell behandling er stort, men få studier har vært rettet mot ungdom. Kognitiv atferdsterapi (KAT) er anbefalt som tilleggsbehandling for pasienter med ADHD og komorbide tilstander. Kunnskap om behandlingseffekten av KAT for ungdom med ADHD er imidlertid mangelfull, og man trenger flere studier for å underbygge denne anbefalingen.

Formålet med denne avhandlingen var å undersøke effekten av kognitiv atferdsterapi i gruppe som tilleggsbehandling til psykoedukasjon og medikamentell behandling for ungdom med ADHD. Vi ønsket også å vurdere måleegenskapene til den norske versjonen av utredningsinstrumentet Weiss Functional Impairment Rating Scale (WFIRS) for bruk ved utredning av funksjonsvansker hos ungdom med ADHD i BUP klinikk og for å evaluere behandlingseffekt i studien. Siden det er stor samsykelighet mellom ADHD og angstlidelser hos ungdom og årsaker til denne assosiasjonen er lite kjent, ønsket vi også å undersøke i hvilken grad vansker med eksekutive funksjoner og funksjonsvansker i hverdagen medierer forholdet mellom ADHD og angst.

Studien baserer seg på data fra 114 ungdommer i BUP klinikk mellom 14 og 18 år med ADHD. Vi brukte ulike spørreskjema som kartlegger ADHD symptomer, funksjonsvansker og eksekutive funksjoner med ungdommene selv, deres foreldre og lærere som informanter. Deltagerne fylte i tillegg ut spørreskjema som kartla angst, depresjon, selvbilde, mestringstro og søvn. Data ble samlet i perioden februar 2017 til januar 2020.

KAT som tilleggsbehandling til psykoedukasjon og medisinering for ADHD viste ingen ytterligere forbedringer verken på ADHD symptomer eller assosierte vansker sammenlignet med en kontrollgruppe som ikke fikk den samme tilleggsbehandlingen. En svakhet med studien var inklusjon av mange behandlingsmoduler og liten tid til trening på hver modul. Både WFIRS foreldrerapport og selvrapport viste akseptable måleegenskaper for bruk ved kartlegging av funksjonssvikt i en klinisk ungdomspopulasjon med ADHD. Ved kartlegging av sammenhenger mellom ADHD og angst, predikerte selvrapporterte oppmerksomhetssvikt symptomer, foreldre- og selvrapportert eksekutiv dysfunksjon og mål på funksjonssvikt angst hos ungdommene. ADHD symptomer alene predikerte ikke angst når vi kontrollerte for eksekutiv dysfunksjon og funksjonsvansker i en medieringsanalyse. Eksekutiv dysfunksjon medierte dette forholdet alene, mens funksjonsvanskene kun påvirket dette forholdet via eksekutiv dysfunksjon.

Oppsummert tyder studien på at gevinsten av KAT som tilleggsbehandling til psykoedukasjon og medikamentell behandling fremdeles er uklar og bør studeres ytterligere før den anbefales for ungdom med ADHD. Funn ved vår studie og andre nyere studier tilsier at behandlingsprogram som inkluderer foreldre og som avgrenser behandlingen til noen få kjernemoduler kan ha større effekt. WFIRS foreldrerapport og selvrapport kan anbefales for bruk ved kartlegging av funksjonsvansker hos ungdom med ADHD. For ungdom med ADHD og samtidige angstlidelser bør eksekutive funksjoner kartlegges og støttetiltak iverksettes som del av en helhetlig behandlingsplan.

Navn kandidat: Anne-Lise Juul Haugan
Institutt: NTNU, Institutt for psykisk helse, RKBU
Veiledere: Torunn Stene Nøvik, Per Hove Thomsen og Stian Lydersen

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Summary

Group cognitive behavioural therapy and functional impairment in adolescents with ADHD

Attention-deficit/hyperactivity disorder (ADHD) is a persistent neurodevelopmental disorder that affects 5% of children and adolescents worldwide. It is characterized by inattention and/or hyperactivity with functional impairment in at least two life domains (DSM-5). ADHD is one of the most prevalent disorders in child and adolescent psychiatry (CAP) clinics, and it is often associated with behavioural disorders, psychiatric disorders, learning disorders, and risky behaviour. Pharmacological treatment is known to decrease the severity of the core ADHD symptoms, but some parents are resistant to medicating their children, and many patients discontinue treatment due to side-effects or limited treatment effects. Additionally, medication does not give patients the skills needed to handle their symptoms and associated functional impairments. This is problematic since two out of three patients continue having the disorder into their adult lives. Cognitive behavioural therapy (CBT) is recommended as a supplemental treatment for young people with ADHD and comorbid disorders. Studies of CBT for adolescents are, however, limited, and more studies are needed to support this recommendation.

The primary aim of this thesis was, to examine the efficacy of a group CBT as an addition to psychoeducation and pharmacological treatment for adolescents with ADHD in a randomized trial. Second, we wanted to explore the psychometric properties of the Norwegian version of the Weiss Functional Impairment Rating Scale (WFIRS) parent- and self-reports, to see if these instruments were appropriate for use with a clinical population of adolescents with ADHD, and for use in the evaluation of treatment effects. Finally, since anxiety disorders are common in this patient group and causes for this ADHD-anxiety association are poorly understood, we wanted to examine whether executive dysfunction and functional impairment mediate in this relationship. Increased knowledge in this area could potentially motivate more targeted treatment.

The studies were based on data from 114 adolescents with ADHD between 14 and 18 years of age from a CAP clinic. Different questionnaires assessing ADHD symptoms, executive functions (EFs) and functional impairment were administered, with the participants, their parents, and teachers as informants. Additionally, the participants completed measures of internalizing symptoms and self-image. Data were collected between February 2017 and January 2020.

The randomized controlled trial revealed no incremental treatment effect of a group CBT as follow up to psychoeducation and pharmacological treatment compared to the control condition regarding ADHD symptoms and accompanying impairments. Limitations with the CBT were the large number and low dosage of treatment components leading to restricted time for practice. The WFIRS parent- and self-reports were both found to be acceptable for use in assessing functional impairment in a Norwegian clinical adolescent ADHD population. In the exploration of the associations between

ADHD and anxiety, both self-reported ADHD inattentive symptoms, parent- and self-rated executive dysfunction and functional impairment predicted anxiety. ADHD symptoms alone were unable to predict anxiety when controlling for EFs and functional impairment in a mediation analysis. EFs mediated the ADHD-anxiety association alone and functional impairment mediated this relationship only through EFs.

In conclusion, we were unable to find an incremental treatment effect of group CBT as a follow-up treatment in addition to psychoeducation and pharmacological treatment in adolescents with ADHD. However, this study, combined with newer research findings does suggest that the inclusion of parents and a focus on fewer treatment modules, leaving room for more extensive practicing of skills, may increase the effectiveness of this type of intervention. More studies are needed to support CBT as a follow-up treatment for this patient group. Moreover, the psychometric properties of the Norwegian version of the WFIRS parent- and self-reports were acceptable, and the instrument can thus be recommended for use in CAP clinics in the assessment of functional impairment in adolescents with ADHD. Since, executive dysfunction seems to mediate the ADHD-anxiety relationship, these functions should be assessed, and supportive measures should be integrated as part of a targeted treatment plan when working with adolescents with ADHD and comorbid anxiety.

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Acknowledgements

This study was conducted between 2017 and 2021 at the Regional Centre for Child and Youth Mental Health and Child Welfare (RKBU), Department of Mental Health, Faculty of Medicine and Health Sciences, NTNU Norwegian University of Science and Technology, and at the Department of Child and Adolescent Psychiatry (BUP), St. Olav's University Hospital, Trondheim, Norway. The study was funded by a PhD grant from RKBU, NTNU. The study received additional funding from the Child and Adolescent Psychiatric Clinic, St. Olav's University Hospital; the Regional Network for Autism, ADHD, and Tourette Syndrome, Mid-Norway Health Trust; The National Research Network for ADHD, Ullevål University Hospital, Oslo, and the Regional Competence Network for ADHD, RKBU, NTNU.

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List of Papers

Paper I

Anne-Lise Juul Haugan, Anne Mari Sund, Per Hove Thomsen, Stian Lydersen, Torunn Stene Nøvik (2021). **Psychometric Properties of the Weiss Functional Impairment Rating Scale Parent and Self-Reports in a Norwegian Clinical Sample of Adolescents treated for ADHD.** Nordic Journal of Psychiatry, 75(1):63-72. https://doi.org/10.1080/08039488.2020.1795252

Paper II

Anne-Lise Juul Haugan, Anne Mari Sund, Susan Young, Per Hove Thomsen, Stian Lydersen, Torunn Stene Nøvik (2022). **Cognitive behavioural group therapy as addition to psychoeducation and pharmacological treatment for adolescents with ADHD symptoms and related impairments – A randomised controlled trial.** BMC Psychiatry, 22 (1):375. https://doi.org/10.1186/s12888-022-04019-6

Paper III

Anne-Lise Juul Haugan, Anne Mari Sund, Per Hove Thomsen, Stian Lydersen, Torunn Stene Nøvik. **Executive Functions Mediate the Association between ADHD Symptoms and Anxiety in a Clinical Adolescent Population.** Frontiers in Psychiatry https://doi.org/10.3389/fpsyt.2022.834356

Abbreviations and Acronyms

AD	Anxiety Disorder
ADHD	Attention Deficit Hyperactivity Disorder
ADHD RS	ADHD Rating Scale
ASD	Autism Spectrum Disorder
BRIEF-P	Behaviour Rating Inventory of Executive Function parent report
BRIEF-S	Behaviour Rating Inventory of Executive Function self-report
CBT	Cognitive behavioural therapy
CBCL	Child Behaviour Checklist
CAP	Child and Adolescent Psychiatry
CAS-CBT	Competence and Adherence Scale for Cognitive Behavioural Therapy
CFA	Confirmatory factor analyses
CFI	Comparative fit index
CGAS	Children's Global Assessment Scale
CGI-S	Clinical Global Impression Scale for Severity
CHP	Challenging Horizons Program
CI	Confidence Intervals
CONSORT	Consolidated Standards of Reporting Trials
DBT	Dialectical Behaviour Therapy
DSM	Diagnostic and Statistical Manual of Mental Disorders
EF	Executive Function
GAD	Generalized Anxiety Disorder
GAF	Global Assessment Functioning
HOPS	Homework, Planning and Organization Skills
ICC	Intraclass Correlation Coefficient
ICD	International Statistical Classification of Disease and Related Health Problems
IE	Independent evaluator
ITT	Intention-to-treat
IQ	Intelligence quotient
Kiddie-SADS-PL	Schedule for Affective Disorders and Schizophrenia for school age children-Present and Lifetime version
MI	Motivational Interviewing
MRI	Magnetic Resonance Imaging
NICE	National Institute for Health and Care Excellence
PedsQL	Pediatric Quality of Life Inventory
RCT	Randomized Controlled Trial

RMSEA	Root mean square error of approximation
SCARED	The Screen for Child Anxiety-Related Emotional Disorders
SES	Socioeconomic status
STAND	Supporting Teens` Academic Needs Daily
TAU	Treatment as usual
TLI	Tucker Lewis Index
WAIS	Wechsler Adult Intelligence Scale
WASI	Wechsler Abbreviated Scale of Intelligence
WISC	Wechsler Intelligence Scales for Children
WFIRS-P	Weiss Functional Impairment Rating Scale parent-report
WFIRS-S	Weiss Functional Impairment Rating Scale self-report
YBP	Young Bramham program

INTRODUCTION

Topic of the thesis

The main aim of this thesis was to investigate whether a novel group cognitive behavioural therapy (CBT) programme directed at adolescents with attention-deficit/hyperactivity disorder (ADHD) would show an incremental treatment effect in ADHD symptoms and associated impairment after the adolescents previously received psychoeducation and pharmacological treatment (treatment as usual). Second, since examining functional impairment is imperative both for diagnostic purposes and in the evaluation of treatment effect, we investigated the psychometric properties of the Norwegian translation of the Weiss Functional Impairment Rating Scale (WFIRS) parent and self-report for use in this patient group. Finally, knowing that anxiety disorders are among the most common comorbid psychiatric disorders in adolescents with ADHD and that the reasons for this are largely unknown, we wanted to explore whether ADHD symptoms, executive functions (EFs) and functional impairment predict anxiety in this population. In addition, we examined whether EFs and functional impairment mediate this ADHD-anxiety relationship.

Motivation and rationale for the thesis

ADHD, also known as hyperkinetic disorder, is the most common neurodevelopmental disorder of patients presenting to child and adolescent mental health, paediatric and health care services (Coghill et al., 2021). ADHD typically starts in childhood and is characterized by age-inappropriate levels of inattention and/or hyperactivity that interfere with normal development or functioning (American Psychiatric Association, 2013). Throughout life, ADHD can increase the risk of social disability, educational and occupational underachievement, psychiatric disorders, accidents, crime, and addictions (Faraone et al., 2015). The disorder is commonly diagnosed in children, but symptoms may lead to impaired functioning in adulthood in up to 70% of childhood cases (Faraone et al., 2015). To date, pharmacological treatment is recognized as the most effective treatment option for reducing the core symptoms of ADHD (Chan et al., 2016). Unfortunately, this treatment alone is seldom sufficient for remediating ADHD and its associated conditions. Some patients experience adverse side effects or do not respond well to medical treatment (Cortese et al., 2018); in addition, some parents are hesitant to medicate their children, functional outcomes

may be unaffected, and the long-term effect of pharmacotherapy is inconclusive (Swanson et al., 2017). Since ADHD often continues into adult life (Uchida et al., 2018), there is a need for additional treatments to learn strategies and skills for coping with functional impairments and executive dysfunction. Unlike childhood treatments in which parents are involved to a large extent, adolescents with ADHD may possess the cognitive ability to play a more active role in coordinating and managing their own treatment, preparing them for an adult-care model (Margaret Weiss et al., 2007).

The National Institute for Health and Care Excellence (NICE) guidelines recommend multimodal treatment for children and young adults with ADHD (National Institute for Health and Care Excellence, 2019). Cognitive behavioural therapy (CBT) is suggested as a treatment option for young people if they still present with impaired symptoms after pharmacological treatment. Similarly, the Norwegian treatment guidelines (Helsedirektoratet, 2016) recommend psychoeducation, supportive interventions in school and pharmacotherapy when the ADHD symptoms cause sufficient impairment. In addition, CBT is suggested as a possible treatment option for ADHD and comorbid conditions. To date, studies on the effect of CBT for this patient group are limited, but some studies have shown preliminary positive results (Sibley et al., 2016; Sprich et al., 2016; Vidal et al., 2015). More studies are, however, warranted to investigate whether CBT can be recommended as treatment for adolescents with ADHD and, since all CBT programmes are not created equally, to explore which elements of CBT are the most efficacious for adolescents with ADHD.

Furthermore, ADHD is associated with functional impairment, and to receive an ADHD diagnosis, one needs to be impaired in at least two life domains (American Psychiatric Association, 2013; World Health Organization, 2019). This clinical evaluation is usually based on a summary of information obtained from different informants and the person's developmental history. Both the International Statistical Classification of Diseases and Related Health Problems (ICD-11)(World Health Organization, 2019) and the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013) emphasize the importance of assessing both clinical symptoms and functional impairment in the diagnoses of psychiatric disorders. A standardized assessment of functional impairment is not yet routine in most child and adolescent psychiatry (CAP) practices (Hoagwood et al., 2012). This is unfortunate, since structured assessments may reveal impairments that are

more easily missed in less structured examinations. Additionally, the use of standardized impairment questionnaires is recommended when evaluating treatment effects (Coghill et al., 2017; Coghill et al., 2019). The WFIRS was developed to assess functional impairment in an ADHD population. There are both parent- and self-report versions of the WFIRS. It is available in several languages and has shown good psychometric properties in different populations; see (Weiss et al., 2018) for a review. We included the WFIRS questionnaires in the CBT study (paper II) to assess functional impairment and evaluate the treatment efficacy of the study population across daily life functions. Since the WFIRS was not previously validated in a Norwegian population, the psychometric properties of the Norwegian version of the parent- and self-report scales were examined for use with a clinical population of adolescents with ADHD.

Finally, it is a well known that most patients with ADHD have one or more comorbid psychiatric disorders (Jensen & Steinhausen, 2015; Larson et al., 2011; Reale et al., 2017). Among children and adolescents with ADHD, anxiety disorders (ADs) are among the most common comorbid diagnoses, with a prevalence rate ranging from 13.6 to 49.0% (Bowen et al., 2008; Joelsson et al., 2016; Reale et al., 2017; Steinhausen et al., 2006; Yüce et al., 2013). Compared to either ADHD only or anxiety only, the combination of ADHD and anxiety has been associated with more attentional problems, school fears, and mood disorders, as well as lower levels of social competence (Bowen et al., 2008). It is not yet clear whether it is ADHD symptoms per se or other accompanying factors that generate the risk or coexisting presence of an anxiety disorder. In a recent study of young adults, EFs and functional impairment significantly mediated the relationship between ADHD and combined symptoms of anxiety and depression (Mohamed et al., 2021). Since adolescents with ADHD and comorbid anxiety often struggle with both executive dysfunction and functional impairments, we wanted to examine whether these factors mediate the ADHD-anxiety relationship in a clinical adolescent population.

ADHD - A historical perspective

"The incapacity of attending with a necessary degree of constancy to any one object, almost always arises from an unnatural or morbid sensibility of the nerves by which means this faculty is incessantly withdrawn from one impression to another. It may be either born with a person or it may be the effect of accidental diseases. When born in a person it becomes evident at a very early period of life and has a very bad effect inasmuch as it

renders him incapable of attending with constancy to any one object of education. But it seldom is in so great a degree as totally to impede all instructions; and what is very fortunate, it is generally diminished with age."

Crichton, 1798, Vol. 1, p271

Depictions of children being excessively hyperactive, inattentive, and impulsive have been described in the literature since the nineteenth century. The first descriptions of a disorder resembling ADHD were described in 1798 by the Scottish physician Sir Alexander Crichton. In 1844, the German physician Heinrich Hoffman created the character "Fidgety Phil", a boy with ADHD-like traits in his illustrated children's book "Struwwelpeter" (Herzog et al., 1995). In this book, Hoffman describes symptoms of inattention and hyperactivity in Philip, and illustrates a family conflict at dinner caused by the fidgety behaviour of the son, culminating in his falling over together with the food on the table (Hoffman, 1990). In 1902, the British physician George Still described a disease he characterized as resulting from a moral character defect (Still, 1902). He described that the disorder manifested itself in patterns of inattentive, restless, and overaroused behaviours. He suggested that the symptoms most likely resulted from brain damage, but that the behaviour could also be caused by hereditary or environmental factors. From 1917 to 1928, an encephalitis epidemic spread around the world. In the aftermath, many of the affected children showed abnormal behaviour, with emotional instability, cognitive deficits, learning difficulties, sleep problems and poor motor control. Thus, from the 1940s, ADHD-like symptoms were linked to the brain stem and described as a minimal brain damage (Warnke & Riederer, 2013).

The first reliable diagnostic criteria of ADHD were presented in 1980, with attention deficit disorder included in the third edition of the DSM (DSM-III) (American Psychiatric Association, 1980), and then attention deficit/hyperactivity disorder included in the DSM-III revised (American Psychiatric Association, 1987). In the DSM-IV (American Psychiatric Association, 1994), the diagnosis was further categorized into the three subtypes: inattentive, hyperactive/impulsive, and the combined inattentive and hyperactive/impulsive type. In the DSM-5 (American Psychiatric Association, 2013), ADHD is included under the category of neurodevelopmental disorders to represent the developmental trajectories of the diagnosis. In this version, the subtypes are referred to as predominantly inattentive or predominantly hyperactive/impulsive presentations to denote that an individual's subcategorization is not fixed across the life span (Doernberg & Hollander, 2016; Wolraich et al., 2019). The ICD-10

(World Health Organization, 1992) uses the narrower diagnostic category of hyperkinetic disorder, which requires that all three problems of attention, hyperactivity and impulsiveness should be present. In the ICD-11 (World Health Organization, 2019), the diagnostic criteria mirror DSM-5 in terms of defining the condition as a neurodevelopmental disorder. Additionally, the diagnosis is defined as ADHD, which is divided into the three abovementioned subtypes, and the age of onset is adjusted from six to twelve years of age.

ADHD diagnosis

ADHD remains a largely clinical diagnosis. Patients with ADHD show marked variation in symptom profiles, impairments, complicating factors, neuropsychological weaknesses, and underlying causes. Thus, effective partitioning of this heterogeneity to refine diagnostic approaches is important to provide tailored and targeted treatment (Faraone et al., 2015). Recommendations for diagnostic evaluation of the disorder include a comprehensive documentation of prenatal, perinatal, and family history; assessment of school performance, documentation of environmental factors; a detailed physical examination; and a mental health assessment used to probe for comorbid conditions (Helsedirektoratet, 2016; Wolraich et al., 2019). The diagnostic criteria for an ADHD diagnosis include a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development. The symptoms should have persisted for at least 6 months to a degree that is inconsistent with developmental level and that directly negatively impacts on social and academic/occupational activities. Several inattentive or hyperactive-impulsive symptoms should be present before the age of 12 years. Several symptoms should be present in two or more settings (such as at home, school, or work; with friends or relatives; in other activities). There should be clear evidence that the symptoms interfere with or reduce the quality of social, school, or work functioning. The symptoms should not be able to be better explained by another mental disorder (such as a mood disorder, anxiety disorder, dissociative disorder, or a personality disorder). One should also specify if the symptoms best fit the combined presentation, the predominantly inattentive or hyperactive/impulsive presentation of ADHD (American Psychiatric Association, 2013; World Health Organization, 2019).

Prevalence

An understanding of the epidemiological aspects of ADHD is useful for providing insight into its distribution and aetiology, as well as planning the allocation of funds for mental health services. A national study using data from the Norwegian Patient Registry and the Norwegian Population Registry from 2008-2011 found that 3.8% of 12-year-old children met the criteria for an ICD-10 hyperkinetic disorder. There was a gender difference, with 5.4% of the boys and 2.1% of the girls receiving a diagnosis. The study revealed large regional discrepancies in ADHD diagnosis, with a prevalence ranging from 1.5% to 5.5% (Surén et al., 2018). This regional diagnostic discrepancy is not considered a specific Norwegian phenomenon, but rather reflects a worldwide pattern, with different literature reviews referring to prevalence rates ranging from as low as 1% to 20% among school-age children (Faraone et al., 2003; Willcutt, 2012). Even though estimates of clinically diagnosed children and adolescents have been increasing over time, the community prevalence of ADHD has remained stable over the past three decades (Rydell et al., 2018; Sayal et al., 2018; Song et al., 2019). Reasons for the varying prevalence are usually explained by methodological factors such as the use of different diagnostic criteria, the incorporation of functional impairment and the type of informants (Polanczyk et al., 2007).

A meta-analysis of more than 100 studies estimated the global prevalence in children and adolescents to be 5.3% (95% CI: 5.01-5.56) (Polanczyk et al., 2007). Furthermore, an updated meta-analysis comprising 135 studies concluded that the prevalence of ADHD among children and adolescents is similar across European countries, Australia, the Americas, Asia, and Africa (Polanczyk et al., 2014). In addition to those who fulfil the diagnostic criteria for ADHD, at least a further 5% of children and adolescents have substantial difficulties with inattention, overactivity and impulsivity that are impairing, but just under the threshold to meet full diagnostic criteria (Sayal et al., 2018).

Gender differences

In children and adolescents, ADHD is more commonly diagnosed in males, with a male to female ratio ranging from 2:1 to 10:1 (Arnett et al., 2015; Mowlem, Rosenqvist, et al., 2019; Nøvik et al., 2006; Willcutt, 2012). However, sex ratios appear to be dependent on the type of sample, with higher male-to-female ratios found in clinical versus population-based samples (Polanczyk et al., 2007). While there is a clear male preponderance in childhood samples, this

sex difference is more modest or nonexistent in adults (Cortese et al., 2016; Moffitt et al., 2015). This suggests that ADHD in female youth is underrecognized and that differences exist in the diagnostic process for males and females with symptoms of ADHD (Mowlem, Rosenqvist, et al., 2019). A possible reason for the predominance of boys in child clinics may be the greater hyperactivity-impulsivity levels they show compared to girls, who more often present inattention symptoms, more internalizing symptoms, and less overt disruptive behaviours (Franke et al., 2018; Mowlem, Rosenqvist, et al., 2019).
Studies from Sweden using a large twin population found hyperactive/impulsive symptoms, externalizing behaviours, and more emotional problems to be stronger predictors of an ADHD diagnosis in females than in males. These findings suggest that females with ADHD may be more easily missed in the diagnostic process unless they have prominent emotional and/or externalizing problems (Mowlem, Agnew-Blais, et al., 2019; Mowlem, Rosenqvist, et al., 2019).

Psychiatric comorbidity

Psychiatric comorbidities are common in children and adolescents with ADHD, with a prevalence ranging from approximately 40% to 80% depending on the sample (Gillberg et al., 2004; Larson et al., 2011; Steinhausen et al., 2006; Wilens et al., 2002). In clinically referred children, the comorbidity may be as high as 67% to 87% (Barkley, 2006). Patients with combined ADHD and severe impairment are more likely to present comorbidities (Reale et al., 2017). The most common comorbid psychiatric disorders in children and adolescents with ADHD are oppositional defiant disorder (ODD) and conduct disorders, which are reported in 4-60% of this population across a wide range of clinical and epidemiological studies (Freitag et al., 2012; Jensen & Steinhausen, 2015; Larsson et al., 2011; Levy et al., 2005). Depression has been reported in 16-26% (Gillberg et al., 2004; Spencer, 2006), anxiety disorders in 10-50% (Bowen et al., 2008; Reale et al., 2017; Spencer, 2006; Taurines et al., 2010; Yüce et al., 2013), bipolar disorders in 0-20% (Taurines et al., 2010), tic disorders in 10 to 20% (Cohen et al., 2013; Steinhausen et al., 2006), and obsessive compulsive disorders in 2-11% (Arnold et al., 2005; Steinhausen et al., 2006). In addition, approximately 70% of children with ADHD show mild to moderate sleep disorders (Mick et al., 2000) with a higher prevalence rate in the combined type of ADHD and in patients with psychiatric comorbidity (Accardo et al., 2012).

Moreover, empathy problems, social deficits and difficulties with peer relationships are also more common in young populations with ADHD (Franke et al., 2018; Ros & Graziano, 2018), and 20 to 50% meet the criteria for autism spectrum disorders (ASDs) (Larson et al., 2011; Rommelse et al., 2011). Furthermore, intellectual disability may be up to 5 to 10 times more common in children with ADHD than in their non-ADHD peers (Simonoff et al., 2007). Major reading and writing difficulties may occur in as many as 25 to 40% (Sciberras et al., 2014); in addition, arithmetic problems and language disorders are also more common in ADHD populations (Hart et al., 2010; Sciberras et al., 2014). In clinical practice, the high rate of comorbid conditions may mask the core symptoms of ADHD. This underlines the importance of excluding other disorders that may overlap with ADHD or mimic ADHD symptoms in the assessment of children and adolescent for ADHD. Comorbid disorders that are recognized or unrecognized may also complicate the treatment process (Gillberg et al., 2004).

Aetiology

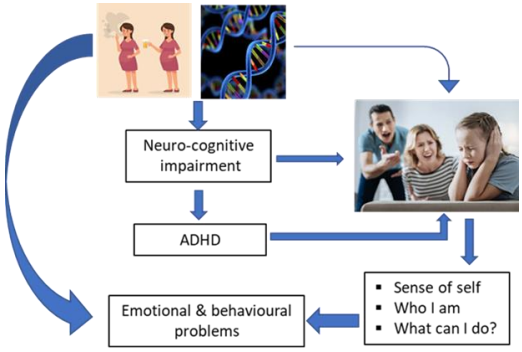
ADHD is considered an impairing, neurobiological disorder that is caused by a complex interplay between biological and environmental risk factors (Faraone et al., 2015). Previous studies on twins and adopted children demonstrate that ADHD is highly familial, with a heritability of 70-80% in both children and adults (Faraone & Larsson, 2019; Larsson, Chang, et al., 2014; Pettersson et al., 2019). Efforts to identify the genes underpinning the heritability have been more challenging than initially expected; however, a large genome-wide study identified multiple genetic variants that combine to increase the risk for the disorder (Demontis et al., 2019). ADHD can also be the result of rare single gene defects (Faraone & Larsson, 2019) or chromosomal abnormalities (Cederlöf et al., 2014). Environmental risk factors may act through a nonshared familial environment and/or through interactions with genes and DNA variants that regulate gene expression (Faraone et al., 2015). In addition, both stable genetic factors and those that emerge through different developmental stages influence the disorder from childhood to adulthood (Chang et al., 2013). Even though research has established a unique genetic risk for ADHD, numerous studies have also found genetic and environmental influences to be partly shared between ADHD and various other psychiatric disorders, such as schizophrenia, depression, bipolar disorder, autism spectrum

disorder, conduct disorder and substance use disorder (Chen et al., 2019; Demontis et al., 2019; Faraone & Larsson, 2019; Ghirardi et al., 2018).

Environmental risk factors associated with ADHD are hard to identify since they may result from correlated genetic and environmental effects. However, environmental risk factors associated with a higher prevalence of ADHD include prenatal exposure to maternal smoking (Dong et al., 2018; Huang et al., 2018), exposure to secondhand cigarette smoke (Huang et al., 2021), prenatal exposure to the anti-epileptic drug valproate (Christensen et al., 2019), obesity in mothers (Andersen et al., 2018), alcohol use (Banerjee et al., 2007), stress (Rodriguez & Bohlin, 2005), low birth weight and premature birth (Franz et al., 2018; Lindström et al., 2011; Momany et al., 2018), and exposure to environmental toxins such as lead (Nilsen & Tulve, 2020). Furthermore, studies of Romanian adoptees who were severely deprived of early maternal care in orphanages before adoption have found a relationship between the length of deprivation and the risk of developing ADHD-like symptoms (Kennedy et al., 2016; Stevens et al., 2008).

In terms of socioeconomic status, a Swedish study of more than 800 000 people found lower levels of family income to be associated with increased rates of ADHD. This was found even after adjusting for shared familial/genetic risk factors in families (Larsson, Sariaslan, et al., 2014). This association has also been found in South Korean and Danish populations (Choi et al., 2017; Keilow et al., 2020). A Danish longitudinal cohort study found that indicators of adversity, such as out-of-home care, low social class, paternal criminality, maternal mental disorder, and severe marital discord were moderately predictive of ADHD (Østergaard et al., 2016).

Figure 1. Different pathways linking gene-environment factors with neurocognitive impairment, ADHD symptoms, emotional and behavioural problems.



Cognitive functions in ADHD

ADHD is associated with various cognitive impairments and brain alterations in both children and adults. Cognitive deficits may encompass cognitive functions such as inhibitory control, visuospatial and verbal working memory, sustained attention, vigilance, intraindividual variability, and reward processing (van Lieshout et al., 2013; Willcutt et al., 2005). Meta-analyses of studies measuring cognitive functions in children have found ADHD to be associated with poorer performance on tasks measuring inhibition, working memory, planning and vigilance (Huang-Pollock et al., 2012; Willcutt et al., 2005). ADHD is also associated with lower IQ scores (Frazier et al., 2004). Studies examining cognitive functions related to IQ, executive dysfunction, and attentional tasks across the lifespan have shown that impairments tend to persist from childhood through adolescence and early adulthood in ADHD persisters (Biederman et al., 2009; Cheung et al., 2016; McAuley et al., 2014). Although many studies have confirmed cognitive deficits in children and adolescents with ADHD compared to their non-ADHD peers, the results across studies are inconsistent, and there are children with ADHD who do not demonstrate problems on cognitive measures (Nigg et al., 2005). Since the overall cognitive differences are small and inconsistent, cognitive measures are not considered useful for diagnosing the disorder (Thome et al., 2012).

Neuroimaging studies

Structural and functional neuroimaging studies have documented abnormalities in brain anatomy and function in people with ADHD (Cortese et al., 2012; Greven et al., 2015). The ENIGMA ADHD working group conducted the largest study on brain volume differences to date, including 1713 participants with ADHD and 1529 healthy individuals (Hoogman et al., 2017). In this study, the research group found individuals with ADHD to have a smaller volume of the amygdala, nucleus accumbens, the caudate nucleus, putamen, and hippocampus, than healthy controls. The effect sizes were significant but small (d=-0.10 to 0.19), and the differences were clustered in childhood and were not seen in adulthood. The results were found regardless of medication use and did not correlate with the severity of ADHD symptoms or other psychiatric disorders. The authors concluded that the results underpinned the theory of ADHD as a brain disorder. In addition, finding the most pronounced effects in childhood in combination with delayed peaks of subcortical volume maturation, supports a model of ADHD as a disorder of brain maturation delay (Hoogman et al., 2017). The differences in caudate and putamen volumes in persons with and without ADHD have been presented in previous studies (Ellison-Wright et al., 2008; Frodl & Skokauskas, 2012; Nakao et al., 2011). The volume of the amygdala showed the largest effect in the ENIGMA study (d = 0.18 in children). The amygdala is a brain structure that has been associated with difficulties recognizing emotional stimuli, the presence of callous emotional traits, emotional dysregulation (Aggleton, 1993; Viding et al., 2012), and hyperactivity (Frodl et al., 2010). All these are traits that have been linked to ADHD (Conzelmann et al., 2009; Herpers et al., 2012; Musser et al., 2013; Shaw et al., 2014). The hippocampus is involved in the regulation of motivation and emotion (Shigemune et al., 2010), similar to the accumbens, which is associated with motivational and emotional dysfunction in people with ADHD as well as with reward processing (Sonuga-Barke et al., 2010).

In addition to examining dysfunction in a limited area of the brain regions, there has been a paradigm shift over the last two decades, with increased interest in dysfunctional brain networks that reshape our understanding of the pathophysiology of ADHD (Cortese & Coghill, 2018). Task-based functional MRI studies (fMRI) with children have demonstrated hypoactivation in the frontoparietal and ventral attentional networks involved in EFs and attention, and hyperactivation in the sensorimotor network and default mode network involved in lower-level cognitive processes (Cortese et al., 2012). Growing literature provides evidence of ADHD-related dysfunction in multiple neuronal systems involved in

higher-level cognitive functions but also in sensorimotor processes, including the visual system and the default network (Cortese et al., 2012).

Theoretical constructs of ADHD

As previously mentioned, ADHD is considered a heterogeneous condition caused by multiple developmental pathways (Sonuga-Barke, 2005). In recent decades, the prevailing neuropsychological theories of ADHD have emphasized the cognitive and behavioural disruptions associated with EFs. These higher-order, top-down cognitive functions are associated with anomalies in the prefrontal-striatal brain circuitry and modulated by the expression of catecholamines (Mahone & Denckla, 2017). Russel Barkley was the first to present a unifying theoretical model of ADHD (Barkley, 1997). His model was based on previous studies suggesting that behavioural inhibition problems are caused by a deficit in the brain's inhibitory control systems (Gray, 1982; Quay, 1988). Barkley proposed that ADHD symptoms are caused by a disruption of the neurocognitive self-control systems, with behavioural inhibition as the core. He suggested that response inhibition comprises three interrelated processes: (I) the ability to inhibit an automatic response, or a response likely to result in immediate reinforcement, (II) the ability to delay a response that has already been initiated, and (III) the ability to remain focused on the response in question and not be distracted by competing stimuli (Pievsky & McGrath, 2018). According to Barkley, compromised inhibition directly disrupts the four EFs: working memory (the ability to hold information in conscious awareness and manipulate it), self-regulation (of one's emotion, motivation and arousal to achieve goals), internalization of speech (one's internal monologue that allows for more complex reasoning and reflection) and reconstitution (analysis and synthesis of verbal and behavioural information) (Barkley, 1997). Disruption of these processes may in turn lead to problems executing complex and goal-directed behaviours, particularly problems with motor control, fluency, and syntax (Pievsky & McGrath, 2018).

Even though deficient inhibitory control is considered a critical component of the ADHD phenotype, subsequent neuropsychological theories found the theory posited by Barkley to be insufficient in explaining the wide range of neuropsychological differences observed in this population. Sergeant and colleagues proposed the cognitive-energetic model of ADHD (Sergeant, 2000). This model explains behaviour characteristic for ADHD as a product of the interplay between the energetic bottom-up systems involving activation, arousal and effort

and cognitive top-down executive control systems that restrict the expression of the energetic drive states, allowing for other EFs to moderate output (Sergeant et al., 2003). This model considers anomalies affecting arousal and activation to be the primary cause of ADHD. In extension, Sonuga-Barke and colleagues introduced the concept of *delay aversion* derived from the motivational model of ADHD, which is based on the influence of the reward systems in the brain (Sonuga-Barke et al., 2008). Delay aversion theory incorporates executive control and dorsal-frontostriatal circuitry in explaining inhibitory control problems similar to the cognitive energetic model (Mahone & Denckla, 2017). The dual-pathway model, however, also incorporates a second reward circuit, represented by ventral frontostriatal dysfunction representing delay aversion (Sonuga-Barke, 2005) and malfunctioning sensitivity to reward (Luman et al., 2009). In 2010, a third pathway possibly affecting problems with temporal processing, difficulties with timing and motor functions was included in the model, linking deficits associated with ADHD with cerebellar cognitive functioning (Sonuga-Barke et al., 2010). In sum, accumulated evidence across studies has made it generally accepted that ADHD is a complex and heterogeneous condition, with deficits in various neuropsychological processes and related brain systems and with different individuals displaying markedly different profiles across diverse cognitive and motivational domains (Sonuga-Barke & Coghill, 2014).

Executive functions in ADHD

One central source of disability associated with ADHD has been deficits in EFs (Biederman et al., 2007). As such, several models of ADHD have included dysfunctional EF processes as important for understanding the diagnosis (Barkley, 1997; Castellanos et al., 2006; Sagvolden et al., 2005; Sonuga-Barke, 2003). EFs include a broad range of cognitive processes that are crucial in guiding effortful and goal-directed behaviour in our daily life functioning (Diamond, 2013). EFs are mainly supported by the prefrontal cortex, which regulates lower-level processes (e.g., perception and motor responses) and thereby enables self-regulation and self-directed behaviour towards a goal, allowing us to make decisions, evaluate risk, plan for the future, prioritize our actions, and cope with novel situations (Banich, 2009; Miyake & Friedman, 2012). The impairment of EFs in children with ADHD has been documented (Barkley, 2006). A meta-analysis of 83 studies comparing typically developing children with children and adolescents with ADHD showed that children with ADHD significantly differed

from those without ADHD across 13 performance-based EF tasks (Willcutt et al., 2005). The most consistent group differences for these school-aged children were found on tasks measuring inhibition, vigilance, and planning (Willcutt et al., 2005). Another study found measures of response inhibition and working memory to discriminate between children with and without ADHD (Holmes et al., 2010). For adolescents, significant group differences have been found on tasks measuring planning, working memory, inhibition and set-shifting ability between those with and without ADHD (Martel et al., 2007; Toplak et al., 2008). Other studies, however, have found that subjects with ADHD perform normally on EF tests (Biederman et al., 2004; Egeland, 2010; Nigg et al., 2005). Several studies have demonstrated a positive effect of ADHD medication on EF tasks measuring inhibition, alertness, divided attention, spatial working memory, set-shifting ability, and planning ability in children (Kempton et al., 1999; Miklós et al., 2019). In a systematic review and meta-analyses of the effect of methylphenidate on cognitive functions in children and adolescents (age 5-18 years) with ADHD, methylphenidate was superior to placebo on measures of executive and nonexecutive memory, reaction time, reaction time variability and response inhibition (Coghill et al., 2014).

Although executive dysfunction is common in ADHD, it is important to bear in mind that laboratory-based tests have been criticized for having poor ecological validity, and ratings of EFs have in comparison shown to be better predictors of real-life impairments in populations with ADHD (Barkley & Fischer, 2011). The Behavior Rating Inventory of Executive Functions (BRIEF) (Gerard A. Gioia et al., 2000) was developed to improve the ecological validity of EF assessments by providing complementary information with respect to a children and adolescents' everyday real-world EFs in addition to performance-based measures (Isquith et al., 2013).

The BRIEF assesses eight interrelated subdomains of EFs known to be associated with ADHD, including inhibit (the ability to resist or delay an impulse), shift (the ability to alter problem-solving strategies during complex tasks), emotional control (the ability to modulate emotional responses), initiate (the ability to begin a task or activity), working memory (the process of holding information in mind for the purpose of completing a task), plan-organize (the ability to anticipate future events, set goals and develop appropriate steps to carry out a task or action), organization of materials (the ability to establish and maintain order within an activity or carry out a task in a systematic manner), and monitor (the ability to check on one's own actions during or shortly after finishing a task in a systematic manner) (Gioia & Isquith,

2004). The items comprising the BRIEF scales were generated through clinical interviews with parents and teachers to ensure good face and content validity (Gioia & Isquith, 2004). The BRIEF has shown modest but consistent correlations with neuropsychological EF tests in different studies (Anderson et al., 2002; Toplak et al., 2008).

Even though executive dysfunction is common in ADHD, such impairments are not restricted to ADHD alone. Indeed, executive dysfunction has been found in a wide range of psychiatric disorders, including autism spectrum disorders, mood disorders, anxiety disorders and schizophrenia (Chang et al., 2020; Millan et al., 2012; Snyder et al., 2015). However, which of the EF components that are most affected may however vary across the psychiatric disorders, which might be explained by genetic liability (Chang et al., 2020).

Barkley and colleagues hypothesized that EFs underpin the functional impairments of youth with ADHD (Barkley, 2001; Barkley & Fischer, 2011). Following this, impaired EFs may prevent the acquisition and implementation of skills related to school functioning (Miller et al., 2012), interpersonal problems (Sprague et al., 2011), and mental health (Mesholam-Gately et al., 2009; Snyder, 2013; Snyder et al., 2014). Biederman and colleagues demonstrated that children with ADHD and executive dysfunction had significantly lower academic achievement and were more likely to repeat a grade than their ADHD-only peers (Biederman et al., 2004). Furthermore, research conducted with children and adolescents has demonstrated that EFs are related to multiple domains of impairment, even after controlling for ADHD symptoms (Biederman et al., 2004; Langberg et al., 2013; Miller & Hinshaw, 2010; Miller et al., 2012). In a study conducted with middle-school-aged youth, the parent- and teacher-rated EF subscale on planning and organization and parent ratings of youth's ability to transition effectively between tasks (set shifting) were found to predict school grades above and beyond symptoms of ADHD and relevant covariates (Langberg et al., 2013). Moreover, a study of college students with ADHD found that student-rated organization and motivation, as well as parent-rated emotion regulation, significantly predicted academic and overall impairment, even when controlling for symptoms of ADHD (Dvorsky & Langberg, 2019).

Functional impairment

ADHD is associated with functional impairment across various life domains in both cross-sectional and prospective outcomes (Du Rietz et al., 2020; Erskine et al., 2016; Sollie &

Larsson, 2016; Uchida et al., 2018). Typically, affected life domains include social skills, self-esteem, learning difficulties, impaired family and peer relationships, disruptive behaviour, risky behaviour and substance abuse (Bagwell et al., 2001; Banaschewski et al., 2013; Barkley et al., 1993; Bernardi et al., 2012; Chang et al., 2014; Cussen et al., 2012; Dalsgaard et al., 2013; Larson et al., 2011; Molina et al., 2013; Ros & Graziano, 2018; Schei et al., 2016; Sollie & Larsson, 2016). Even though patients referred to treatment for ADHD often mention problems associated with functional impairments as their main complaint, physicians have traditionally been more focused on decreasing symptoms and symptom severity (Weiss et al., 2018). This is unfortunate given the overwhelming evidence that suggests that treatments for ADHD also need to target associated functional impairment.

According to the DSM-5 (American Psychiatric Association, 2013) and ICD-11 (World Health Organization, 2019), the diagnostic criteria for a psychiatric diagnosis, including ADHD, are only met if the symptoms cause a substantial impact on psychosocial functioning. Despite these recommendations, a systematic screening and evaluation of functional impairment has yet to become routine in clinical settings or in research (Weiss et al., 2018). A review of all experimental studies of child and adolescent treatment and service effectiveness published between 1996 and 2011 demonstrated that 95.5% of the studies focused on symptoms and diagnosis as the main outcome, followed by 47.5% assessing functioning/impairment (Hoagwood et al., 2012). This is unfortunate since studies suggest that functional impairment may persist among youth with ADHD after medical treatment, leaving them vulnerable and with unresolved problems (O'Connor et al., 2015).

There are several reasons for including measures of both symptoms and impairments when evaluating the impact of treatment for ADHD. First, ADHD-related symptoms and impairments, although related, have been shown to be different constructs (Gathje et al., 2008; Gordon et al., 2006). Hence, an improvement in one may not directly be associated with an improvement of the other. Second, long-term outcomes and prognosis for children and adolescents with ADHD are more often tied to impairments than symptoms (Barkley et al., 2006; O'Connor et al., 2015). Third, in many cases, improvements in symptoms seem to be unrelated to reliable improvement in impairment, which may suggest that current treatments for ADHD may not adequately address the full range of deficits related to ADHD (Epstein et al., 2010; Karpenko et al., 2009; Owens et al., 2009). In sum, a valid measure of functional impairment for use with adolescents with ADHD would be of great value in diagnostic evaluations, treatment planning and evaluation, and the evaluation of treatment

outcomes in CAP clinical research. The WFIRS was developed for assessing functional impairment in people with ADHD (M. Weiss et al., 2007) and comprises both a parent (WFIRS-P) and self-report (WFIRS-S), which may be used with adolescents with ADHD (Canadian Attention Deficit Hyperactivity Disorder Resource Alliance, 2011). The questionnaires have been used in both research and practice (Weiss et al., 2018); they cover six to seven domains related to family, school, social functioning, learning, life skills and risky behaviour, and are available in 19 different languages, including Norwegian (Weiss et al., 2018). Previous studies have found acceptable psychometric properties for both the WFIRS-P (Dose et al., 2019; Gajria et al., 2015; Tarakcioglu et al., 2015) and WFIRS-S (Hadianfard et al., 2019; Micoulaud-Franchi et al., 2019; Takeda et al., 2017).

Treatment for ADHD

Pharmacological treatment

A positive effect of an amphetamine compound was first reported on ADHD symptoms in 1937, followed by approval by the Food and Drug Administration (FDA) in 1955. Since then, many studies of pharmacotherapy have been published. Medications for ADHD comprise stimulants (amphetamines and methylphenidate) and nonstimulants (atomoxetine and extended-release clonidine and guanfacine). Amphetamine and methylphenidate both modulate the action of dopamine by blocking the dopamine transporter. Amphetamine also promotes the release and reverse transport of dopamine (Faraone et al., 2015). Although the efficacy of both classes of stimulants is similar, some patients preferentially respond to and tolerate one or the other (Faraone & Buitelaar, 2010). Atomoxetine has shown a positive effect in the management of ADHD with comorbid tics, anxiety, and depression (Bangs et al., 2007; Kratochvil et al., 2005). Numerous randomized controlled trials (RCTs) have established the short-term efficacy of medications, particularly stimulants, for reducing the core symptoms of ADHD in children, adolescents, and adults (Cortese et al., 2018). A systematic review of 40 studies from Europe, North America, and Asia showed a reduced risk of seizures, depression, mania, and suicidality in patients treated with ADHD medications (Chang et al., 2019). A short-term beneficial treatment effect has also been documented for behavioural and neuropsychiatric outcomes such as educational performance, substance use disorders and injuries, with an estimated risk reduction rate of 9-58% for these outcomes. However, the long-term effects of ADHD medication are more unclear (Chang et al., 2019).

Although medication has been proven to be effective in alleviating the core symptoms of ADHD, the prevalence of medication use for ADHD varies from 0.39% (France) to 5.56% (in the United States) (Cortese, 2020). The geographic variations in the sequencing of pharmacological and nonpharmacological treatments reflect differences in national treatment guidelines. For example, in the United States, pharmacological treatment is typically the first approach, whereas in Europe, medication is usually recommended for severe cases or for mild to moderate cases that do not respond to psychosocial treatments (Atkinson & Hollis, 2010). In a systematic review including 91 original studies and 36 expert opinion reviews on ADHD medication discontinuation, the average treatment duration with stimulants was 136 days in children and 230 days in adults (Gajria et al., 2014). Similarly, in a Swedish total population cohort study of all individuals aged 6-45 years from 2006 to 2009, patients between the ages of 15 and 21 were the most likely to discontinue their ADHD medication (Zetterqvist et al., 2013). Common reasons for medication discontinuation were dislike of taking medication, side effects (e.g., initial insomnia, decreased appetite, dysphoria, and irritability), perceived lack of effectiveness, problems with the transition from child to adult services, no need for medication and stigma (Faraone et al., 2015; Gajria et al., 2014; Zetterqvist et al., 2013). The high rate of medication discontinuation, particularly in children and youth, highlights the need for additional nonpharmacological treatments for adolescents with ADHD.

Psychosocial treatment

National and international ADHD treatment guidelines recommend multimodal treatments for children and adolescents with ADHD (Helsedirektoratet, 2016; National Institute for Health and Care Excellence (NICE), 2019). Psychoeducation is typically recommended as the first step of treatment. This usually involves 1 or 2 sessions to provide information about the diagnosis to the patient and parents and/or close family members from the CAP clinician, with a presentation of information on typical ADHD symptoms, information on the causes and impact of the disorder, and advice on different parent strategies, as well as a presentation of different treatment choices (including medication) and prognoses of the disorder. A collaborative meeting with a schoolteacher to provide information about the diagnosis and discuss supportive measures in school is also recommended. Furthermore, it is also advisable for information about ADHD support groups and organizations to be provided

(Helsedirektoratet, 2016; National Institute for Health and Care Excellence (NICE), 2019). The primary aim of psychoeducation is thus to increase knowledge of ADHD and common associated impairments related to the disorder in daily life.

In addition to psychoeducation, pharmacological treatment is recommended for patients with moderate to severe ADHD symptoms; however, medical treatment for ADHD is not recommended for everyone. Especially during adolescence, treatment compliance can be low (Adler & Nierenberg, 2010), pharmacological treatment alone may not produce an optimal treatment response across ADHD-related impairments (Faraone et al., 2015), and parents and clinicians can have reservations against medication use and may prefer nonpharmacological treatment options (Fiks et al., 2013).

The NICE guidelines recommend CBT for young people with ADHD who have benefited from medication but whose symptoms are still causing a significant impairment in at least one domain (i.e., social skills, problem solving, self-control, active listening skills or dealing with and expressing feelings) (National Institute for Health and Care Excellence (NICE), 2019). The combination of methylphenidate and CBT/behavioural treatment has previously been found to be superior to pharmacological treatment alone in the reduction of ADHD symptoms and improved global functioning in children and adolescents (Jensen et al., 2001; Majewicz-Hefley & Carlson, 2007; MTA Cooperative Group, 2004; Sprich et al., 2016). However, to date, there is no universal agreement on which treatment elements need to be included for a programme to be defined as a CBT programme. In a systematic review of treatments developed for adolescents with ADHD, Chan and colleagues (2016) divided the different psychosocial treatments into behaviour therapy, which emphasizes selective reinforcement of desired behaviour and selective ignoring of problem behaviour (i.e., behaviour contingency management); skills training, which addresses common deficits associated with ADHD, such as problems with planning and organization, time management and study skills; and cognitive behavioural therapy, which identifies negative and/or automatic thoughts, and modifies them through cognitive restructuring techniques, motivational interviewing, and mindfulness (Chan et al., 2016). Most treatment programmes directed at adolescents with ADHD are, however, multicomponent treatments that combine elements from behavioural, cognitive behavioural and skills-training techniques to target functional impairment associated with ADHD.

Behavioural management approaches

Behavioural interventions are the best-established and most widely used form of psychological treatment for children and adolescents with ADHD (Pfiffner & Haack, 2014). Principles of positive and negative reinforcement, as well as social learning, provide the foundation for various techniques that are used to reduce inappropriate and enhance appropriate behaviour and to improve parent-child relationships (Pfiffner & Haack, 2014; Wells et al., 2000). In young children, these interventions typically take the form of parent training programmes, which are positively received by families, especially when child compliance and conduct disorder are the primary problem (Fiks et al., 2013). A meta-analyses by Daley and colleagues found blinded evidence that behavioural interventions used to treat children and adolescents with ADHD had beneficial effects on improved parenting by means of decreasing negative and increasing positive parenting and by decreasing children's comorbid conduct problems (Daley et al., 2014). Although meta-analyses have found evidence to support the use of behavioural treatments on adverse parenting and behaviour problems in children and adolescents with ADHD, meta-analyses of RCTs focusing on blinded outcomes found these behavioural interventions to have minimal effect on ADHD core symptoms (Daley et al., 2014; Sonuga-Barke et al., 2013).

School-based treatment programmes

School-based treatment interventions directed at adolescents with ADHD typically involve skills training to improve inattention, social and scholastic skills in middle-school students (11 to 14 years). The Challenging Horizons Program (CHP), an after-school study programme, incorporates skill-straining, coaching and behaviour contingency management in a school setting (Evans et al., 2011). This is a comprehensive programme that involves weekly sessions over one academic year. A randomized controlled trial (RCT) revealed significant improvements in parent-rated organization and time-management skills as well as ADHD inattention symptoms and homework completion in the adolescents participating in the CHP compared to participants attending two control conditions involving a shorter mentor version or community care condition (Evans et al., 2016). The Homework, Organization and Planning Skills (HOPS) programme is a shorter treatment programme delivered by school mental health providers during the school day (Langberg et al., 2011). The 16-session programme aims to improve homework problems and organizational skills. A

randomized trial comparing adolescents receiving HOPS with a waitlist control condition revealed significant parent-reported improvements in the management of materials, planning skills and homework completion in favour of HOPS (Langberg et al., 2012). Parents were involved in both the CHP and the HOPS treatment programmes, and both programmes showed significant improvements in primary outcomes posttreatment. However, teacher raters reported no group difference on either of the interventions, and none of the studies included a long-term follow-up.

Clinic-based treatment programmes

Several clinic-based treatment programmes directed at adolescents have been established during the last decade. The Supporting Teens' Academic Needs Daily (STAND) programme by Sibley and colleagues (2013) is a 10-session skills-training programme for adolescents between 11 and 15 years of age. It targets homework, organization, time management, test taking, and note taking skills using motivational interviewing techniques (Sibley et al., 2016; Sibley et al., 2013). In this programme, parents provide rewards based on the adolescent's use of the targeted skills at home and in school. Motivational interviewing is integrated to enhance treatment engagement. Both a pilot study and a randomized trial revealed significant improvements in parent-rated academic problems and ADHD symptom severity (Sibley et al., 2016; Sibley et al., 2013). However, teacher reports did not suggest significant improvements in either ADHD symptoms or academic performance. In another study comparing a STAND group version versus the dyadic version, the two versions produced equivalent overall outcomes, with positive effects on both ADHD symptom severity and functional outcomes in an adolescent population (aged 11 to 17 years) (Sibley et al., 2020). When comparing the effectiveness of the STAND programme to usual care (UC) in community clinics, STAND was unable to outperform UC on the outcome trajectories in an adolescent ADHD population (same age as above) (Sibley et al., 2021).

Boyer and colleagues developed two short-term (8 sessions) CBT programmes targeting adolescents with ADHD (Boyer et al., 2015). The Plan My Life (PML) programme aims to improve planning and organizational skills, with a special attention to school and homework. The Solution-Focused Treatment (SFT) programme does not have a preplanned programme, and hence, it was up to the participants to decide what they wanted to discuss. Both the PML programme and SFT include elements from motivational interviewing and cognitive

behavioural thought restructuring techniques. Parents were involved in two of the sessions in both programmes (Boyer et al., 2015). A study comparing the two types of CBT found posttreatment improvements in parent-rated ADHD symptoms, planning and EFs for both the PML and SFT. A limitation of the study was the lack of a waitlist or treatment as usual control group, limiting interpretations of the results.

Another RCT conducted by Sprich and colleagues with medicated adolescents (14 to 18 years) with ADHD used a downwards extension of an adult individual 12-session CBT programme incorporating psychoeducation, cognitive restructuring techniques and training in organization and planning skills (Sprich et al., 2016). In this RCT, the CBT programme was compared with a waitlist control condition. The CBT participants showed significant improvements in both parent- and self-rated ADHD symptoms, as well as a rater-blinded symptom severity posttreatment. Measures of functional impairment were not included in this study.

The first RCT of a group CBT programme directed at adolescents/young adults with ADHD was conducted by Vidal and colleagues. In this study, a 12-session group CBT programme was compared with a waiting list condition, receiving only medical treatment (Vidal et al., 2015). The sessions provided instructions on 12 sets of skills, and parents were not involved in the programme. ADHD symptoms and functional impairment were significantly improved posttreatment in both parent and self-reports, suggesting a preliminary positive effect of group CBT interventions without parent involvement. However, in a recently published Swedish study with adolescents with ADHD, Meyer et al. (2021) evaluated a 14-session dialectical behaviour therapy (DBT) group programme with skills training elements versus a control group receiving three two-hour sessions with psychoeducation (Meyer et al., 2021). In this RCT, the authors found no significant group differences in favour of DBT for any of the study outcomes.

In sum, even though research evidence to date supports the use of multicomponent psychosocial treatments/CBT programmes to improve some ADHD-related functional outcomes, studies also reveal inconsistent and more modest effects on parent ratings of ADHD symptoms and cooccurring emotional and behavioural symptoms (Chan et al., 2016; Evans et al., 2017). Thus, there is an urgent need for more studies to strengthen the evidence base for psychosocial treatments to alleviate ADHD symptoms and associated impairments in adolescents.

Contributions of this thesis to the current body of knowledge

When planning this thesis, there were no validated instruments measuring functional impairment in adolescents with ADHD available in Norway. As such, an assessment of the psychometric properties of the WFIRS parent and self-reports for use with a Norwegian clinical adolescent ADHD population (study I) would be valuable before implementing these measures in the CAP clinic and for use when evaluating the research outcomes.

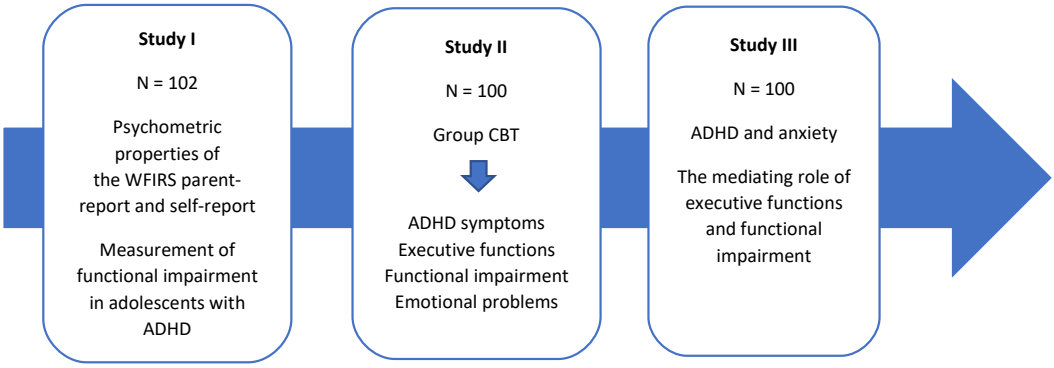
As outlined above, there is a great need for more studies on psychosocial treatments for adolescents with ADHD. More specifically there is a need for controlled studies that assess the efficacy of various CBT programmes to see which components are the most important when treating adolescents and young adults, and thereby strengthen the evidence base for future treatment recommendations. The CBT study in this thesis (study II) is, to our knowledge, the first RCT to examine the efficacy of group CBT in addition to psychoeducation and medical treatment, which are treatments recommended in our national treatment guideline (Helsedirektoratet, 2016) and the NICE treatment guideline (National Institute for Health and Care Excellence, 2019), in adolescents with ADHD. The results from this study will contribute to the knowledge base on which treatment programmes work best for adolescents with ADHD and associated problems.

Finally, since anxiety disorders are common in adolescents with ADHD and the reasons for this association are largely unknown, we wanted to explore whether EFs and functional impairment mediate this relationship (study III). More knowledge of this association could both be salient for the understanding of aetiological factors and have important implications for treatment when working with adolescents with ADHD and comorbid anxiety disorders.

AIMS OF THE THESIS

The overall aim of this thesis was (I) to explore whether a novel group CBT with skills training elements could have an incremental treatment effect on ADHD symptoms and associated impairments in adolescents with ADHD who previously received psychoeducation and pharmacological treatment, (II) to examine the psychometric properties of the WFIRS for use in a Norwegian adolescent population, and to assess ADHD-related functional impairment before and after the CBT intervention, and (III) to examine the role of EFs and functional impairment as possible mediators in the ADHD-anxiety relationship. More specifically, the aims were as follows:

Figure 1. Themes of the studies included in this thesis



Paper I: The aim was to assess the psychometric properties of the Norwegian translation of the WFIRS-P and the WFIRS-S for use with a clinical population of adolescents with ADHD. We examined the conceptual framework of both questionnaires to see if they were comparable to the original models and estimated the internal reliability and cross-informant agreement between the questionnaires. The convergent and divergent validity was examined using measures of adaptive functioning and ADHD symptoms.

Paper II: The main objective was to evaluate whether a 12-week group CBT programme would have an incremental treatment effect on ADHD symptoms and associated impairments in adolescents who previously received a short psychoeducational intervention and were on pharmacological treatment for ADHD (treatment as usual) but still presented with impaired ADHD symptoms. We compared the CBT group with a control group that received the same previous interventions, but no additional CBT. We also examined the possible moderating effect of age, IQ, socioeconomic status (SES), severity of ADHD symptoms and anxiety symptoms on treatment outcome.

Paper III: In this study we wanted to explore whether ADHD symptoms, EFs and functional impairment would predict anxiety in adolescents with ADHD. We particularly wanted to examine whether EFs and functional impairment would mediate this ADHD-anxiety relationship. We explored whether there were differences between parent and self-reports, and whether age and sex acted as confounders in this relationship.

METHODS

Participants

All the participants included in this thesis were recruited from a population of adolescents between the ages of 14 and 18 who previously had received a clinical diagnosis of ADHD according to the International Statistical Classification of Disease and Related Health Problems (ICD-10) (World Health Organization, 1992). The participants were recruited from three CAP outpatient clinics at St. Olav University Hospital in Mid-Norway, with a catchment area of approximately 230 000 inhabitants (the city of Trondheim and a few surrounding municipalities). Government-funded CAP clinics are the main service providers for child and adolescent psychiatric disorders in Norway, and outpatient clinics are the primary treatment settings (Indergård et al., 2018). The Norwegian CAP clinics offer treatment to approximately 5% of the population between 0-18 years of age (Indergård et al., 2018). Among the 100 participants included in studies II and III, there were 57 females (57%) and 43 (43%) males. The mean age was 15.8 years (SD= 1.3).

The inclusion criteria of the RCT (study II) were a previous ICD-10 diagnosis of ADHD, a DSM-5 diagnosis of ADHD or subthreshold ADHD (ADHD medicated), confirmation of the diagnosis through the administration of the Schedule for Affective Disorders and Schizophrenia for School-age Children-Present and Lifetime Version (Kiddie-SADS-PL) interview with the participant, and evidence of clinically impairing symptoms (a Clinical Global Impression Scale for Severity (CGI-S) clinician score of 3 (mildly ill) or greater at baseline). Participants with a comorbid diagnosis, including mild to moderate depressive disorders, anxiety disorders, bipolar disorders, tic disorders, ODD and a mild degree of autism spectrum disorders, were included in the study. All participants needed to have been on a stable pharmacological treatment for ADHD for at least two months prior to randomization into the study. However, participants who had previously been medicated but terminated treatment because of minimal treatment effect or because of the experience of intolerable side effects after at least two medication trials were also included. The participants could not receive a parallel psychosocial intervention during the study period. The exclusion criteria were severe depression, suicidal behaviour, conduct disorder, psychoses, intellectual disability (IQ < 70) and current substance abuse. Patients not interested in psychopharmacological treatment and patients in on-going psychotherapy or previously having received CBT for ADHD were also excluded. At the time of study inclusion, 91% of

the participants were on pharmacological treatment for ADHD, and 53% had at least one current comorbid condition according to the DSM-5 (see Table 1 for characteristics of the participants).

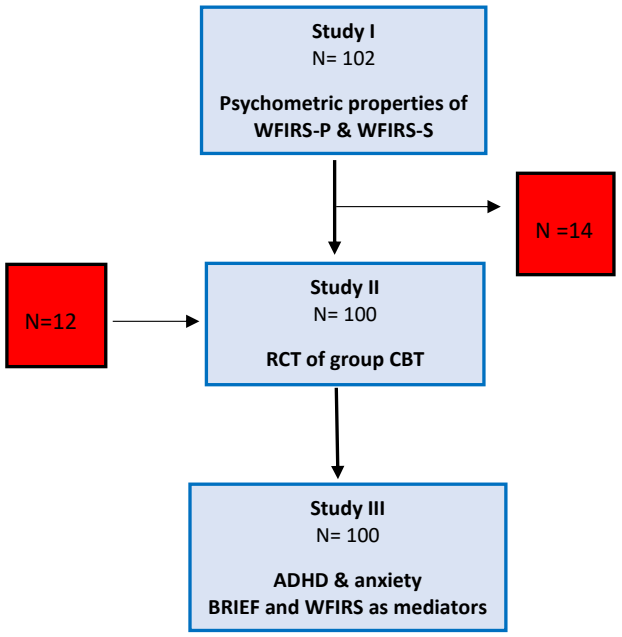
Of the 102 participants in study I, eighty-eight (86.0%) were included in the RCT of study II (see Figure 2). The additional 14 participants included in this study had similar characteristics as the participants in the RCT (see Table 1 for the characteristics of the participants in studies I-III). In this population, 93% were medicated for ADHD, 14.3% had one or more comorbid internalizing disorders, and 7.1% had comorbid externalizing disorder.

Table 1. Characteristics of the participants in studies I-III

Characteristics	**Study I (n=102)**	**Study II & III (n= 100)**
Mean age, years (SD)	15.4 (1.2)	15.8 (1.3)
Male patients (n, %)	49 (48%)	43 (43%)
Full-scale IQ (n [mean, SD])	89 (93.6, ±12.9)	86 (93.9, ±12.9)
Parent rated ADHD symptoms		
ADHD RS-IV total score (n, mean, SD)	99 (23.9, 9.1)	97 (25.0, 8.8)
ADHD RS Inattention score (n, mean, SD)	100 (14.8, 5.1)	98 (15.5, 5.1)
ADHD RS Hyperactivity score (n, mean, SD)	101 (9.2, 5.6)	99 (9.4, 5.5)
Medication		
[1]ADHD medication (n,%)	95 (93%)	91 (91%)
[2]Other pharmacological treatment (n,%)	5 (4.9%)	7 (7%)
Psychiatric comorbidities		
[3]Internalizing disorders (n,%)	35 (34.3%)	49 (49%)
[4]Externalizing disorders (n,%)	4 (3.9%)	11 (11%)

Note. *SD* Standard deviation, *Full-scale IQ* Wechsler Intelligence Scale for Children or Adults (WISC-IV, WAIS-IV), *ADHD-RS-IV* Attention Deficit Hyperactivity Disorder Rating Scale version IV, [1]*ADHD medication* includes methylphenidate, lisdexamphetamine, atomoxetine, and guanfacine,[2]*Other pharmacological treatment* includes neuroleptic medication; risperidone, quetiapine; anti-epileptic medication: valproate, lamotrigine, [3] *Internalizing* disorders include anxiety disorders, depression and Post Traumatic Stress Disorder (PTSD), [4]*Externalizing disorder* includes Oppositional Defiant Disorder (ODD) and Disruptive Behaviour Disorder not otherwise specified (NOS), *Psychiatric* comorbidities are based on Kiddie-SADS-PL interview with the adolescents and converted to DSM-5 diagnoses.

Figure 2. Flow diagram of participants of this thesis



Study design and procedure

Study I (paper I) is an observational study examining the psychometric properties of the WFIRS-P and WFIRS-S. Study II (paper II) is a two-arm parallel randomized controlled efficacy trial (RCT) comparing CBT group therapy with a passive no CBT control condition. Study III (paper III) is a cross-sectional observational study.

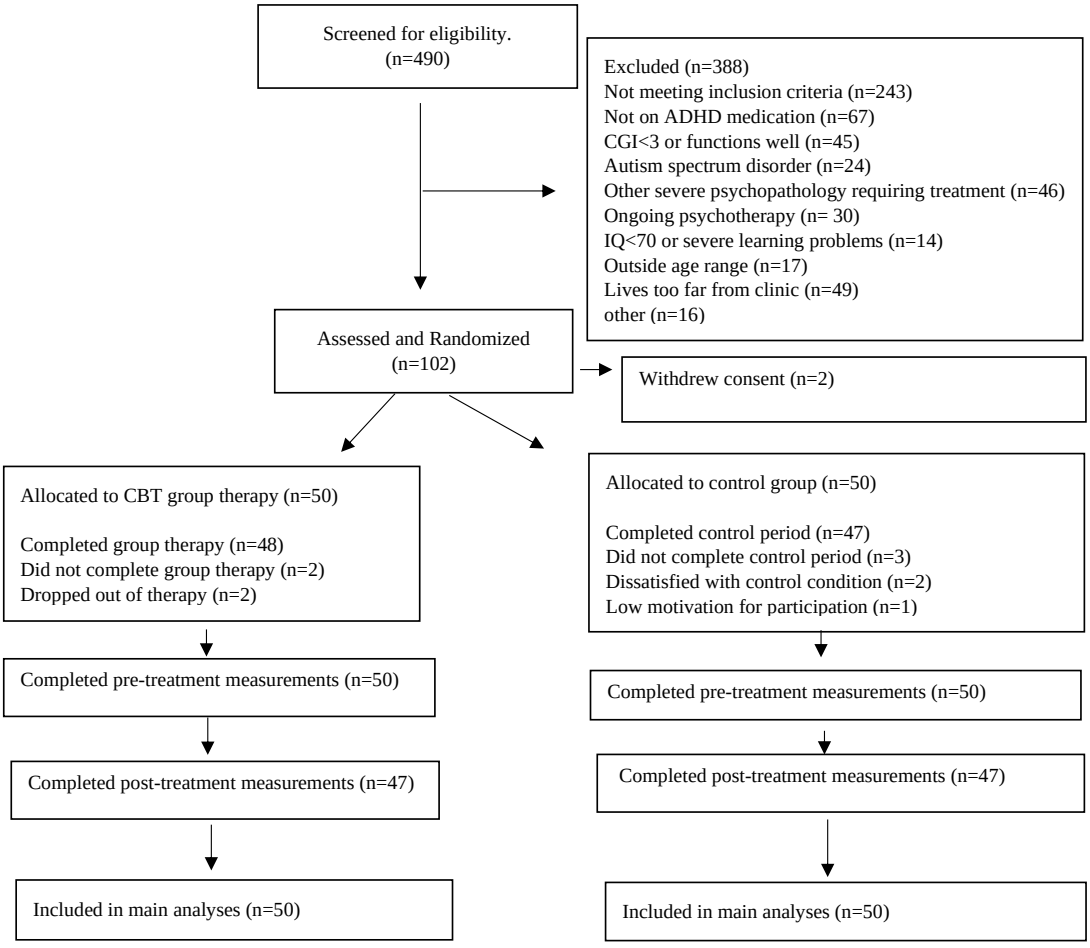
The 100 participants of the RCT (study II) were recruited from two CAP clinics from February 2017 to September 2019. Six of the participants were additionally recruited through primary care physicians after advertising via social media and postings in a local newspaper. All participants and their parents received oral and written information about the content of the study and the different treatment arms from their CAP clinicians. The total number of patients screened for eligibility was 490, and 102 of these patients were assessed and randomized for study inclusion. Two patients withdrew consent before the start of the study, leaving 100 participants to be randomized to the two treatment arms (see Figure 3 for a flow diagram of participants included in the study). The measures in the study included parent,

self- and teacher reports, and the data were collected two to four weeks before the intervention and two weeks after the intervention (see Table 3 for the measures included in the study). One hundred participants completed the baseline assessment. Those who completed measures at baseline but not posttreatment were included in the analyses according to intention-to-treat (ITT) principles.

The 102 participants included in study I were recruited from three CAP clinics from April 2017 to April 2019. Eighty-eight of the participants (86%) were the same as those in study II. Additionally, we collected questionnaires from 14 patients with ADHD of the same age, mostly from catchment areas other than that for the RCT, but otherwise they had similar characteristics. All participants included in the RCT provided informed consent and completed the WFIRS-S at the CAP clinic. Participants who were not included in the RCT, received a document explaining the purpose of the WFIRS-study. These participants responded to the WFIRS questionnaire anonymously on a visit with their clinician. One of the parents completed the WFIRS-P simultaneously (72% were biological mothers). These data were sent to the project leader without an identifiable ID. The Children's Global Assessment Scale (C-GAS) was scored by the first and last author of paper II for the RCT group and by experienced clinicians for the non-RCT participants.

The participants in study III were the same as those in study II. Only the baseline data of the RCT study (study II) were used in this paper.

Figure 3. Flow diagram of participants in the RCT (study II)



Note. Haugan et al. BMC Psychiatry, 2022

Content of the CAP standard intervention

After receiving an initial ADHD diagnosis at the CAP clinic, the participants were offered a short psychoeducational intervention of 1-2 hours with or without their parents delivered by their CAP clinician. This intervention typically consisted of information about ADHD diagnoses, symptoms, causes and treatment options. Some participants were offered an additional 1-2 hours of individual psychoeducation either in addition to the meeting with the parent or as the only psychoeducational intervention received at the clinic (see Table 2 for an overview of the interventions received by the participants in study II). Ninety-two percent of the participants in study II received at least one of these interventions. In addition, parents and a schoolteacher of the participants had a collaborative meeting with the CAP clinician and/or a clinical education specialist so they could receive information about the ADHD diagnosis and discuss individualized supportive measures in school (1 hour). Parents and a schoolteacher were also offered a standardized full-day lecture delivered by various ADHD specialists, with information about ADHD, pharmacotherapy, psychosocial interventions, and school interventions. We refer to Additional file 1 in paper II in the Appendix for more detailed information about the content of these different psychoeducational interventions.

Table 2 Overview of the CAP clinical treatment interventions received by the participants in study II

CAP Clinical Interventions	**CBT (n=50)**	**Control (n=50)**
Previous CAP psychosocial treatments (n [%])		
Webster Stratton, Incredible years	10 (20)	6 (12)
Cognitive behavioral Therapy (CBT)	2 (4)	1 (2)
Routine Clinical Care[a]	18 (36)	24 (48)
Other[b]	4 (8)	4 (8)
CAP standard clinical intervention (n [%])		
Short psychoeducational intervention with patient and parents	33 (66)	32 (64)
Short psychoeducational intervention with patient alone	24 (48)	29 (58)
School collaborative meeting	47 (94)	48 (96)
ADHD full day lecture	35 (70)	36 (72)

Note. [a] *Routine clinical care* Supportive therapy for patients and/or parents for mild emotional and behavioural problems, [b]*Other* Dialectic behaviour therapy (DBT), eye movement desensitizing and reprocessing (EMDR), habit reversal training (HRT) and family therapy.

Content of the group CBT intervention

The group CBT programme (study II) was developed in cooperation with Dr Susan Young, and based on the "Young Bramham programme" (YBP), which is a CBT programme developed for adolescents and adults with ADHD and comorbid symptoms (Young & Bramham, 2012). The CBT programme was adapted to fit a 12-week group format with 90-minute sessions. The content of the programme included information on ADHD, the principles of CBT and strategies for managing the core ADHD symptoms, such as inattention and memory problems, impulsivity, and organization and time management issues. Modules with strategies for problem solving, interpersonal problems, anxiety, depression, frustration, and anger management were also included, as these are common comorbid problems associated with ADHD in the CAP adolescent population (see Table 3 for the content of the different treatment sessions). Basic CBT elements, including the triangulation of thoughts, feelings, and behaviour; identification of dysfunctional thoughts/cognitive restructuring techniques; and the use of positive reinforcement, were used throughout the programme. All the sessions were structured using the same format, with psychoeducation, group discussions, skills training, role-play, and individualized weekly home assignments. The groups consisted of 4–6 participants and were led by two clinicians recruited from the clinic. All the group leaders had experience with CBT and were trained (receiving a full day course on CBT and delivering the research treatment manual before the intervention) before delivering the intervention. A research assistant telephoned the participants each week to remind them of the homework assignment and helped them if needed, to evaluate their medical adherence, and to make sure they were not receiving any other psychosocial treatments. The participants also received one routine medical follow-up. Parents were not involved in this programme. We refer to Additional file 2 in paper II in the Appendix for more detailed information about the content of the CBT programme.

Table 3. Contents of the Group Cognitive-Behavioural Therapy (CBT) programme

	Session	Themes
Core symptom modules	1	Orienting participants to the program, including content, structure, and the basic CBT principles. Participants receive psychoeducation about ADHD and write down individual treatment goals.
	2	Attention: Various forms of attention and the impact of motivation, anxiety and stress are introduced and discussed. Various attention control strategies are presented and rehearsed in session.
	3	Memory: The various memory systems are introduced. External and internal memory strategies are presented. Memory games and exercises are practised within group meetings.
	4	Organizing and time-management: Consequences of dysfunctional planning and time-management are discussed. Six steps for making a time plan, including use of daily planners and rewards. are introduced and rehearsed.
	5	Impulsivity: Consequences of having low self-control are introduced and discussed. Various impulse control strategies, including self-talk and distraction techniques, are presented, and rehearsed in the session.
Comorbid and associated problem modules	6	Problem solving: The participants learn how to define problems, generate solutions, and evaluate them. We rehearse in session, and finally, we evaluate the level of success.
	7	Anxiety: Psychoeducation on basic CBT principles, how to cope with negative thoughts, the three-legged table, relaxation strategies and the role of exposure in changing behaviour.
	8	Depression and sleep management: Introducing the cognitive model of depression, challenging negative thoughts and the positive role of activity. Psychoeducation about sleep and sleep strategies are introduced.
	9	Interpersonal relationships and communication: Introducing and rehearsing verbal and nonverbal communication strategies.
	10	Frustration and anger management: Consequences of bad anger management are discussed. We introduce various management strategies, including self-talk, distraction techniques, reframing the situation and relaxation.
	11-12	Preparing for the future: We present and discuss the challenges of having ADHD in the transition to young adulthood. We repeat some of the highlights from the program and discuss the participants' future goals and which skills can be used to achieve them.
Note: All sessions include group activities, homework assignments and telephone coaching between sessions. The content is based on the CBT programme of Young and Bramham, 2012.		

Note. Haugan et al. BMC Psychiatry, 2022

Control condition

This was a passive control group with no additional interventions received after the initial psychoeducation and medical treatment in the CAP clinic. These participants continued their medical treatment and received one medical follow-up similar to the CBT group. The research assistant contacted the participants each week to monitor their medical adherence and ensure that they were not receiving any other psychological treatment.

Ethics

The participants were provided oral and written information about the content of the studies by CAP clinicians. Written informed consent was obtained from adolescents and parents (parents signed the forms for participants under 16 years). The studies were approved by the Regional Committee for Medical and Health Research Ethics in Southeast Norway

(2015/2115) and were conducted according to the principles set forth in the Declaration of Helsinki from 1964 and later amendments.

Measures

The measures used in this thesis are presented in Table 3.

Table 3. Measures used in study I-III

Measure	**Description**	**Form**	**Study**		
Adolescent informant			**I**	**II**	**III**
ADHD RS-IV	ADHD symptoms	Questionnaire	*	*	*
ASWS	Sleep quality	Questionnaire		*	
BRIEF-SR	Executive functions	Questionnaire		*	*
C-GAS	Illness severity related to ADHD	Clinician rated	*	*	
GPSES	Self-efficacy	Questionnaire		*	
Kiddie-SADS-PL	Psychiatric symptoms and diagnosis	Interview		*	*
RSES	Self-esteem	Questionnaire		*	
SCARED	Anxiety	Questionnaire		*	*
SMFQ	Depression	Questionnaire		*	
WAIS-IV	Intelligence	Testing	*	*	*
WISC-IV	Intelligence	Testing	*	*	*
WFIRS-S	Functional impairment	Questionnaire	*	*	*
Parent informant					
ADHD RS-IV	ADHD symptoms	Questionnaire	*	*	*
BRIEF-P	Executive functions	Questionnaire		*	*
CGI-S	General psychosocial functioning	Clinician rated		*	
WFIRS-P	Functional impairment	Questionnaire	*	*	*
Teacher informant					
ADHD RS-IV	ADHD symptoms	Questionnaire		*	
BRIEF-T	Executive functions	Questionnaire		*	

Note. *ADHD-RS* Attention-Deficit/Hyperactivity Disorder Rating Scale, *ASWS* Adolescents' Sleep-Wake Scale, *BRIEF* Behaviour Rating Inventory of Executive Function, *GPSES* General Perceived Self-Efficacy Scale, *Kiddie-SADS-PL* the Schedule for Affective Disorders and Schizophrenia for school-age children-Present and Lifetime Version, *RSES* Rosenberg Self-Esteem Scale, *SCARED* Screen for Child Anxiety Related Emotional Disorders, *SMFQ* Short Mood and Feeling Questionnaire, *WAIS/WISC* Wechsler Adult Intelligence Scale or Intelligence scale for children, *WFIRS* Weiss Functional Impairment Rating Scale, *P* parent-report, *SR* self-report, *T* teacher-report.

Diagnostic assessment of ADHD and comorbid disorders

For all the participants included in the studies of this thesis project, a child and adolescent psychiatrist or a clinical psychologist made psychiatric diagnoses at the first intake to the CAP clinic. The assessment and diagnosis of hyperkinetic disorder was based on the national guidelines for the assessment and treatment of ADHD (Helsedirektoratet, 2016), which are similar to the NICE ADHD guidelines (National Institute for Health and Care Excellence (NICE), 2019). The diagnostic procedure requires a thorough developmental history, a somatic assessment, an examination of comorbid psychiatric disorders, and the use of questionnaires completed by the adolescents, parents, and teacher informants to obtain ADHD symptom scores (ADHD rating scale). The diagnostic criteria for hyperkinetic disorder in the ICD-10 are nearly identical to those of the DSM-5 (American Psychiatric Association, 2013) diagnosis of ADHD combined presentation. The Norwegian ADHD guidelines (Helsedirektoratet, 2016) allow for hyperkinetic disorder to be diagnosed in patients with severe inattentive symptoms only, corresponding to the DSM-5 Inattentive type. To assess for the presence of ADHD symptoms and psychiatric comorbidities before inclusion in the RCT (study II), we interviewed the participants with the Schedule for Affective Disorders and Schizophrenia for school-age children-Present and Lifetime Version (Kiddie-SADS-PL). The instrument provides a DSM-IV psychiatric diagnosis for school-age children (age 6–18), and findings suggest that it generates reliable and valid child psychiatric diagnoses (Kaufman et al., 1997).

Cognitive testing/intelligence tests (WISC-IV/WAIS-IV)

The cognitive ability of the participants was tested with the Wechsler Intelligence Scale for Children (WISC-IV) for participants under 16 years of age or the Wechsler Adult Intelligence Scale (WAIS-IV) for adolescents aged 16 and above. Both scales are considered the "gold standard" of intelligence testing. The scales generate four index scores that individually rate verbal comprehension, perceptual reasoning, working memory and processing speed. In addition, a total IQ score (FIQ) that represents a general intellectual ability is calculated. The WISC-IV has shown good psychometric properties, with high internal consistency for the four indices and the total IQ score. The associations between the total IQ score and the lower-order indices were high across different age groups, and the test- retest reliability coefficients were high to medium. Confirmatory Factor analyses (CFA) has shown good model fit for both factors, as well as a higher-order overall IQ factor (Canivez et al., 2017; Wechsler,

2003). The WISC-IV FIQ has shown good convergent validity with other measures of intelligence (WISC-III, Wechsler Abbreviated Scale of Intelligence [WASI]) (Wechsler, 2003). CFAs have confirmed a good model fit for the factor structure of the WAIS-IV, the construct validity was supported with strong associations with another measure of intellectual ability (WAIS-III), and the internal reliability has been acceptable to excellent (Wechsler, 2008).

ADHD symptoms

The *ADHD Rating Scale* (ADHD RS-IV) (DuPaul et al., 1998) was used to assess the ADHD symptoms of the participants in study I-III. We used self-reports in addition to parent and teacher reports to assemble symptom descriptions from different perspectives and across situations. The ADHD RS questionnaire contains 18 items corresponding to the diagnostic criteria for ADHD. Each item is rated from 0 = not at all to 3 = very often; the range = 0-54, with 54 indicating the greatest level of symptom severity. The scale represents a total score and two subscales that consist of nine symptoms of inattention and nine symptoms of hyperactivity. The scale has been validated for children and adolescents (age 5–18) with ADHD, with adequate reliability and validity (DuPaul et al., 1998). A European study found strong evidence for cross-cultural factor validity, internal consistency and convergent and divergent validity across several European countries, supporting the use of the ADHD RS-IV (Dopfner et al., 2006). In study II, the Cronbach's alpha coefficients were 0.78 to 0.81 on the ADHD RS-IV parent report, 0.80 to 0.82 for teacher ratings, and 0.80 to 0.84 for self-ratings.

Functional impairment

The *BRIEF* (Gioia et al., 2000) is an assessment of EF behaviours at home and school for children and adolescents from 5 to 18 years. It includes an 86-item parent-and-teacher report (BRIEF-P, BRIEF-T) and an 80-item self-report (BRIEF-SR). The scales range from 0 = not true to 2 = very true and converted T-scores above 65 indicate executive dysfunction. The inventories contain both a metacognitive index (MI) and a behaviour regulation index (BRI) score, in addition to a global executive composite (GEC) score. We used the GEC index T-score in study II, and the GEC, MI, and BRI T-scores in study III. The inventories have shown good psychometric properties in American and Norwegian children and

adolescent populations (Egeland & Fallmyr, 2010; Fallmyr & Egeland, 2011; Gioia et al., 2002).

The CGI-S (Guy, 1976) was used to rate the severity of a patient's illness related to ADHD symptoms in study II. Experienced child and adolescent psychiatrists interviewed the participants and a parent and rated the symptom severity based on observed and reported symptoms, behaviour, and function in the past seven days at baseline and post treatment. The CGI-S has a 7-point scale, where 1= normal, meaning not at all ill; 3 = mildly ill; 7 = among the most extremely ill patients; and 0 = not assessed. Higher scores indicate more severe ADHD symptoms. This scale is often used in psychopharmacological research and has been shown to have adequate sensitivity in drug trials (Guy, 1976).

The *CGAS* (Shaffer et al., 1983) is a numeric scale used to measure the general psychosocial functioning of children under the age of 18 during the last month. The range is from 1 (lowest function) to 100 (excellent function). The Norwegian version has shown acceptable convergent, discriminant and predictive validity as well as acceptable interrater reliability (Jozefiak et al., 2018).

The WFIRS-P and WFIRS-S (Canu et al., 2020) consist of 50 and 69 items, respectively, divided into six and seven domains of impairment that are typically affected in ADHD (family, work, school and learning, life skills, self-concept, social activities and risky activities). The WFIRS-P and WFIRS-S are not parallel forms, but there are many parallel items. Items are recorded on a scale ranging from 0 = not at all to 3 = very often, where 4 = not applicable, with higher scores indicating more impairment. Clinicians can consider any domain with a mean score > 1.5, two items with a score ≥ 2, or one item with a score = 3 as impaired (Canadian Attention Deficit Hyperactivity Disorder Resource Alliance, 2011). In study I, the Norwegian version showed acceptable psychometric properties for use in an adolescent ADHD population (Haugan et al., 2021). The Cronbach's alpha coefficients were 0.66 to 0.89 for the WFIRS-P and 0.79 to 0.93 for the WFIRS-S. The mean total score was used in studies II and III, which represented the mean of all the subscales.

Associated emotional and functional problems

The *Adolescent Sleep-Wake Scale (ASWS) (LeBourgeois et al., 2005)* is a 28-item scale widely used to measure sleep quality in 12- to 18-year-old adolescents. The scale ranges from

1 = always to 6 = never. Eight of the items were reversed for opposite scores. A higher score indicates a better quality of sleep. We calculated the mean score for use in study II. The scale is considered a reliable and valid measure of overall sleep behaviour in a young adult population, with good psychometric properties (Huber et al., 2020; LeBourgeois et al., 2005). The Cronbach's alpha was 0.70 in study I.

The *Mood and Feelings Questionnaire-short version* (SMFQ) (Angold et al., 1995) is a 13-item inventory tool that measures depressive symptoms in children and adolescents from 8 to 18 years. The scale ranges from 0 = not true to 2 = true. We used the total score in study II, with higher scores representing more depressive symptoms. In a Swedish clinical population, the SMFQ's ability to detect depression was fair for boys and good for girls. A Norwegian study found the measure to be a fast, practical, and feasible measure to detect depression in school adolescents (Jarbin et al., 2020; Larsson et al., 2016). The Cronbach's alpha was 0.93 in study I.

The *General Perceived Self-Efficacy Scale* (Schwarzer & Jerusalem, 1995) is a ten-item one-dimensional scale that is designed to assess belief in one's ability to cope with a broad range of stressful and challenging demands in life. The items are scored on a scale ranging from 1 = all wrong to 4 = completely right, and a high score represents positive self-efficacy. Studies have found self-efficacy to be a universal construct with high internal consistency across 25 nations, and convergent validity with other similar constructs has been moderate to low (Luszczynska et al., 2005; Scholz et al., 2002). In study I, the Cronbach's alpha was 0.88.

The *Rosenberg Self-Esteem Scale (RSES)* (Rosenberg, 1965) is a ten-item self-report instrument for evaluating one's overall sense of worthiness as a person in adolescents and adults. Responses are coded on a 4-point scale ranging from 1 = strongly disagree to 4 = strongly agree. Items 2, 5, 6, 8 and 9 are reversed to yield opposite values, and a high total score indicates positive self-esteem. The scale has exhibited high internal consistency, acceptable criterion validity and discriminant validity, as well as sensitivity to change (Eklund et al., 2018). In study I, the Cronbach's alpha was 0.93.

The *Screen for Child Anxiety-Related Emotional Disorders* (SCARED) (Birmaher et al., 1997) is a 41-item self-report screening questionnaire measuring anxiety symptoms in youth. The item scale ranges from 0 = not at all to 2 = often, and a total score ≥ 25 may indicate the presence of an anxiety disorder. The instrument is sensitive to detecting specific and/or comorbid anxiety diagnoses in youth (Rappaport et al., 2017). The Norwegian version has

shown excellent internal consistency and convergent validity with other measures of anxiety in a nonclinical population (Skarphedinsson & Villabø, 2015). The Cronbach's alpha was 0.95 in study II.

Statistical analysis

The statistical analyses were performed using the SPSS versions 25 and 26 (IBM, SPSS INC., Chicago) and Mplus version 8 (Muthén & Muthén, 1998-2017). The PROCESS macro for IBM SPSS (www.processmacro.org) was used to conduct the serial multiple mediator model in study III. In study I, missing values were handled using available case analyses; that is, each analysis included the cases that included the data required for the analysis. In studies II and III, missing data were handled using single imputation on scales using the mean item score if 70% or more of the questions were answered. Otherwise, the outcome of that specific scale for that participant was treated as missing. Normality of residuals was evaluated by visual inspection of QQ-plots. We regard correlation coefficients between 0.10 and 0.29 as low, correlations between 0.30 and 0.49 as moderate, and correlations of 0.50 and above as high (Cohen, 1988). In studies I and II, Two-sided p values ≤ 0.05 were considered to signify statistical significance. In study III, we regarded two-sided p values under 0.01 as significant to reduce the risk of false positive findings due to multiple hypotheses. Where relevant, 95% confidence intervals (CIs) are reported.

In study I, Spearman correlation coefficients were used to measure internal validity, cross-informant reliability, and convergent validity. Spearman correlations were used because some of the variables were nonnormally distributed. Mean scores were calculated, omitting items with a missing or "not applicable" response, to produce the domain scores and a total score. We conducted CFAs for ordinal categorical variables to confirm the construct validity of the WFIRS scales. The weighted least square estimator with robust standard errors and mean- and variance- adjusted chi square test statistic (WLSMV) were used as estimators for this setting. We applied a first-order correlated factor model with six and seven domains in the WFIRS-P and WFIRS-S, respectively, as factors. Second, we carried out a second-order hierarchical factor analysis including the factors of the WFIRS-S and WFIRS-P individually to examine the factor loadings on a global total factor. Model fit was based on the commonly used indices (Hu & Bentler, 1999; Schermelleh-Engel et al., 2003).

Cronbach's alpha coefficients were used to assess reliability/internal consistency in each domain and for the total scores on the WFIRS-P and the WFIRS-S. A coefficient of at least 0.7 was regarded as acceptable to confirm consistency (Chronbach & Meehl, 1955). Spearman's correlations were computed to assess the convergent and divergent validity of the WFIRS scales. Multiple linear regression was conducted to analyse the association between the ADHD RS-IV total score (independent variable) and the WFIRS-P and WFIRS-S total scores (dependent variable) separately, adjusting for age, sex, IQ score and internalizing psychiatric disorders. All the covariates were regarded as potential confounders.

In study II, the sample size was calculated for a six-point difference, assuming a standard deviation of nine on the ADHD RS-IV, as recommended by Coghill and Seth (Coghill & Seth, 2015). With a 5% significance level and to obtain a power of 80%, we needed 48 participants in each group, allowing for dropouts. Analyses were conducted using mixed models, with the outcome variable as the dependent variable, time point and the interaction between treatment group and time point as fixed effects, and the patient as a random effect. Analyses were based on ITT. Separate analyses were conducted for each outcome. Post hoc subgroup analyses were conducted to explore whether age, IQ, the severity of anxiety symptoms or the severity of ADHD symptoms would act as moderators, using the parent-rated ADHD RS-IV total score. This was done by adding the potential moderator and the relevant interactions into the linear mixed models.

In study III, regression analyses were conducted to analyse the individual contributions of parent- and self-rated ADHD symptoms, executive dysfunction, and functional impairment to the severity of anxiety symptoms. Regression analyses were also conducted to explore which of the subscales from the ADHD RS-IV and the BRIEF questionnaire predicted anxiety the most when controlling for the other questionnaire subscale. Separate analyses were used for parent and self-reports. Multicollinearity was checked to avoid high correlations between the independent variables (r =.70 and above) as recommended by Dormann (Dormann et al., 2013). To explore whether EFs and functional impairment acted as mediators in the association between ADHD symptoms and anxiety, a serial multiple mediator model recommended by Hayes (2017) was conducted. We entered the ADHD RS-IV total score as the predictor variable, the BRIEF GEC as the first mediator, and the WFIRS total score as the second parallel mediator. The self-rated SCARED total score was the outcome variable in all mediation analyses. The PROCESS command was used to generate bootstrap CIs for all

indirect effects and possible pairwise comparisons between indirect effects. A total of 5000 bootstrap samples were used in these analyses. Age and sex were considered confounders and entered as covariates in all the analyses. In addition, we carried out supplementary analyses also adjusting for IQ and SES.

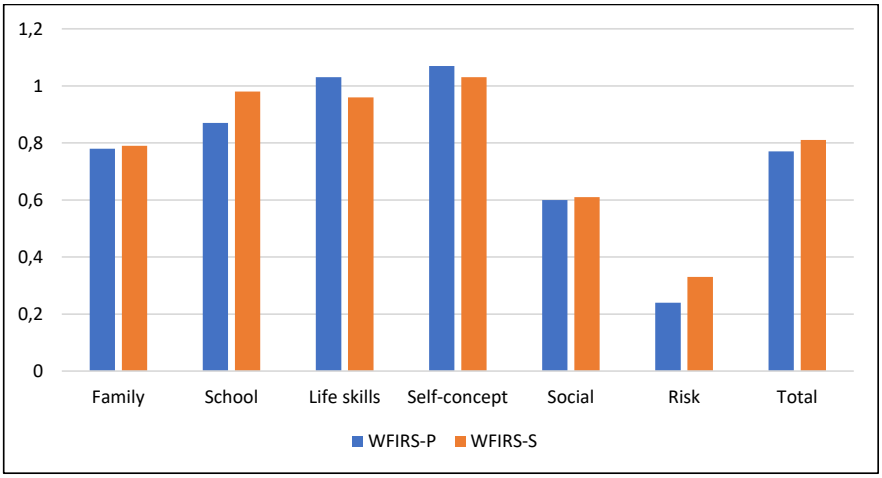
RESULTS

Paper I

Psychometric properties of the Weiss Functional Impairment Rating Scale parent and self-reports in a Norwegian clinical sample of adolescents treated for ADHD

CFA supported the original factor structure of the questionnaires with a six-factor solution for the WFIRS-P and a seven-factor solution for the WFIRS-S. Both a first-order and a second-order model revealed acceptable model fit. The item-to-factor loadings ranged from .47 to .97, and the different factor loadings with the overall global factor ranged from .66 to .88. The internal consistency was satisfactory across domains ($\alpha > 0.71$), except for the life skills domain in the WFIRS-P ($\alpha > 0.66$). The parent-adolescent agreement on the WFIRS questionnaires was moderate. The divergent validity of the WFIRS-P and WFIRS-S with ADHD RS-IV was supported, with moderate to weak correlations (r= .49 to r= .28). The correlations between the WFIRS-P and WFIRS-S with the C-GAS were low to moderate (r = -0.29 to -0.38); thus, convergent validity was not supported. In multiple regression analyses, the ADHD RS total score was the strongest predictor of the total score in both WFIRS questionnaires, with internalizing disorder showing an additional small contribution. Age, sex, and full-scale IQ yielded no additional contribution in explaining the variance.

Figure 4. Mean scores of the WFIRS parent-report (WFIRS-P) and self-report (WFIRS-S)

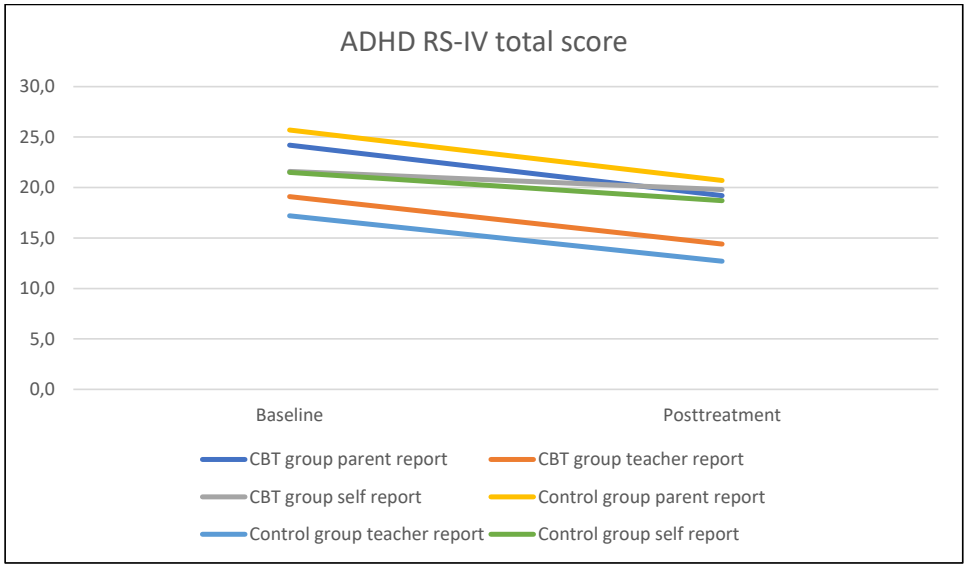


Paper II

Cognitive behavioural group therapy as addition to psychoeducation and pharmacological treatment for adolescents with ADHD symptoms and related impairments – A randomized controlled trial

No differences were observed between the CBT group and the control group regarding parent-, self- and teacher-reported changes in ADHD symptoms posttreatment. Additionally, no significant differences were found regarding symptom impairment, functional impairment, executive dysfunction, or emotional symptoms. Post hoc subgroup analyses exploring the potential moderating effects of age, IQ, the severity of anxiety symptoms and ADHD symptoms revealed no significant effect on treatment outcome using parent-rated ADHD symptom scores. Measures of psychiatric symptoms, self-efficacy and self-esteem showed only minor, nonsignificant effects on the part of CBT treatment, and no group differences were detected posttreatment.

Figure 5. ADHD RS-IV total scores for CBT group and control group at baseline and posttreatment



Paper III

Executive functions mediate the association between ADHD symptoms and anxiety in a clinical adolescent population

In the regression analyses, parent-rated ADHD symptoms did not predict anxiety, but ADHD inattention symptoms predicted anxiety in the self-reports (p= 0.002, 95% CI, 0.380 to 1.590). All the BRIEF EF indices, including the GEC, the MI, and the BRI, as well as the WFIRS total functional impairment score, predicted anxiety in both the parent and self-reports.

In the mediation analyses, parent-rated ADHD symptoms alone did not predict anxiety, but executive dysfunction mediated this relationship as expected (coefficient = 0.466, CI 0.013 to 1.024). Functional impairment did not mediate the ADHD-anxiety relationship (coefficient = -0.101, CI: -0.275 to 0.0241); however, the indirect effect of executive dysfunction and functional impairment in serial was positive and significant (coefficient = 0.362, CI: 0.087 to 0.665). The association between ADHD symptoms and anxiety thus seems to be mediated by EFs affecting functional impairment, which in turn mediates symptoms of anxiety. This was found regardless of age, sex, IQ, and SES, and the results were similar in both the parent and the self-reports.

DISCUSSION

Summary of findings

This thesis aimed to examine whether a novel group CBT treatment would have an incremental treatment effect on adolescents who previously received psychoeducation and were medicated but still presented residual ADHD symptoms and functional impairment. An evaluation of functional impairment related to ADHD is imperative for both diagnostic purposes, for guiding treatment planning, and for evaluating treatment outcomes. To accommodate this, the psychometric properties of the Norwegian versions of the WFIRS-P and WFIRS-S were examined to see if they were acceptable for use in a clinical adolescent population. Finally, anxiety disorders are common in adolescents with ADHD, but the reasons for this are unknown. The associations between symptoms of ADHD and anxiety were investigated by examining whether ADHD symptoms, EFs and functional impairment were able to predict anxiety, and whether EFs and functional impairment mediate this relationship.

To summarize, although well liked by the adolescents, compared to the control condition, the additional group CBT did not demonstrate an incremental treatment effect on either ADHD symptoms or associated impairments. The psychometric properties of the WFIRS-P and WFIRS-S were found to be acceptable for use in a clinical adolescent population and can thus be recommended for use in both research and clinical work when assessing functional impairment associated with ADHD. Finally, ADHD inattention symptoms predicted anxiety in adolescent self-reports, but not parent reports. Both executive dysfunction and functional impairment predicted anxiety in both groups of informants. In the mediation analyses, ADHD symptoms alone were unable to predict anxiety; however, executive dysfunction mediated this relationship as expected. Functional impairment mediated this relationship only indirectly through EFs. The results were similar in the parent- and self-reports, pinpointing executive dysfunction as an important treatment target in alleviating anxiety in adolescents with ADHD.

General discussion

Validation of the WFIRS

Confirmatory factor analyses supported the scale construction, the internal reliability, and the divergent validity of the Norwegian adaptions of the WFIRS-P and the WFIRS-S. Thus, the scales can be recommended for use in a clinical adolescent ADHD population. However, the fit of the model was not optimal. In the examination of the score distributions of the items in the WFIRS questionnaires, four items from the WFIRS-P and twelve items from the WFIRS-S were removed due to the high rate of "not applicable" responses and/or a "floor effect". These items were considered "not applicable" primarily due to the young age of the sample (mean age was 15.4 years) and were mainly from the family, work, and risk domains. Many of these items describe problem behaviours such as risky driving and substance abuse, symptoms that are more common in older adolescents or young adults with externalizing disorders, who were underrepresented in this study population. The removal of items and consequent adaptation of the WFIRS questionnaires to better fit the symptom profiles and age of the study population has been referred to in other validation studies (Hadianfard et al., 2019; Kernder et al., 2019; Tarakcioglu et al., 2015). Nonetheless, the items were kept in the questionnaires, knowing that the inclusion of these items would improve the clinical value when relevant.

CFA confirmed both the first-order, six-factor structure of the WFIRS-P and the seven-factor structure of the WFIRS-S, similar to the original scales and in line with previous validation studies in other languages (Gajria et al., 2015; Hadianfard et al., 2019; Micoulaud-Franchi et al., 2019; Takeda et al., 2017; Tarakcioglu et al., 2015). CFA also revealed satisfactory results supporting a second-order model, with the respective factors loading on a global impairment factor. The chi-square values and RMSEA indicated a good model fit, and the TLI and CFI values were in the borderline range on both questionnaires. The internal consistency of both WFIRS scales was satisfactory overall.

The total mean scores on the WFIRS-P and the WFIRS-S were 0.77 and 0.81, respectively. Both scores were thus above 0.65, which has been defined as an appropriate threshold for differentiating between an ADHD and a normative population (Thompson et al., 2017). In terms of clinical implications, parents rated the adolescents as most functionally impaired in the life-skills domain (e.g., excessive use of TV/computer/PC games, problems getting ready

for school and getting ready for bed, problems with eating and sleeping), the self-concept domain (feels bad about himself or herself, my child is not happy with his or her life), and school domains (has difficulties with school work, needs help in school, needs tutoring, receives grades below abilities, causes problems for the teacher). The adolescents rated themselves as most impaired in the self-concept, work (e.g., problems performing required duties, problems getting work done), and school domains. This is in line with previous research showing that ADHD is highly related to functional impairment in the school arena and also affects adolescents' self-esteem (Danckaerts et al., 2010; Erskine et al., 2016). In this study, there was moderate agreement between the parent and adolescent reports. A comparable study examining cross-informant agreement based on the responses of college students and collateral informants found small to moderate correlations (Canu et al., 2020). The moderate association in this study may be explained by the fact that the participants were living at home at the time of assessment and were therefore in closer contact with their parent informants.

In contrast to a previous validation study (Tarakcioglu et al., 2015) that found moderate to high correlations between the WFIRS-P and CGAS, supporting convergent validity, the correlations between the WFIRS scales and the CGAS were low to moderate in this study. Reasons for this may be the use of different informants, with clinicians scoring the CGAS score based on a Kiddie-SADS-PL interview with the adolescents without parents on the one hand and with both parents and the adolescents scoring the WFIRS on the other hand. In addition, we suggest that the instruments measure different concepts, with the CGAS representing a more generic measure of overall clinical severity and the WFIRS representing more specific impairments related to ADHD.

In line with previous validation studies (Canu et al., 2020; Tarakcioglu et al., 2015), the WFIRS-P correlated moderately with the ADHD RS-IV total score, as well as the inattention and hyperactivity subscale scores. This was as expected since the instrument originally was developed to assess functional impairment in persons with ADHD (Canadian Adhd resource Alliance: CADDRA, 2006). Even though the constructs measured by these instruments have something in common, they nevertheless seem to measure nonoverlapping aspects of function, supporting divergent validity.

In this study, we found support for both a first-order and a second-order model in both the WFIRS-P and WFIRS-S. For use in clinical practice, the first-order model is recommended since the inspection of impairment across different life domains is considered more relevant for diagnostic purposes, as well as for use in treatment planning and evaluation of treatment effect. Furthermore, since several of the items in the questionnaires (particularly in the family, work, and risk domains) were considered irrelevant or "not applicable" due to the young age of the participants and/or low rate of behaviour problems, we recommend calculating the mean score of relevant items for each domain or simply inspecting the profile scores for each domain when evaluating these patients in clinical practice. The use of a total mean score could be preferable for use in research.

Efficacy of group CBT as addition to psychoeducation and pharmacological treatment

Contrary to our hypothesis, the CBT group did not demonstrate an incremental treatment effect compared to the control group. This contrasted with previous studies of CBT directed at adolescents, which found larger posttreatment reductions in ADHD symptoms and improved functional impairments in the treatment group than in the waitlist controls (Sprich et al., 2016; Vidal et al., 2015). Different from these comparable studies, the participants in the present CBT study had previously received psychoeducation (including information about ADHD and school interventions) in addition to being medicated for ADHD. The ADHD symptoms at baseline were thus somewhat lower than in the comparable studies by Sprich (2016) and Vidal (2015). Other reasons for the lower baseline score could be actual differences in populations such as more female than male participants, fewer hyperactivity symptoms and few participants with comorbid externalising symptoms, such as ODD. Although receiving previous interventions in the CAP clinic could partly explain the lack of treatment effect on ADHD symptoms compared to studies including participants with more severe symptoms, other explanations need to be discussed. First, the mean age of the participants in this study was 15.8 years (SD = 1.3); and thus the participants were younger than those in the group study by Vidal et. al. (2015), where the mean age was 17.2 years (SD = 1.8). This may suggest that a group format is more appropriate for older adolescents or young adults who are more mature, and thus more able to incorporate the skills learned in group therapy into their daily lives. Second, the CBT group programme included eleven modules with different themes and skills to be learned in each session. Such a comprehensive programme leaves little time to practice new skills. As such, a narrower CBT programme

similar to those in previously published studies (Boyer et al., 2015; Sibley et al., 2016; Sprich et al., 2016) with more sessions targeting the different skills to be learned, as well as more time to practice between sessions, could have improved treatment outcome. Furthermore, only one-third of the homework assignments were completed, according to the participants' own reports. This lower-than-expected completion rate may have contributed to the lack of treatment effect, and may represent a particular challenge working with teens who often struggle with decision making and have poor insight into their own functioning (Buitelaar, 2017). To accommodate this, the inclusion of more engagement-focused components such as individually directed treatment goals, motivational interviewing techniques, and stronger emphasis on rewards using contingency management principles (with help from the parents), similar to other evidence-based treatment programmes (Sibley et al., 2016; Sprich et al., 2016), could perhaps improve the efficacy of the programme. Parent involvement has been considered an important treatment component in other programmes directed at helping adolescents with ADHD who struggle with time management, organization, and homework assignments (Boyer et al., 2015; Sibley et al., 2016; Sprich et al., 2016). As such, the inclusion of parents in the CBT programme could have improved treatment outcomes. Parent- and teacher-rated executive dysfunction was high in the adolescent population across baseline and posttreatment. This indicates a need for more extensive training in time-management, planning and organization across several sessions, as suggested in previous school-based (Evans et al., 2016; Langberg et al., 2012) and clinic-based studies (Boyer et al., 2015; Sibley et al., 2016). Furthermore, 37% of the participants in the RCT had a comorbid anxiety disorder. The CBT programme did not alleviate symptoms of anxiety, which was similar to the study by Vidal et al. (2015) and suggests a need for more extensive treatment to reduce these symptoms. A structured group format naturally limits room for individually targeted treatment and follow-up. Perhaps an integrated individual and group programme would be more appropriate to alleviate both ADHD symptoms and comorbid conditions, as suggested by the preliminary positive results in a study of adults with ADHD (Emilsson et al., 2011).

The association between ADHD symptoms and anxiety, with EFs and functional impairment as mediators

In this study, ADHD inattention symptoms predicted anxiety in the self-ratings of the adolescents, while symptoms of hyperactivity did not. This is in line with previous studies

(Koyuncu et al., 2014; Newcorn et al., 2001) showing a stronger association between inattention symptoms and anxiety than hyperactivity. For the parent ratings, neither the ADHD RS-IV total score, nor the subdomains predicted anxiety. A reason for this may be that the anxiety symptoms were based on self-reports. Additionally, parents may have more difficulty capturing this association because of the less overt nature of both inattention and anxiety in adolescents. Furthermore, executive dysfunction predicted anxiety in both parent and self-reports. This was found both for the GEC, and for the MI and the BRI. The MI represents executive dysfunctions related to working memory, planning, organizing and task completion. These cognitive functions are considered imperative for scholastic skills, as well as for the attainment of future goals. As such, it is reasonable to think that difficulties in these areas may trigger a lack of control, which again may lead to low self-efficacy and reduced self-esteem, which may increase anxiousness. The BRI reflects problems with emotional regulation, mental flexibility, and impulsivity. Emotional dysregulation is naturally related to anxiety. Furthermore, mental inflexibility has been associated with increased anxiousness in previous studies (Castagna et al., 2019; Toren et al., 2000; Visu-Petra et al., 2014). Impulsiveness, on the other hand, has been inversely associated with anxiety, with studies showing that less inhibited children and adolescents present lower anxiety symptoms than those who are more inhibited (Maric et al., 2018; Schatz & Rostain, 2006). Post hoc analyses found the same to be true in this population, showing impulsivity to be negatively associated with anxiety. Finally, the WFIRS total score representing functional impairment in family life, school, social arenas, life skills, risky behaviour, and self-concept also predicted anxiety in both parent and self-reports, as expected.

In the mediation analyses, ADHD symptoms alone were unable to predict anxiety when controlling for executive dysfunction and functional impairment. However, executive dysfunction mediated the ADHD-anxiety relationship. Hence, levels of ADHD symptoms predicted levels of executive dysfunction, which mediated the severity of anxiety symptoms. This was found when controlling for age and sex and was similar in both the parent and self-reports. This result is in line with a previous study (Mohamed et al., 2021) where EFs and functional impairment explained most of the variance in combined anxiety and depression symptoms in college students with symptoms of ADHD. This result suggests that EFs rather than ADHD symptoms per se may lead to comorbid anxiety disorders. In addition, ADHD symptoms alone were unable to predict functional impairment, but functional impairment

predicted anxiety. Functional impairment was thus unable to mediate the ADHD-anxiety relationship by itself but acted as a mediator through EF. The link between EF and functional impairment in both social arenas and school settings has previously been presented in studies with children and adolescents with ADHD (Sjöwall & Thorell, 2014; Tseng & Gau, 2013). In a study of young adults with ADHD, emotional lability/impulsivity and difficulties with planning and organizing predicted impairment in family functioning, social functioning, the academic arena and risky behaviour. Working memory and mental inflexibility marginally predicted impairment in the same arenas (Roselló et al., 2020). Together, these results pinpoint executive dysfunction as an important treatment target in the prevention of functional impairment across several life domains.

Strengths and limitations

The strengths of the RCT (study II) include (I) the use of a control condition (which controls for covariates that may impact treatment outcomes other than the CBT intervention and thus prevent bias); (II) the inclusion of blinded evaluators (assessors were unaware of who received what intervention) and treatment fidelity ratings (a measure of the reliability of the administration of the intervention); (III) the use of multiple informants with self-, parent and teacher ratings, which is considered a strength when evaluating treatment effect (Coghill et al., 2021); (IV) the inclusion of diverse outcome measures encompassing functional impairment, EFs and psychiatric symptoms covering different areas in which CBT may have potential treatment effects; and (V) the delivery of the study in a real-world setting, using clinical staff, and covering a total catchment area.

The study also had several limitations that must be considered when interpreting the results. First, 91% of the population was medicated for ADHD, limiting the generalizability of the findings to nonmedicated patients. Although 66% of the participants reported symptoms above the threshold for a DSM-5 ADHD diagnosis at study inclusion, 34% reported subthreshold ADHD (ADHD medicated), limiting the room for further symptom improvement. Additionally, the large number and low dosage of treatment components may have affected the treatment outcome due to restricted time to practice. Although the treatment fidelity and delivery of the CBT programme was acceptable, the CBT experience and background of the group leaders varied, which may have affected the treatment outcome. In addition, the SES of the participants was higher than in a typical ADHD population (Larsson,

Sariaslan, et al., 2014; Østergaard et al., 2016), limiting the generalizability of the results to populations with lower SES. Furthermore, girls represented 57% of the study population, which is higher than in a standard CAP ADHD population (Nøvik et al., 2006; Surén et al., 2018). In addition, data on homework completion were incomplete, restricting analyses on its impact on treatment outcome. Finally, there were substantially fewer teacher ratings than self- and parent ratings. This is considered a limitation since teacher ratings may represent unbiased observations compared to the more proximate and potentially biased parent observations.

Eighty-six percent of the population in study I was the same as that in study II (the RCT study); hence, ninety-three percent of the total sample was on stable medical treatment for ADHD. This naturally affected the level of ADHD symptoms, making this population less functionally impaired than a nonmedicated population. The WFIRS scores in this study thus represent function after the initiation of medical treatment and are therefore not representative of scores for adolescents with ADHD who are not on medical treatment. Additionally, when recruiting patients for the RCT study, adolescents with mild to moderate behaviour disorders were hard to enrol, females were easier to recruit than boys, and adolescents with severe comorbid psychiatric disorders fell under the exclusion criteria. All these factors represent selection bias, which may have contributed to lower impairment scores than we would expect to find in clinical, unmedicated patients with more severe psychiatric symptoms and conduct symptoms. The mean age of the sample in study I was 15.4 years (SD = 1.2), and their ages from 14 to 18 years. As such, the results may not be representative of younger or older age groups.

Study III is, to our knowledge, the first study to explore the mediating effect of EFs and functional impairment on the ADHD-anxiety relationship in a clinical adolescent population. The inclusion of ADHD patients with common comorbid psychiatric conditions increases the generalizability of the results to a clinical CAP setting. The inclusion of both parent and self-report measures improves the validity of the results. Additionally, the male to female ratio of participants was equal, which is positive when controlling for the possible moderating effect of sex in the ADHD-anxiety relationship. Limitations of this study were the high proportion of medicated participants (same population as in study I), which affected the level of ADHD symptoms. The results of this study may thus not be representative of ADHD populations with more severe ADHD symptoms or patients with ADHD who are not on medication for ADHD. Second, the data in this study were restricted to the use of parent- and self-report

questionnaires. The inclusion of more objective measures, such as computer tests or neuropsychological tests, measuring attention symptoms and executive symptoms could have been of value, even though there is controversy concerning the ecological validity of such tests (Nigg et al., 2005; Spooner & Pachana, 2006; Toplak et al., 2009). Furthermore, a high correlation between the BRIEF and WFIRS index scores suggests some conceptual overlap between the questionnaires. The questionnaires do, however, also represent distinct nonoverlapping problem areas, making each measure of distinct value as clinical assessment instruments. Finally, the cross-sectional design of the study limited the ability to follow up and explore different developmental pathways for the participants.

Conclusion with future research perspectives

The Norwegian versions of the WFIRS parent- and self-report questionnaires show acceptable psychometric properties for use with a clinical population of adolescents with ADHD. These questionnaires may be useful when examining functional impairment as part of the diagnostic examination of ADHD but also as part of treatment planning and evaluation. The use of both a parent report and a self-report gives the opportunity to look at the patient's impairment from different perspectives. This is of great value, particularly when working with adolescents, who tend to underreport, or have limited insight into their own problems (positive illusory bias) (Colomer et al., 2020; Sibley et al., 2019), but also when assessing challenges and impairments in areas where parents may have limited access, such as risky behaviour. Future research should examine the validity of the WFIRS scales with children and adolescents with ADHD prior to treatment. The use of adjusted norms for different age groups would also be preferable.

In this thesis, group CBT did not have an incremental treatment effect compared to the control condition. However, the participants receiving this add-on CBT were positive about joining the programme and the dropout rates were low (Andersen et al., 2022). Future research should examine whether CBT-based treatments focusing on the core ADHD symptoms and EFs that include individualized skills training, contingency management, and MI components, with parent involvement, would be even more effective for this patient group. These are components included in other promising treatment programmes (Sibley et al., 2016; Sprich et al., 2016) but that were not included in the current CBT programme.

Despite receiving medical treatment and psychoeducation, the adolescents in the CBT study presented impairing executive dysfunction and anxiety symptoms both at baseline and posttreatment. These observations suggest that more specific and comprehensive treatment interventions are needed to alleviate these impairing symptoms in adolescents with ADHD. In this regard, it is relevant to explore whether more individualized CBT treatment perhaps in parallel with a group programme, would be more effective than a standardized programme intended to fit all.

The preliminary results from the last study in this thesis (study III) suggest that EFs act as a mediator in the ADHD-anxiety relationship. Following this, more comprehensive skills training focusing on improving executive dysfunction may thus have a secondary positive effect on both functional impairment and comorbid anxiety in adolescent ADHD populations. This result highlights the need to examine executive dysfunction when working with adolescents with ADHD and comorbid anxiety and to implement supportive measures that target specific dysfunctions as part of a treatment plan. To date, no studies have examined the effect of improving executive dysfunction to treat anxiety disorders in children and adolescents with ADHD. Our preliminary results suggest that skills training targeting executive dysfunction should be included as part of a more comprehensive CBT treatment programme in future studies of anxiety disorders in children and adolescents with ADHD.

Although treatment guidelines recommend CBT as additional treatment for ADHD in adolescents who still experience functionally impairing symptoms after receiving psychoeducation and medical treatment (National Institute for Health and Care Excellence (NICE), 2019), more research is needed to support this statement.

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APPENDIX

Appendix A. Overview of the instruments used in this thesis

Instrument	Description	Age	Use	Scores	Psychometric properties	References
Adolescents Sleep Wake Scale (ASWS)	A measure of sleep quality in adolescents	12-18 years	Self-report questionnaire 18-items, five subscales and a total score	The scale ranges from 1 = always to 6 = never A high total score equals a better quality of sleep	The scale is considered a reliable and valid measure of overall sleep behaviour in a young adult population, with good psychometric properties	LeBourgeois et al., 2005 Huber et al., 2020
ADHD Rating Scale (ADHD-RS-IV)	A measure of the severity of ADHD symptoms	5-18 years	Parent, teacher, and self-report. 18 items scale with 9 symptoms of inattention, and 9 symptoms of hyperactivity-impulsivity	Scored 0= not at all to 3= very often A high total score equals more severe symptoms	Confirmatory factor analyses have shown good model fit for both a one factor model and a two- factor model for both parent and teacher ratings.	(DuPaul et al., 1997) Du Paul et al., 1998
Behaviour Rating Inventory of Executive Function (BRIEF)	An assessment of executive function behaviours at home and in school	6-18 years	86-item parent- and teacher report, and 80 item self-report that contain a metacognitive index (MI), behaviour regulation index (BRI) and a global executive index (GEC) score.	Scored 0= not true to 2= very true. T-scores above 65 indicate executive dysfunction	The inventories have shown good psychometric properties in American and Norwegian children and adolescent populations	Gioia et al., 2002 Fallmyr & Egeland, 2011
Children`s Global Assessment Scale (C-GAS)	Index of psychosocial functioning	4-16 years	Clinician rated one-dimensional scale Lowest level for a specified time-period	Scoring: 0-100 Higher scores equal higher functioning	Inter rater reliability (IRR): .84; test-retest stability (ICC): .69-.95 Discriminant validity: inpatients show significantly lower scores than outpatients	Shaffer et al., 1983 (Rey et al., 1995) (Schorre & Vandvik, 2004)
Clinical Global Impression Scale for severity (CGI-S)	Rates the severity of a patient's illness	Children and adults	Clinician rated observation of global functioning	7-point scale from 1= normal to 7= extremely ill. Higher scores indicate more severe symptoms	The CGI has shown to be a reliable measure of disease severity and is sensitive to change. High correlations have been found between CGI and standard ratings of depression and anxiety	Guy 1976 (Bandelow et al., 2006) (Leucht & Engel, 2006)
General Perceived Self-Efficacy Scale	Assess belief in one's ability to cope with a broad range of stressful and challenging demands in life	Children and adults	A ten-item one-dimensional scale	Items range from 1= all wrong to 4= completely right Higher scores represent positive self-efficacy.	Studies have found self-efficacy to be a universal construct with high internal consistency across 25 nations, and convergent validity with other similar constructs has been moderate to low	Schwarzer et al., 1995 Scholz et al., 2002 Luszczynska et al., 2005
Mood and Feelings Questionnaire-short version (SMFQ)	Measures depressive symptoms in children and adolescents	8-18 years	13-item self-report scale One-dimensional scale	Scored 0= not true to 2= true. Higher scores represent more depressive symptoms	In a Swedish clinical population, the SMFQ`s ability to discriminate depression was fair for boys and good for girls. A Norwegian study found the measure to be a fast, practical, and feasible measure to	Angold et al., 1995 Larson et al., 2016 Jarbin et al., 2020

					detect depression in adolescents	
Rosenberg Self-Esteem Scale (RSES)	Evaluate one's overall sense of worthiness as a person in adolescents and adults		10-item, self-report instrument One-dimensional scale	Scored: 1= strongly disagree to 4=strongly agree A high total score indicates positive self-esteem	The scale has exhibited high internal consistency, acceptable criterion validity and discriminant validity, as well as sensitivity to change	Rosenberg, 1965 Eklund, Bäckström & Hanson, 2018
Schedule for Affective Disorders and Schizophrenia for School-Age Children- (K-SADS-PL) Revised version 2009	Psychiatric diagnosis based on the Diagnostic and Statistical Manual of mental Disorders (DSM-IV) (present and lifetime)	6-18 years	Semi-structured psychiatric interview (child/adolescent and parents) Trained interviewer	Diagnoses are scored as: definite, probable (≥75% of criteria), or not present	Inter-rater reliability 98% (range: 93-100 % agreement) Validity: high concurrent validity when compared with questionnaires on ADHD, behavioural problems, depression, and anxiety	Kaufman et al., 1997 (Miller et al., 2008) (Lund et al., 2011)
Screen for Child Anxiety-Related Emotional Disorders (SCARED)	Screening questionnaire measuring anxiety symptoms in youth		41-items Self-report Total score and five subscale scores	The scale ranges from 0= not at all to 2= often A total score ≥25 may indicate an anxiety disorder	The instrument is sensitive to detecting specific and/or comorbid anxiety diagnoses in youth. The Norwegian version has shown excellent internal consistency and convergent validity with other measures of anxiety in a non-clinical population	Birmaher et al., 1997 Rappaport et al., 2017 Skarphedinsson & Villabø, 2015
Wechsler Adult Intelligence Scale, fourth edition (WAIS-IV)	Intelligence test for adults	16-89 Years	Cognitive tests of verbal ability, perceptual reasoning, working memory and processing speed	0-100 percentiles, T-scores and IQ scores. Higher scores equal higher IQ	CFA analyses have confirmed a good model fit for the factor structure. Internal reliability has been acceptable to excellent, and the construct validity is supported, with strong associations with another measure of intellectual ability (WAIS-III)	Wechsler, 2008
Wechsler Intelligence scale for children, fourth edition (WISC-IV)	Intelligence test for children	6-18 years	Cognitive tests of verbal ability, perceptual reasoning, working memory and processing speed	Cognitive tests of verbal ability, perceptual reasoning, working memory and processing speed	The WISC-IV has shown good psychometric properties with high internal consistency for the four indices and the total IQ scale. Test–retest reliability coefficients have been high to medium. CFA has shown good model-fit for the four factors, as well as a higher-order overall IQ factor	Wechsler, 2003 Canivez, Watkins & Good, 2017
Weiss Functional Impairment Rating scale (WFIRS)	A measure of functional impairment for patients with ADHD	Children and adults	Parent-report: 50 items divided into six domains Self-report: 69 items divided into seven domains	0= not at all to 3= very often, 4= not applicable. Higher scores indicate more impairment	The WFIRS-S and WFIRS-P have demonstrated robust internal reliability, moderate cross-informant agreement, and acceptable convergent and divergent validity with other relevant measures	Canu et al., 2016 Haugan et al., 2020

Paper I

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ARTICLE

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Psychometric properties of the Weiss Functional Impairment Rating Scale parent and self-reports in a Norwegian clinical sample of adolescents treated for ADHD

Anne-Lise Juul Haugan[a], Anne Mari Sund[a,b], Per Hove Thomsen[a,c], Stian Lydersen[a] and Torunn Stene Nøvik[a,b]

[a]Regional Centre for Child and Adolescent Mental Health, Norwegian University of Science and Technology (NTNU), Trondheim, Norway; [b]Department of Child and Adolescent Psychiatry, St. Olav University Hospital, Trondheim, Norway; [c]Department of Child and Adolescent Psychiatry, Aarhus University Hospital, Skejby, Denmark

ABSTRACT

Objective: To analyze the psychometric properties of the Norwegian version of the Weiss Functional Impairment Rating Scale parent and self-reports (WFIRS-P and WFIRS-S) in adolescents with ADHD.

Methods: 102 clinically referred patients, of which 86% were enrolled in an ongoing RCT program (Clinical trials NCT02937142), were diagnosed with ADHD according to the Diagnostic and Statistical Manual of Mental Disorders version IV (DSM-IV). The conceptual framework of the WFIRS-P and the WFIRS-S was evaluated using confirmatory factor analysis (CFA), reliability was estimated using Cronbach's alpha, convergent and divergent validity was assessed using correlations with the Children's Global Assessment Scale (C-GAS) and the ADHD Rating Scale-IV (ADHD-RS-IV).

Results: CFA supported the original factor structure of the questionnaires, both a first-order and a second-order model revealed acceptable model fit. Internal consistency was satisfactory across domains. The parent-adolescent agreement was moderate. The correlations between the C-GAS and the total scores of the WFIRS-P and WFIRS-S were low to moderate ($r = -0.29$ to -0.38). The ADHD-RS-IV correlated moderately ($r = 0.49$) with WFIRS-P, the correlation with WFIRS-S was weak ($r = 0.28$) supporting divergent validity. In multiple regression analyses, the ADHD-RS total score was the strongest predictor of the total score in both the WFIRS questionnaires, with internalizing disorder showing an additional small contribution. Age, gender and full-scale IQ gave no additional contribution in explaining the variance.

Conclusions: The findings support the use of the Norwegian version of the WFIRS-S and the WFIRS-P in the evaluation of functional impairment in adolescents with ADHD.

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ADHD; adolescents; functional impairment; Weiss Functional Impairment Rating Scale; psychometric properties

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is defined as persistent developmentally age-inappropriate inattentiveness and/or hyperactivity-impulsivity [1]. It is a common neurodevelopmental disorder affecting approximately 5% of children and adolescents worldwide [2]. Comorbid conditions such as anxiety and depression disorders, oppositional defiant disorder, sleep disorder and learning disorders are common in this patient group [3,4]. The diagnosis is typically associated with underperformance in school, low self-esteem and reduced quality of life [5,6].

Even though both the DSM-5 [1] and the International Classification of Diseases (ICD-10) [7] emphasize the importance of assessing both clinical symptoms and functional impairment when diagnosing psychiatric disorders, systematic assessment of ADHD-related impairment has not yet become routine in clinical practice. When treating ADHD, the alleviation of symptoms is typically the main focus, although functional impairment may be the primary reason for referral [8]. Research addressing impairment in ADHD has found that functional impairment may persist after medical treatment [9–11], which may leave the patient vulnerable and with unresolved problems. Knowing that impairments typically vary with age and differ among patients [12–14], we need assessment tools that describe functional impairments related to ADHD, and are sensitive to treatment effects over time.

Several questionnaires that address ADHD-related functional impairment have surfaced during the last decades. The Impairment Rating Scale (IRS) [15], the Barkley Functional Impairment scale (BFIS) [16] and the ADHD-FX [17] are all questionnaires that assess impairment from a parent's or teacher's perspective, but none of them include a collaborative patient report. We regard this as a limitation when

CONTACT Anne-Lise Juul Haugan anne-lise.j.haugan@ntnu.no RKBU Mid-Norway, NTNU, P.O. Box, 8905, 7491, MTFS, Trondheim, Norway

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working with adolescents, since discrepancies have been found in the ratings of psychopathology between parents and this specific patient group [5].

The Weiss Functional Impairment Rating Scale (WFIRS) is, to our knowledge, the only questionnaire that comprises both a comprehensive parent report and a self-report for the assessment of functional impairment in adolescents with ADHD, and it is commonly used both in research and practice [18,19]. The questionnaires cover six to seven domains related to family, learning and school, work, life skills, child/adolescents' self-concept, social activities and risky activities. Both parent and self-report have been validated in multiple cultures, and are available in 19 different languages, including Norwegian [18]. The examination of factor structures in WFIRS-P using CFA has supported different model solutions. One study [20] found support for both a first-order correlated factors model with five a priori expected factors (excluding the risky activities domain, considered by the authors to be more representative of disruptive behavior), a second-order hierarchical model (including first-order factors and an overall impairment factor) as well as a bifactor model (a general factor and group factors compete equally in explaining the item variance). Other studies have presented acceptable model-fit for a six factor-model [19], and a seven-factor model with school divided into separate learning and behavior domains [21].

The above-mentioned studies have found acceptable internal reliability for all domains except for the risky activities' domain in one study [21]. Test–retest reliability have shown strong correlations between ratings across varying time assessments [19,21]. Former studies have found statistically significant, low to moderate correlations between the total and domain scores on the WFIRS-P and the ADHD-RS-IV, the C-GAS and the Pediatric Quality of Life Inventory (PedsQL)[19–21]. Tarakçioğlu with colleagues [21] found strong associations ($r > 0.6$) between the total score on the WFIRS-P and the C-GAS on the one hand and the Clinical Global Impression Severity (CGI-S) on the other hand, supporting convergent validity.

Validation studies of the WFIRS-S using CFA have confirmed a seven-factor solution [22,23], as well as strong internal consistency for the total score and acceptable to a good consistency for the different domains [22–25]. One study found low to moderate cross-informant reliability between a student sample and collateral reporters on a revised collateral version [25]. The WFIRS-S has shown a moderate correlation with the Global Assessment Functioning (GAF) and Conners Adult ADHD Rating Scale (CAARS) on most domains [22]. The WFIRS-S domains and total score have shown good discriminant ability differentiating between ADHD and non-ADHD populations. Both the WFIRS-P and the WFIRS-S have demonstrated sensitivity to treatment effects [20,26–28].

The implementation of the WFIRS-S and-WFIRS-P in our clinic and its inclusion in a randomized controlled trial (RCT) of group Cognitive Behavior Therapy (CBT) for adolescents with ADHD [29] demanded examination of the psychometric properties of the Norwegian version of the WFIRS questionnaires. A current review of published WFIRS studies [18] includes results from child and adult populations, but none of the published validation studies to date have included clinically referred adolescents with ADHD. Our aim was thus to provide evidence for the utility of the WFIRS questionnaires in the examination and treatment of functional impairment related to ADHD in adolescence. We wished to examine the psychometric properties of the Norwegian version of the WFIRS-S and the WFIRS-P assessing construct validity, internal reliability and convergent validity. We expected an acceptable model fit for a first-order correlated factors model, with a six-factor solution in WFIRS-P and a seven-factor solution in WFIRS-S in line with the structure of the original scale and previous findings [19,22,23,30]. We also anticipated an acceptable model fit for a second-order hierarchical model, with an overall impairment factor in addition to the first-order factors, as in a previous study [20]. We further expected the internal reliability to be acceptable across domains. Cross- informant reliability between the questionnaires' corresponding total and domain-scores was expected to be low to moderate as found in previous studies [25,31]. As the WFIRS was originally developed as a measure of functional impairment related to ADHD, we anticipated a stronger association between the total and domain scores of the WFIRS-P with the total and subscale scores of the ADHD-RS-IV, than with internalizing disorder (including DSM-IV anxiety and/or depressive disorders), thus supporting discriminant validity. The association between the total score of the WFIRS-P and the C-GAS, another measure of functional impairment, was expected to be high, possibly supporting convergent validity. Furthermore, we wanted to explore the effect of age, gender and IQ in explaining the variance in the WFIRS-P and WFIRS-S total and domain scores.

Method

Participants

Totally 102 patients (14–18 years) were recruited from Child and Adolescent Psychiatric (CAP) Outpatient Clinics in Mid-Norway from April 2017 to April 2019 for this observational study. 88 patients (86%) were included in an ongoing RCT of group CBT for adolescents who still have impairing symptoms after medication [29]. In addition, we assembled questionnaires from 14 patients with ADHD of the same age, mostly from other catchment areas than the RCT study took place, but otherwise with similar characteristics. 93% of this population was medicated for ADHD, 14.3% had comorbid internalizing disorder and 7.1% had comorbid externalizing disorder. Inclusion criteria for the RCT were: a diagnosis of ADHD according to DSM-IV [32] and a CGI-S score of 3 or above (mildly ill or greater) after medical treatment [33]. The patients should use medication, but could be included in the RCT if they had tried medication with little effect or experienced intolerable side effects. The diagnostic process included information from multiple informants (patients, parents and teachers). After a first assessment of emotional and behavioral problems using the Achenbach Symptom Checklists [34], ADHD symptoms were evaluated using the

ADHD-RS-IV [35] in a parent interview. In addition, the patients were examined for ADHD symptoms and comorbid psychiatric disorders by the first and last authors, using the Kiddie Schedule for Affective Disorders and Schizophrenia for School-Aged Children -Present and Lifetime Version (Kiddie-SADS-PL) [36]. Patients with mild to moderate internalizing and comorbid externalizing disorders (other than ADHD) were included in the study. Exclusion criteria for all participants included mental retardation, severe suicidal behavior, psychotic symptoms and moderate to severe autistic disorders. IQ scores were obtained by using the Wechsler Intelligence Scales for Children (WISC-IV) [37] or Adults (WAIS-IV) [38].

Instruments

Weiss functional impairment scale

The WFIRS-S was available in Norwegian at the start of the present study (www.helsebiblioteket.no/psykisk-helse/skaringsverktoy/wfirs-s-weiss-functional-impairment-rating-scale-self-report). The last author of the present study initiated the translation of the parent version (WFIRS-P). A professional forward-backward procedure was adopted. Margaret Weiss approved the final version in June 2016. The WFIRS-P consists of 50 items divided into six domains: family, school, life skills, self-concept, social and risk. The WFIRS-S includes 69 items divided into seven domains; it includes work as a separate domain in addition to the domains mentioned above. The WFIRS-P and WFIRS-S are not parallel forms, but there are many parallel items. Each item employs a four-point Likert rating scale from zero (never or not at all) to three (very often, very much). In addition, each item can be rated as 'not applicable' by the responder if it is considered irrelevant. Mean scores were calculated, omitting items with a missing or 'not applicable' response, to produce the different domain scores and a total score. A higher score on each domain and on the total mean score indicates greater functional impairment. Clinicians can consider any domain with a mean score > 1.5, two items with a score ≥ 2, or one item with a score $= 3$ as impaired [30].

ADHD Rating Scale-IV

The ADHD-RS-IV [35] is an instrument intended to measure the severity of ADHD symptoms. The instrument comprises 18 items, nine of which cover inattention and nine of which are related to hyperactivity-impulsivity. Each item is rated on a four-point Likert scale, with a high score indicating a more severe problem. A total score was computed for the sum of the scores on all 18 items, and subscale scores were computed for the sum of the inattention items (Inattention subscale) and the hyperactivity-impulsivity items (Hyperactive subscale). The instrument has shown acceptable psychometric properties including inter-rater reliability, test–retest reliability, internal consistency, factor structure, convergent and divergent validity, discriminant validity, and responsiveness to treatment effects [39,40].

Children's global assessment scale (C-GAS)

The C-GAS is a general measure of functional impairment of adaptive functioning, ranging from 0 to 100 (low to high functioning). A clinician typically scores the C-GAS based on all available clinical information [41]. In a recent review of Scandinavian versions of the C-GAS [42] the authors found satisfactory evidence for convergent, discriminant, and predictive validity, as well as interrater reliability. The C-GAS has shown a good ability to differentiate between different patient groups and shown sensitivity to treatment effects [43,44].

Wechsler intelligence test for children and adults (WISC-IV/WAIS-IV)

The WISC-IV is an intelligence scale for children aged 6–16. The WAIS-IV is an intelligence scale for adolescents and adults 16 years of age and above. Both scales are considered the 'gold standard' of intelligence testing. The scales generate four index scores that individually rate verbal comprehension, perceptual reasoning, working memory and processing speed. In addition, a total IQ score (FIQ) that represents a general intellectual ability is calculated. The WISC-IV test has shown good psychometric properties with high internal consistency for the four indices and the total IQ scale. The associations between the total IQ score and the lower order indices across different age groups, have been high, the test–retest reliability coefficients high to medium. CFA has shown good model-fit for the four factors, as well as a higher-order overall IQ factor [37,45]. The WISC-IV total IQ score has shown good convergent validity with other measures of intelligence (WISC-III, Wechsler Abbreviated Scale of Intelligence [WASI]) [37]. CFA analyses have also confirmed a good model fit for the factor structure of the WAIS-IV, internal reliability has been acceptable to excellent, and the construct validity is supported, with strong associations with another measure of intellectual ability (WAIS-III) [38]. The total IQ score (FIQ) was used in the present study.

Procedure

All participants included in the RCT provided informed consent and completed the WFIRS-S at the CAP clinic. The non-RCT participants received a document explaining the purpose of the WFIRS-study. These participants responded to the WFIRS questionnaire anonymously on a visit with their clinician. The data were sent to the last author without an identifiable id. One of the parents, most frequently the biological mother (72%), completed the WFIRS-P simultaneously. All questionnaires were completed prior to CBT treatment. The C-GAS was scored by experienced clinicians for the non-RCT patients, and by the first and last authors for the RCT group. The study was conducted according to the principles set forth in the Declaration of Helsinki.

Statistical analyses

Spearman correlation coefficients were used to measure the relationships between the WFIRS-P and WFIRS-S domain scores with each other and with the total scores (internal validity), as well as in the analyses of cross-informant reliability and convergent validity. Spearman correlations were used because the variables were non-normally distributed. Normality of the data was evaluated by visual inspection of QQ-plots. We regard correlation coefficients between 0.10 and 0.29 as low, correlations between 0.30 and 0.49 as moderate, and correlations of 0.50 and above as high [46]. Raw scores on the WFIRS were converted to mean scores for each domain and a total mean score for all the included items.

Missing values were handled using available case analyses; that is, each analysis included the cases that included the data required for the analysis. We report 95% confidence interval (CI) where relevant and regard two-sided p-values $\leq$ 0.05 as significant. Statistical analyses were conducted using SPSS 25 and Mplus8.

Construct validity

CFA for ordinal categorical variables were conducted to confirm the conceptual framework of the WFIRS-P and the WFIRS-S. We used the estimator WLSMV (weighted least square estimator with robust standard errors and mean- and variance-adjusted chi-square test statistic), which is the default estimator in Mplus for this setting. We applied a first-order correlated factors model with six and seven domains in the WFIRS-P and WFIRS-S, respectively, as factors. We also carried out a second-order hierarchical factor analysis including the factors of WFIRS-S and WFIRS-P individually, to look at the factor loadings on a global total factor. Goodness of fit was assessed based on the following: The chi- square value (χ^2) was considered relative to its degrees of freedom (df). The value should be as small as possible, values between 2 and 3 was considered 'good' and 'acceptable', respectively [47]; in addition, a root mean square error of approximation (RMSEA) less than 0.08, a comparative fit index (CFI) and Tucker Lewis Index (TLI) $\geq$ 0.95 were used in line with recommendations [48]. Among the 50 items in WFIRS-P, four items (item 4 and 5 in the school behavior domain and item 6 and 10 in the risk domain) caused unstable results in the CFA due to their low variance (>98% of the parents rated these items 0 = not a problem or not applicable). The CFA was thus conducted with the remaining 46 items (see the response distribution of the items in WFIRS-P in Supplementary Table S5).

A CFA was not possible to carry out with 69 items on the WFIRS-S. Hence, 12 items (item 2 in the family domain, items 4 and 5 in the work domain, item 6 in the life skills domain, and items 1–3, 6, 8, and 10–12 in the risk domain) were omitted because of the high rate (>50%) of 'not applicable' responses (not relevant due to the young age of the participant or to other circumstances) and/or low variance (many 0 = 'never or not at all a problem' responses). (See the response distribution of the items in WFIRS-S in Supplemental Table S6). The CFA was subsequently conducted for the remaining 57 items.

Reliability

Cronbach's alpha coefficients were used to assess internal consistency in each domain and for the total scores on the WFIRS-S and WFIRS-P. A coefficient of at least 0.7 was regarded as acceptable to confirm consistency [49]. In the WFIRS-S several items in four domains had low variance (high response rate with zero scores = not a problem) or a high percentage (>50%) of 'not applicable' responses. In the family domain, we therefore analyzed internal consistency first with all items included, and then with the exclusion of item 2: 'Problems with spouse/partner'. In the work domain we used the same procedure, first including all items and then excluding item 4:' Problems keeping a job' and item 5: 'Getting fired from work'. We also first included all items in the life skills domain, and then excluded item 6: 'Problems with sex' for comparison. In the risky activities domain, we omitted item 3: 'Road rage', item 6: 'Being involved with the police', item 8: 'Smoking marihuana' and item 10: 'Taking street drugs' in the initial analyses due to low variance (mainly zero scores). Last, we removed three additional items because of the high response rate (>50%) of not applicable responses: item 1: 'Aggressive driving', item 2: 'Doing other things while driving' and item 11: 'Sex without protection'.

Cross-informant reliability

Spearman's correlations were computed to assess whether the six and seven domains and the total score on WFIRS-P and WFIRS-S were associated with each other.

Convergent validity

Convergent validity refers to the degree to which two measures or constructs that should be related theoretically, are in fact related. Spearman correlations were computed to assess the convergent validity of the WFIRS-P and WFIRS-S total and domain scores and the C-GAS score, individually. Convergent validity is sometimes claimed if the correlation coefficient is above 0.50, although above 0.70 is usually recommended [50].

Divergent validity

We examined the association between the ADHD-RS-IV total and subscale scores with the total and domain scores on the WFIRS-P and WFIRS-S individually using Spearman correlations.

We used multiple linear regression to analyze the association between ADHD-RS-IV total score (independent variable) and the WFIRS-P and WFIRS-S total scores (dependent variable) separately, adjusting for gender, age, IQ score and internalizing psychiatric disorders, to see if these covariates had an additional impact on the association between the dependent and independent variable. All covariates were regarded as potential confounders. Internalizing psychiatric disorders included DSM-IV diagnoses of an anxiety disorder and/or a

depressive disorder. Psychiatric comorbidity was regarded as a categorical variable (0 = none, 1 = internalizing disorder).

Results

Sample characteristics

The participants were aged 14–18 years ($M = 15.4$, SD = 1.2). 52% were females. 95 (93%) of the participants were on a psychostimulant or non-stimulant ADHD medication when completing the questionnaires. The mean ADHD-RS-IV total score was 23.9 (SD = 9.1), the mean Inattention subscale score was 14.8 (SD = 5.1) and the mean Hyperactivity subscale score was 9.2 (SD = 5.6). 35 patients (34.3%) had a comorbid internalizing disorder, four patients (3.9%) had externalizing disorder (DSM-IV diagnosis of oppositional or conduct disorders), and 15 patients (14.9%) had a comorbid somatic disorder requiring medical attention such as diabetes, epilepsy and migraine. Five patients (4.9%) had been prescribed sleep medicine. The FIQ was 93.5 (±12.9). The mean score on the CGAS was 62.5 (SD = 7.1).

Construct validity

See Supplementary Table S1 for results from the CFA analysis. 46 of the items in the WFIRS-P were entered in the CFA item to factor model. The goodness of fit indices for the six factors were: $\chi^2/df = 1277/974 = 1.3$, CFI = 0.89, TLI = 0.88, RMSEA= 0.06 [95% CI: 0.05–0.06]. The fit indices for the second-order model were: $\chi^2/df = 1313/983 = 1.3$, CFI = 0.88, TLI = 0.87, RMSEA= 0.06 [95% CI: 0.05–0.07]. Standardized item to factor loadings were all significant ($p < 0.01$) and ranged from 0.30 to 1.0. The factor loadings with the overall global factor ranged from 0.62 to 0.87.

Regarding WFIRS-S, 57 of the items were entered in the first-order solution with seven factors. The goodness of fit indices were: $\chi^2/df = 2062/1518 = 1.4$, CFI = 0.90, TLI = 0.89, RMSEA= 0.06 [95% CI: 0.05–0.07]. The fit indices for the second-order model were: $\chi^2/df = 2174/1532 = 1.4$, CFI = 0.88, TLI = 0.87, RMSEA= 0.06 [95% CI: 0.06–0.07]. The item to factor loadings ranged from 0.47 to 0.97 and the different factor loadings with the overall global factor ranged from 0.66 to 0.88. Two out of four fit indices were indicative of good/acceptable model fit in all of the CFA analyses. The CFI and TLI were under recommended cut off. Thus, the results yield acceptable support for both a first- order, and a second-order model for both questionnaires.

Reliability

Cronbach's alpha coefficients on the domains and total scores are provided in Table 1. The domains in the WFIRS-P showed acceptable to good internal consistency ($\alpha > 0.71$) except life skills ($\alpha = 0.66$). All domains in the WFIRS-S showed good internal consistency with all items included ($\alpha > 0.79$). Analyses excluding items with low variance and high not applicable score (>50%) yielded comparable results ($\alpha > 0.71$). The overall internal consistency was thus satisfactory.

In WFIRS-P the correlations between the domains and the total score were all significant and moderate to high ($r = 0.52$–0.77). The inter-domain correlations were also significant and varied from low to high ($r = 0.23$–0.60). We found high correlations between the self-concept and the social domain and the family and risk domain (see results in Supplementary Table S2).

In WFIRS-S the correlations between the domains and the total score were all significant and high ($r = 0.63$–0.81), and the inter-domain correlations were all moderate to high ($r = 0.31$–0.70). We found high correlations between the work and school domain and the school and life-skills domain. We also found strong correlations between the social activities' domain and the self-concept, school and family domains respectively (see Supplementary Table S3).

Mean scores on the WFIRS-P and WFIRS-S

Table 2 shows the mean scores and standard deviations for each domain and the total scores on the WFIRS-P and the WFIRS-S. The mean total score on the WFIRS-P was 0.77. The domains with the highest impairment scores were self-concept and life skills. The risk domain had the lowest mean score. The mean total score on the WFIRS-S was 0.81. The domains with the highest impairment scores were self-

Table 1. Internal consistency for the WFIRS-P and the WFIRS-S.

	WFIRS-P			WFIRS-S		
Domain	Number of items	α	*n*	Number of items	α	*n*
Family	10	0.89	94	8 (7)	0.85 (0.84)	21 (62)
Work	0	–	–	11 (9)	0.79 (0.85)	19 (52)
School	10	0.75	85	10	0.87	90
Life skills	10	0.66	83	12 (10)	0.89 (0.83)	20 (86)
Self-concept	3	0.86	100	5	0.93	98
Social activities	7	0.81	95	9	0.87	86
Risky activities	10	0.71	95	10 (7)	0.84 (0.71)	18 (46)
Total	50	0.90	67	65 (57)	0.96	16

WFIRS-P: Weiss Functional Impairment Rating Scale-Parent form; WFIRS-S: Weiss Functional Impairment Rating Scale Self-report; *n*: number; α: Cronbach's alpha. The WFIRS-S Risky activities domain was initially analyzed omitting 4 items due to low variance, numbers in parentheses are analyses where items with more than 50% missing/not applicable answers were omitted from the analyses, available case analyses.

Table 2. Mean domain scores of the WFIRS-P and WFIRS-S.

	WFIRS-P			WFIRS-S		
Domains	Number of items	Mean (SD)	*n*	Number of items	Mean (SD)	*n*
Family	10	0.78 (0.56)	102	8	0.79 (0.60)	102
Work	–	–	–	11	1.00 (0.69)	81
School	10	0.87 (0.54)	102	10	0.98 (0.64)	102
Life skills	10	1.03 (0.51)	102	12	0.96 (0.57)	102
Self-concept	3	1.07 (0.81)	101	5	1.03 (0.92)	101
Social activities	7	0.60 (0.57)	102	9	0.61 (0.55)	102
Risky activities	10	0.24 (0.35)	102	14	0.33 (0.33)	91
Total	50	0.77 (0.38)	102	69	0.81 (0.47)	102

WFIRS-P: Weiss Functional Impairment Rating Scale-Parent form; WFIRS-S: Weiss Functional Impairment Rating Scale Self-report. WFIRS-P and WFIRS-S mean scores represent the mean of answered questions.

concept, work and school. The lowest score was found for the risk domain.

Cross-informant reliability

The Spearman correlations between the corresponding domains and the total scores of the WFIRS-P and the WFIRS-S were all statistically significant, the effect sizes were moderate and, in most cases, stronger than for the non-corresponding domains. Between the non-corresponding domains, we found moderate correlations between the WFIRS-P risk and the WFIRS-S family domain, the WFIRS-P social activities and the WFIRS-S self-concept domain, the WFIRS-P life skills and WFIRS-S school domain, and the WFIRS-P school and WFIRS-S work domain. The results are presented in Table 3.

Convergent validity

The Spearman correlations between the C-GAS and the WFIRS-P total and domain scores were all weak ranging from $r = -0.07$ to -0.26. Correlations between the C-GAS and WFIRS-S total and domain scores were low to moderate. Both the social activities, the family and the school domains showed moderate correlations with the C-GAS, hence the convergent validity was weak (see results in Table 4).

Divergent validity

Table 4 shows the correlations between the WFIRS-P and the WFIRS-S total and domain scores with the ADHD-RS-IV score, Internalizing disorder and IQ score. The WFIRS-P total score correlated moderately with the ADHD RS total score, as well as the Inattentive and Hyperactive subscales. The correlations between the ADHD-RS-IV total score and the WFIRS-P domain scores were all significant and low to moderate, except the self- concept domain that was non-significant. Overall, the results were below 0.5 supporting divergent validity.

Internalizing disorder showed a moderate correlation with the self-concept domain in WFIRS-S, and a significant, but weak correlation with self-concept and risky activities in WFIRS-P. FIQ showed a low, but significant association with the Life skills domain in both WFIRS-S and WFIRS-P, but none of the other domains.

In multiple regression analyses, the ADHD-RS-IV total score was the best predictor of the variance in both the WFIRS-P and WFIRS-S total scores respectively (standardized $\beta = 0.53$, 0.32, $p < 0.05$), with internalizing disorder providing an additional small contribution ($\beta = 0.22$, 0.26, $p < 0.05$).

Table 3. Spearman correlations between WFIRS-S and WFIRS-P domain scores, (*n*).

	WFIRS-P						
WFIRS-S	Family	School	Life skills	Self-concept	Social	Risk	Total
Family	0.54** (101)	0.23* (101)	0.23* (101)	0.22* (100)	0.27** (101)	0.39** (101)	0.42** (101)
Work	0.11 (81)	0.310.** (81)	0.27* (81)	0.21** (81)	0.22* (81)	0.29** (81)	0.31** (81)
School	0.25* (102)	49** (102)	0.320.** (102)	0.22* (101)	0.26*(102)	0.25* (102)	0.40** (102)
Life skills	0.19 (102)	0.21* (102)	0.44** (102)	0.30** (101)	0.29** (102)	0.12 (102)	0.40** (102)
Self-concept	0.21* (101)	0.23* (101)	0.29** (101)	0.54** (100)	0.32** (101)	0.18 (101)	0.47** (101)
Social	0.25* (102)	0.19* (102)	0.24* (102)	0.34** (101)	0.57** (102)	0.26** (102)	0.48** (102)
Risk	0.30** (91)	0.14* (91)	0.26* (91)	0.27** (91)	0.28** (91)	0.39** (91)	0.36** (91)
Total	0.31** (102)	34** (102)	0.38** (102)	0.39** (102)	0.40** (102)	0.25* (102)	0.51** (102)

WFIRS-S: Weiss Functional Impairment Rating Scale-Self-report; WFIRS-P: Weiss Functional Impairment Rating Scale Parent-report.
*$p < 0.05$. **$p < 0.01$.

Table 4. Spearman correlations between the WFIRS-S and WFIRS-P domain and total scores, with ADHD RS IV, C-GAS, IQ and internalizing disorders.

	ADHD Total	n	ADHD Inattentive	n	ADHD Hyper	n	C-GAS	n	Intern. disorder	n	FIQ	n
WFIRS-S domains												
Family	0.37**	98	0.22*	99	0.39**	100	−0.38**	101	0.17	101	−0.09	89
Work	0.20	78	0.27*	79	0.09	80	−0.15	81	0.07	81	0.01	71
School	0.19	99	0.30**	100	0.07	101	−0.32**	102	0.08	102	0.07	90
Life skills	0.17	99	0.27**	100	0.06	101	−0.22*	102	0.19	102	0.25*	90
Self-concept	0.19	98	0.26**	99	0.08	100	−0.28**	101	0.33**	101	0.18	89
Social activities	0.26**	99	0.16	100	0.28**	101	−0.41**	102	0.18	102	0.05	90
Risky activities	0.28**	88	0.18	89	0.28**	90	−0.18	91	0.02	91	0.03	80
Total	0.28**	99	0.31**	100	0.18	101	−0.38**	102	0.23*	102	0.11	90
WFIRS-P domains												
Family	0.55**	99	0.36**	100	0.54**	101	−0.18	102	−0.01	102	0.03	90
School	0.35**	99	0.47**	100	0.16	101	−0.26**	102	0.08	102	−0.08	90
Life skills	0.36**	99	0.47**	100	0.20*	101	−0.07	102	−0.01	102	0.24*	90
Self-concept	0.19	98	0.21*	99	0.09	100	−0.17	101	0.29*	101	0.14	89
Social activities	0.24*	99	0.17*	100	0.23*	101	−0.25*	102	0.14	102	−0.14	90
Risky activities	0.48**	99	0.32**	100	0.47**	101	−0.07	102	−0.23*	102	−0.11	90
Total	0.49**	99	0.45**	100	0.37**	101	−0.29**	102	0.15	102	0.04	90

WFIRS-S: Weiss Functional Impairment Rating ScaleSelf-report; WFIRS-P: Weiss Functional Impairment Rating Scale Parent-report; ADHD: ADHD RS IV total score, inattention score and hyperactive/impulsive score, Internalizing disorders: DSM-IV diagnoses of anxiety or depression; FIQ: Full scale IQ from the Wechsler Intelligence Scale for Children or adults (WISC-IV/WAIS-IV); n: number.
*$p < 0.05$; **$p < 0.01$.

Gender, age and IQ gave no additional contribution to explaining the variance in the WFIRS-P overall score. The IQ score showed a small nonsignificant effect ($\beta = 0.17$, $p = 0.10$) in explaining the variance in WFIRS-S. Gender and age had no additional effect on the total variance (see supplemental Table S4).

Discussion

The evaluation of functional impairment in addition to symptoms is imperative for identifying ADHD, guiding treatment planning and evaluating outcome. The aim of this study was to evaluate the psychometric properties of the Norwegian version of the WFIRS-S and WFIRS-P in an adolescent ADHD population. A second aim was to examine the questionnaires' clinical utility in the assessment of functional impairment in this patient group. Overall, the findings support the scale construction, the internal reliability and divergent validity of the Norwegian adaptation of both the WFIRS-S and the WFIRS-P. However, the fit of the model was not optimal. When we examined the score distribution of the items in the WFIRS questionnaires, four items were removed from the WFIRS-P and twelve items were removed from the WFIRS-S due to the high rate of 'not applicable' responses and/or a 'floor effect'. These items were mainly from the family, work and risk domains and were considered 'not applicable' largely because of the young age of our sample (mean age 15.4 years). Many of the behavior and risk-related items are considered more relevant for adolescents with conduct disorders, a group underrepresented in our study population. Knowing that the inclusion of these items would improve the instruments clinical value when relevant, led us to keep them in the Norwegian version.

Both a first-order CFA of the six-factor structure of the WFIRS-P and a seven-factor structure of the WFIRS-S, as well as a second-order model with the respective factors loading on a global impairment factor revealed satisfactory results. Chi-square values and RMSEA provided a good model fit, but the TLI and CFI values were below cut off values (borderline range) on both questionnaires. The item-to-factor loadings were all above 0.30 which is the minimum standard of item-convergent validity [51]. The results support the original factor structure in the questionnaires and are in line with validation studies in other languages [19,21–24]. For clinical practice, we suggest the first-order solution to be the more relevant model, since the inspection of impairment across different domains is useful both for diagnostic purposes, as well as targeting treatment intervention for the individual patient. The use of a more narrowband measure also makes it easier to adjust treatment over time, knowing that impairment may shift in different areas for multiple reasons. The use of a global impairment factor may be more relevant in research, measuring treatment effects on a more global scale.

The WFIRS-P showed acceptable internal consistency ($\alpha = 0.71$–0.89) across domains except in the case of the life skills domain ($\alpha = 0.66$). All domains in the WFIRS-S showed good internal consistency. The inter-domain correlations in the WFIRS-P were low to high, while they were moderate to high in the WFIRS-S. The correlations between the domains and the total scores were moderate to high in both questionnaires. Thus, the overall internal consistency of both questionnaires was satisfactory.

The total mean scores on the WFIRS-S and the WFIRS-P were 0.81 and 0.77, respectively. A mean score above 0.65 is an appropriate threshold for differentiating between an ADHD and a normative population [52]. All the domains in the WFIRS-P and WFIRS-S were above this threshold, except the social activities and risk subdomains, which were in the normal range in both questionnaires. These domains were thus less sensitive in revealing functional impairment in our study population. This may be caused by population bias; more research is needed to explore this further.

On the WFIRS-P, the parents reported the highest impairment scores in the life skills, self-concept and school domains, whereas risk received the lowest mean score. The adolescents (WFIRS-S) reported the highest impairment in the self-concept, work, and school domains and the lowest impairment in the risk domain. This is consistent with clinical research demonstrating that ADHD is highly related to functional impairment in the school arena as well as affecting adolescents' self-esteem [5,6]. This pattern in WFIRS-S is similar to patterns presented in American, French and Japanese validation studies of college students and adults with ADHD [22,24,25]. Unfortunately, there are no comparable studies to date of clinical adolescent ADHD populations; however, a WFIRS-S validation study of Iranian adolescents with no ADHD found results similar to ours, with self-concept being the most impaired domain [23]. The mean score in the Iranian population was lower than the mean score in our ADHD sample (0.45 versus 1.0). Even though the results are not directly comparable, this pattern may imply that ADHD symptoms act as an additional risk factor for low self-esteem.

The impairment scores in our adolescent population are similar to the scores reported for American college students with ADHD [25]. The French and Japanese validation studies presented higher impairments scores in their adult populations [22,24]. Reasons for this may be that our sample was younger in age, and under treatment for ADHD at the time of assessment. The importance of psychosocial interventions, including the support of family, teachers and friends with knowledge about ADHD, the implementation of support measures at school, and not least, medical treatment, may all be important contributors to this finding. The discrepancy related to age may also reflect the advantage of being diagnosed in childhood as this may prevent severe comorbid disorders from developing over time and producing accompanying functional impairments. The results nonetheless support a common cross-cultural pattern in impairment profiles, with self-concept, school/work and family being the most affected domains irrespective of cultural disparities in patients with ADHD.

Considering cross-informant validity, we found a moderate agreement between the corresponding domains and total scores on WFIRS-P and WFIRS-S. In most cases the correlations were stronger for the corresponding than the non-

corresponding domains. In the study of Canu et al. 2016 [25] correlations between the responses of college students and collateral informants were low to moderate. A possible explanation for the moderate association in our study may be that the adolescents were living at home during the assessment, and therefore in closer contact with their parent informants.

We found a moderate correlation between the C-GAS score and the WFIRS-S total score, while the correlation with the WFIRS-P total score was low. In the Turkish validation study [21], the correlations between the C-GAS and the WFIRS-P total and domain scores were moderate to high. In our study, a clinician scored the C-GAS on the basis of a Kiddie-SADS-PL interview with the adolescents, which may explain the higher concordance with the WFIRS-S than the WFIRS-P score. The use of different informants with clinicians scoring C-GAS versus parent and adolescents' scoring WFIRS, may also be a possible explanation for the weak correlation. Our finding, as it stands, thus provides limited convergent validity between the WFIRS measures and the C-GAS. We suggest the instruments measure different concepts, with the CGAS representing a more generic measure of overall clinical severity, rather than specific impairment related to ADHD. More studies are needed to further explore this finding.

The WFIRS-P total score showed moderate correlations with the ADHD-RS-IV total score as well as the Inattention and Hyperactivity subscale scores. The ADHD-RS-IV total score correlated significantly with all the WFIRS-P domains, except the self-concept domain. The Inattentive subscale showed strong correlations with the school and life skills domains. The Hyperactive subscale correlated strongly with the family, risk and social domains. A similar pattern is referred in other studies [21,25], although some also found a strong association between the Hyperactivity subscale and the school and learning domains [19,25]. The relatively low hyperactivity score in our clinical sample (probably due to the effect of medication) may explain this discrepancy. Overall, we find that the constructs measured by the ADHD-RS-IV and the WFIRS have something in common; nonetheless, the instruments seem to measure different aspects of function that do not overlap, supporting divergent validity.

The ADHD-RS-IV total score was the best predictor of the overall score in both WFIRS-P and WFIRS-S controlling for IQ, age, gender and internalizing disorder. Only internalizing disorder (comprising both anxiety and depression disorders) showed an additional small and significant contribution in both measures. A previous validation study reported moderate correlations between depression and WFIRS-S total and domain scores in an adult ADHD population [24]. In our clinical population, anxiety disorder was the most common comorbid internalizing disorder. Depression is a more impairing condition for general functioning than anxiety disorder, which could explain the stronger correlations in the adult study.

Some limitations should be considered when interpreting the results. First, 86% of our population was included in an ongoing RCT of group CBT for adolescents treated for ADHD [29] and adolescents with comorbid externalizing disorders (other than ADHD) were underrepresented in our total population ($n = 4$). Second, 93% of the total sample was on stable stimulant or non-stimulant medication. The effect of medical treatment could have reduced behavior problems for some adolescents to below the cut-off for externalizing disorders. Medication also have a significant impact on the level of ADHD symptoms, making this population better functioning than non-medicated patients. As the WFIRS impairment scores represent function after the initiation of medical treatment, our findings are not representative of all adolescents with ADHD in clinical practice. Third, a high proportion of the participants (52%) were females. Although this is considered a strength in our RCT, the high female proportion may have had an impact on the prevalence of the externalizing and behavior problems, since girls with ADHD generally present less behavior problems and more internalizing problems than boys [53,54]. Furthermore, our population was restricted to adolescents 14–18 years of age in mid-Norway, the results may not be representative of younger or older age groups, nor may the population be equally representative of the population at large.

Finally, several items in the family, work and risk domains were considered irrelevant or 'not applicable' because of the young age of our sample. This may represent a bias in the calculation of overall scores. We therefore recommend calculating the mean scores of relevant domain items and the overall score, or simply inspecting the score profiles in the different domains when evaluating these patients in clinical practice. The age limit for driving is 18 in Norway and getting work and holding a job before the age of 18 is relatively rare. One can therefore preferably omit the work domain in clinical practice with younger patient groups. Future research should investigate WFIRS scores in adolescents with ADHD prior to treatment. The use of adjusted norms for different age groups would also be preferable.

Conclusion

Despite limitations, the overall results of this study suggest the Norwegian WFIRS-P and the WFIRS-S have acceptable psychometric properties. Our findings support both a first-order, item to factor solution, as well as a second-order model, with a general construct of functional impairment in addition to specific domain constructs. The internal reliability was acceptable and the cross-informant reliability was moderate. The convergent validity with C-GAS was weaker than expected, the correlations with ADHD RS were as expected, supporting divergent validity.

We regard the WFIRS questionnaires as useful in the examination of functional impairment in patients with ADHD and comorbid disorders.

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Notes on contributors

Anne-Lise J. Haugan, clinical neuropsychologist and a PhD student. Her main research interests are functional impairment and treatment of ADHD in children and adolescents.

Anne Mari Sund, MD, PhD and professor of Child and Adolescent Psychiatry. Her primary research areas include anxiety, depression and epidemiological studies in children and adolescents.

Per Hove Thomsen, MD, PhD and professor of Child and Adolescent Psychiatry and head of the research unit. PHT's primary area of research is ADHD and OCD in children and adolescents. PHT is child and adolescent editor of NJP.

Stian Lydersen, PhD, professor of medical statistics. He is one of the authors of the books "Medical Statistics in Clinical and Epidemiological Research" (2012) and "Statistical Analysis of Contingency Tables" (2017). Since 2008, he has been the methodological adviser for The Annals of Rheumatic Diseases. His research area is longitudinal epidemiological studies and clinical trials.

Torunn Stene Nøvik, MD, PhD, is a Consultant Child and Adolescent Psychiatrist and Associate Professor. Her current clinical and research interests include the assessment and treatment of children and adolescents with ADHD and mood disorders.

ORCID

Anne-Lise Juul Haugan http://orcid.org/0000-0002-1838-1062
Stian Lydersen http://orcid.org/0000-0001-6613-8596
Torunn Stene Nøvik http://orcid.org/0000-0003-1179-5649

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Supplementary material: Paper I

Table S1. Confirmatory factor analyses of the WFIRS-P and WFIRS-S: Range of standardized factor loadings and fit statistics for the first- and second- order model

Domain	Items		WFIRS-P	WFIRS-S
Family	(7)	1	0.59-0.91	0.81-0.88
		2	0.58-0.92	0.80-0.88
Work	(9)	1	Not included	0.68-0.87
		2	in WFIRS-P	0.67-0.90
Learning and school	(10)	1	0.59-0.95	0.59-0.95
		2	0.59-0.95	0.59-0.96
Life skills	(11)	1	0.30-0.74	0.52-0.84
		2	0.33-0.73	0.51-0.84
Self -concept	(5)	1	0.87-0.91	0.87-0.97
		2	0.87-0.91	0.87-0.97
Social	(9)	1	0.62-1.0	0.56-0.82
		2	0.61-1.0	0.57-0.83
Risk	(6)	1	0.64-0.97	0.48-0.90
		2	0.63-0.97	0.47-0.90
Correlations between the latent factors		1	0.28-0.70	0.41-0.94
Correlations between the latent factors and the overall factor		2	0.62-0.87	0.66-0.88
Goodness of fit statistics				
χ^2		1	1277.45*	2062.84*
		2	1313.62*	2174.50*
df		1	974	1518
		2	983	1532
χ^2/df		1	1.3	1.4
		2	1.3	1.4
RMSEA		1	0.06 (0.05-0.06)	0.06 (0.05-0.07)
		2	0.06 (0.05-0.07)	0.06 (0.06-0.07)
CFI		1	0.89	0.90
		2	0.88	0.88
TLI		1	0.88	0.89
		2	0.87	0.87

Note, the analysis were conducted with 46 of the 50 items in WFIRS-P and 57 of the 69 items in WFIRS-S, *1*= First order model, *2*= Second- order model,χ^2=chi-square, *df* degrees of freedom, *RMESEA* root mean square error of approximation, *CFI* comparative fit index, *TLI* Tucker Lewis Index, Estimator WLSMV,
*p<0.001 two- tailed

Table S2. WFIRS-Parent Inter-domain correlations, Spearman`s rho (n= 102)

WFIRS-P	Family	School	Life skills	Self	Social	Risk
School	.37**					
Life skills	.43**	.40**				
Self-concept	.23*	.24*	.40**			
Social	.33**	.24*	.37**	.60**		
Risk	.50**	.31*	.30**	.25*	.31**	
Total	.61**	.55**	.69**	.77**	.76**	.52**

Note. WFIRS-P= Weiss Functional Impairment Rating Scale Parent-report, *p<.05. **p<.01

Table S3. WFIRS-Self Inter-domain correlations, Spearman`s rho (n=102)

Domains	Family	Work	School	Life skills	Self	Social	Risk
Work	.41** (81)						
School	.50** (101)	.70**(81)					
Life skills	.45** (101)	.55** (81)	.64**(102)				
Self	.34* (101)	.43**(81)	.48**(101)	.63**(101)			
Social	.53** (101)	.54**(81)	.57**(102)	.54**(102)	.58**(101)		
Risk	.41**(90)	.31**(75)	.44**(91)	.40**(91)	.53**(90)	.53**(91)	
Total	.63** (101)	.73**(81)	.79**(102)	.81**(102)	.80**(101)	.79**(102)	.64**(91)

Note. WFIRS-S= Weiss Functional Impairment Rating Scale Self-report. *p<.05. **p<.01

Table S4. Multiple linear regression analyses with WFIRS-P or WFIRS-S as dependent variable and ADHD-RS IV, sex, age, FIQ and Internalizing disorder as covariates. N=87

	ADHD RS IV	Sex	Age	FIQ	Internalizing disorder
WFIRS-P Total score	0.53**	0.07	0.06	0.04	0.22*
WFIRS-S Total score	0.32**	0.05	0.02	0.17	0.26*

Note. Standardized coefficients, *WFIRS-P* Weiss Functional Impairment Rating Scale-Parent, *WFIRS-S* Weiss Functional Impairment Rating Scale Self report, *ADHD-RS- IV ADHD Rating scale IV, FIQ Full scale IQ (WISC-IV/WAIS-IV). Internalizing disorder* includes a DSM-IV diagnoses of anxiety or depression, WFIRS-P and WFIRS-S are independent variables.
**p<0.01, *p<0.05

Table S5. The WFIRS-P item response distribution. English and Norwegian version

	Never 0	Sometimes 1	Often 2	Very often 3	n/a	missing	n
A. Family/ Familie							
1. Having problems with brothers & sisters 1. Problemer med brødre og søstre	24	47	14	13	4	0	102
2. Causing problems between parents 2. Skapt problemer mellom foreldre	41	40	15	0	6	0	102
3. Takes time away from family members' work or activities 3. Har tatt tid fra familiemedlemmers arbeid eller aktiviteter	25	51	17	8	1	0	102
4. Causing fighting in the family 4. Forårsaket krangel i familien	31	47	22	1	0	1	102
5. Isolating the family from friends and social activities 5. Isolert familien fra venner og sosiale aktiviteter	79	17	5	1	0	0	102
6. Makes it hard for the family to have fun together 6. Gjør det vanskelig for familien å ha det morsomt sammen	59	32	10	1	0	0	102
7. Makes parenting difficult 7. Gjør foreldrerollen vanskelig	31	39	26	5	0	1	102
8. Makes it hard to give fair attention to all family members 8. Gjør det vanskelig å gi like mye oppmerksomhet til alle familiemedlemmer	44	36	15	6	1	0	102
9. Provokes others to hit or scream at him/her 9. Provoserer andre til å slå eller rope til han/henne	52	39	9	1	1	0	102
10. Costs the family more money 10. Koster familien ekstra penger	58	29	10	5	0	0	102
B. School- learning/ Skole-læring							
1. Makes it difficult to keep up with schoolwork 1. Gjør det vanskelig å holde tritt med skolearbeidet	16	29	30	25	0	2	102
2. Needs extra help at school 2. Trenger ekstra hjelp på skolen	20	25	30	25	0	2	102
3. Needs tutoring 3. Trenger veiledning	13	35	28	24	0	2	102
4. Receives grades that are not as good as ability 4. Får karakterer som ikke er så gode som evnene tilsier	18	31	25	24	3	1	102
B. School- behaviour/Skole-atferd							
1. Causes problems for the teacher in the classroom 1. Skaper problemer for læreren i klasserommet	59	27	5	0	11	0	102
2. Receives "time-out" or removal from the classroom 2. Får "time-out" eller blitt tatt ut av klasserommet	73	13	3	0	13	0	102
3. Having problems in the school yard 3. Har problemer i skolegården	67	22	1	90	11	1	102
4. Receives detentions (during or after school) 4. Har måttet sitte igjen (under eller etter skoletid	90	2	0	0	9	1	102
5. Suspended or expelled from school 5. Blir suspendert eller utvist fra skolen	93	1	0	0	8	0	102
6. Misses classes or is late for school	56	23	9	10	4	0	102

6. Gått glipp av skoletimer eller kommet for sent							
C. Life Skills/Ferdigheter							
1. Excessive use of TV, computer, or video games 1. Overdreven bruk av TV/data eller TV-spill	17	31	21	33	0	0	102
2. Keeping clean, brushing teeth, brushing hair, bathing, etc 2. Problemer med personlig hygiene, tannpuss, børste håret, bade, etc.	65	20	12	4	1	0	102
3. Problems getting ready for school 3. Problemer med å gjøre seg klar til skolen	38	28	14	22	0	0	102
4. Problems getting ready for bed 4. Problemer med å gjøre seg klar til å sove	20	31	29	21	0	1	102
5. Problems with eating (picky eater, junk food) 5. Problemer med å spise (kresen i matveien, usunn mat)	30	25	30	17	0	0	102
6. Problems with sleeping 6. Problemer med å sove	16	39	26	21	0	0	102
7. Gets hurt or injured 7. Blir såret eller skadet	67	21	8	3	2	1	102
8. Avoids exercise 8. Unngår trening	41	29	11	17	3	1	102
9. Needs more medical care 9. Trenger medisinsk behandling	60	24	5	1	10	2	102
10. Has trouble taking medication, getting needles or visiting the doctor/dentist 10. Har problemer med å ta medisin, sprøyter eller lege-/tannlegebesøk	68	20	5	6	2	1	102
D. Self- concept/Selvforståelse							
1. My child feels bad about herself/himself 1. Barnet mitt har det ikke godt med seg selv	21	49	20	11	1	0	102
2. My child does not have enough fun 2. Barnet mitt har ikke nok moro	37	40	15	9	1	0	102
3. My child is not happy with his/her life 3. Barnet mitt er ikke fornøyd med livet sitt	32	39	21	8	1	1	102
E. Social activities/ Sosialt							
1. Being teased or bullied by other children 1. Blir ertet eller mobbet av andre barn/unge	64	31	4	0	3	0	102
2. Teases or bullies other children 2. Erter eller mobber andre barn/unge	85	14	0	0	3	0	102
3. Problems getting along with other children 3. Problemer med å komme overens med andre barn/unge	52	31	10	8	1	0	102
4. Problems participating in after-school activities (sports, music, clubs) 4. Problemer med å delta i fritidsaktiviteter (sport, musikk, klubber)	52	31	10	8	1	0	102
5. Problems making new friends 5. Problemer med å få seg nye venner	52	32	9	9	0	0	102
6. Problems keeping friends 6. Problemer med å holde på venner	46	31	16	9	0	0	102
7. Difficulty with parties (not invited, avoids them, misbehaves) 7. Problemer med selskaper (blir ikke invitert, unngår dem, oppfører seg upassende)	57	24	14	5	2	0	102
F. Risky activitites/Risikofylte aktiviteter							
1. Easily led by other children (peer pressure)	48	34	12	8	0	0	102

1. Lar seg lett lede av andre barn/unge (gruppepress)							
2. Breaking or damaging things	70	25	3	1	2	1	102
2. Ødelegger eller skader ting							
3. Doing things that are illegal	87	11	1	0	3	0	102
3. Gjør ulovlige ting							
4. Being involved with the police	96	3	0	0	3	0	102
4. Er involvert med politiet							
5. Smoking cigarettes	92	5	0	0	4	1	102
5. Røyker sigaretter							
6. Taking illegal drugs	97	1	0	0	4	0	102
6. Tar ulovlige stoffer							
7. Doing dangerous things	91	8	0	0	3	0	102
7. Gjør farlige ting							
8. Causes injury to others	97	3	0	0	2	0	102
8. Forårsaker skade på andre							
9. Says mean or inappropriate things	61	24	11	4	2	0	102
9. Sier slemme eller upassende ting							
10. Sexually inappropriate behaviour	93	3	0	0	6	0	102
10. Seksuelt upassende atferd							
Note. WFIRS-P= Weiss Functional Impairment Rating Scale- Parent report							
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Table S6. The WFIRS-S item response distribution. English and Norwegian version

	Never	**Sometimes**	**Often**	**Very often**	**n/a**	**missing**	**n**
	0	**1**	**2**	**3**			
A. Family/ Familie							
1. Having problems with family	33	44	15	6	3	1	102
1. Problemer med familien							
2. Having problems with spouse/partner	21	5	0	0	72	4	102
2. Problemer med ektefelle/partner							
3. Relying on others to do things for you	30	43	17	5	5	2	102
3. Overlater til andre at ting gjøres							
4. Causing fighting in the family	28	34	28	6	5	1	102
4. Skaper krangel i familien							
5. Makes it hard for the family to have fun together	53	35	6	3	4	1	102
5. Gjør det vanskelig for familien å ha det moro sammen							
6. Problems taking care of your family	52	15	3	1	28	3	102
6. Problemer med å ta vare på familien							
7. Problems balancing your needs against those of your family	33	35	14	4	13	3	102
7. Problemer med å balansere egne behov mot familiens behov							
8. Problems losing control with family	48	20	12	1	19	2	102
8. Problemer med å miste kontroll i familien							
B. **Work/ Arbeid**							
1. Problems performing required duties	15	37	17	10	18	5	102
1. Problemer med å utføre pålagte arbeidsoppgaver							

2. Problems with getting your work done efficiently 2. Problemer med å få gjort jobben på en effektiv måte	20	23	22	13	19	5	102
3. Problems with your supervisor 3. Problemer med overordnede	32	19	9	4	30	8	102
4. Problems keeping a job 4. Problemer med å holde på jobben	20	7	1	0	67	7	102
5. Getting fired from work 5. Blir oppsagt fra jobben	20	1	0	1	71	9	102
6. Problems working in a team 6. Problemer med å arbeide i team	28	32	7	3	25	7	102
7. Problems with your attendance 7. Problemer med oppmøte	44	14	6	7	24	7	102
8. Problems with being late 8. Problemer med for sent komming	37	19	8	8	24	6	102
9. Problems taking on new tasks 9. Problemer med overgang til nye oppgaver	17	35	13	6	24	7	102
10. Problems working to your potential 10. Problemer med å utnytte ditt potensial	21	23	17	9	24	8	102
11. Poor performance evaluations 11. Dårlige tilbakemeldinger på arbeidsutførelse	29	25	7	2	31	8	102
C. **School/ Skole**							
1. Problems taking notes 1. Problemer med å ta notater	22	39	22	18	1	0	102
2. Problems completing assignments 2. Problemer med å fullføre oppgaver	18	40	26	18	0	0	102
3. Problems getting your work done efficiently 3. Problemer med å gjøre arbeidet på en effektiv måte	15	38	31	17	0	0	102
4. Problems with teachers 4. Problemer med lærer	60	25	9	6	1	1	102
5. Problems with school administrators 5. Problemer med skoleledelsen	80	10	3	5	3	1	102
6. Problems meeting minimum requirements to stay in school 6. Problemer med å oppfylle minstekravene for å fortsette på skolen	70	17	9	2	4	0	102
7. Problems with attendance 7. Problemer med oppmøte	62	17	8	12	3	0	102
8. Problems with being late 8. Problemer med for sent komming	55	22	9	14	2	0	102
9. Problems with working to your potential 9. Problemer med å utnytte ditt potensial	29	34	19	18	0	2	102
10. Problems with inconsistent grades 10. Problemer med varierende karakterer	24	38	25	13	2	0	102
D. **Life Skills/ Ferdigheter**							
1. Excessive or inappropriate use of internet, video games or TV 1. Overdreven eller uhensiktsmessig bruk av internett/dataspill eller TV	19	34	28	21	0	0	102
2. Problems keeping an acceptable appearance 2. Problemer med å opprettholde et akseptabelt utseende	70	21	5	4	2	0	102
3. Problems getting ready to leave the house 3. Problemer med å komme tidsnok ut av huset	36	30	17	16	3	0	102

4. Problems getting to bed 4. Problemer med å komme i seng	29	34	23	14	0	2	102
5. Problems with nutrition 5. Problemer med kosthold	39	37	10	14	1	1	102
6. Problems with sex 6. Problemer med sex	30	1	1	1	66	3	102
7. Problems with sleeping 7. Problemer med søvn	24	34	23	20	0	1	102
8. Getting hurt or injured 8. Blir såret eller skadet	56	29	9	2	5	1	102
9. Avoiding exercise 9. Unngår mosjon	44	33	16	5	1	3	102
10. Problems keeping regular appointments with doctor/dentist 10. Problemer med å holde faste avtaler med lege/tannlege	79	14	3	3	3	0	102
11. Problems keeping up with household chores 11. Problemer med å få gjort husarbeid	16	48	24	11	2	1	102
12. Problems managing money 12. Problemer med å holde orden på økonomien	22	16	10	8	43	3	102
E. **Self-concept/ Selvforståelse**							
1. Feeling bad about yourself 1. Har ett dårlig selvbilde	40	34	12	15	1	0	102
2. Feeling frustrated with yourself 2. Føler meg frustrert over meg selv	32	30	21	18	1	0	102
3. Feeling discouraged 3. Føler meg motløs	42	28	16	13	1	2	102
4. Not feeling happy with your life 4. Føler liten glede over livet mitt	52	27	12	9	1	1	102
5. Feeling incompetent 5. Føler meg utilstrekkelig	35	35	20	10	1	1	102
F. Social/ Sosialt							
1. Getting into arguments 1. Havner i krangler	43	38	15	6	0	0	102
2. Trouble cooperating 2. Problemer med å samarbeide	47	40	11	4	0	0	102
3. Trouble getting along with people 3. Problemer med å komme overens med andre	56	37	7	2	0	0	102
4. Problems having fun with other people 4. Problemer med å ha det moro sammen med andre	67	29	6	0	0	0	102
5. Problems participating in hobbies 5. Problemer med å delta i fritidsaktiviteter	58	23	14	5	2	0	102
6. Problems making friends 6. Problemer med å skaffe venner	61	24	13	4	0	0	102
7. Problems keeping friends 7. Problemer med å holde på venner	58	29	9	6	0	0	102
8. Saying inappropriate things 8. Sier upassende ting	39	38	16	8	0	1	102
9. Complaints from neighbours 9. Får klage fra naboer	85	2	2	0	13	0	102
G**. Risk/Risikofylte aktiviteter**							
1. Aggressive driving 1. Aggressiv kjøring	18	4	1	0	72	7	102
2. Doing other things while driving	18	5	0	0	72	7	102

2. Gjør andre ting mens jeg kjører							
3. Road rage	20	1	0	0	73	8	102
3. Sinneutbrudd når jeg kjører							
4. Breaking or damaging things	57	18	4	1	17	5	102
4. Knuser eller ødelegger ting							
5. Doing things that are illegal	63	11	1	0	22	5	102
5. Gjør ulovlige ting							
6. Being involved with the police	71	1	0	0	26	4	102
6. Kommer i klammeri med politiet							
7. Smoking cigarettes	62	6	0	0	30	4	102
7. Røyker sigaretter							
8. Smoking marijuana	66	1	0	0	31	4	102
8. Røyker hasj							
9. Drinking alcohol	48	25	2	0	23	4	102
9. Drikker alkohol							
10. Taking "street" drugs	66	0	0	0	31	5	102
10. Bruker narkotika							
11. Sex without protection (birth control, condom)	35	4	1	0	57	5	102
11. Sex uten beskyttelse (prevensjon, kondom)							
12. Sexually inappropriate behaviour	47	3	0	0	48	4	102
12. Seksuelt upassende atferd							
13. Being physically aggressive	56	23	2	1	16	4	102
13. Er fysisk aggressiv							
14. Being verbally aggressive	43	23	10	8	14	4	102
14. Er verbalt aggressiv							

Note. WFIRS-S= Weiss Functional Impairment Rating Scale- Self-report. n/a=not applicable, n=total responses

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Paper II

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RESEARCH

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Cognitive behavioural group therapy as addition to psychoeducation and pharmacological treatment for adolescents with ADHD symptoms and related impairments: a randomised controlled trial

Anne-Lise Juul Haugan[1*], Anne Mari Sund[1,2], Susan Young[3,4], Per Hove Thomsen[1,5], Stian Lydersen[1] and Torunn Stene Nøvik[1,2]

Abstract

Background: Cognitive behavioural therapy (CBT) is recommended for attention-deficit/hyperactivity-disorder (ADHD) in adolescents. However, all CBTs are not created equal, and the guidelines do not specify which CBT interventions are the most effective for this patient group. This study examines the efficacy of a group CBT without parent involvement as follow-up treatment compared to no additional CBT in adolescents with persistent and impairing ADHD symptoms after a short psychoeducational intervention and medical treatment.

Methods: The authors conducted a two-arm parallel randomized controlled trial in two child and adolescent mental health outpatient clinics in Norway. One hundred patients aged 14–18 years with a diagnosis of ADHD (66%) or subthreshold ADHD (34%) were randomized to either a 12-week group CBT program ($N=50$) or a non-CBT control condition ($N=50$). Assessments were made at admission to the clinic, two weeks before and two weeks after treatment. The primary outcomes were parent-, teacher- and self-ratings of ADHD symptoms (ADHD Rating Scale-IV), and the secondary outcomes were ratings of ADHD symptom severity, executive function, functional impairment, and emotional problems. Evaluators blinded to group allocation rated ADHD symptom severity with the Clinical Global Impression Scale for Severity (CGI-S) at baseline and post-treatment.

Results: Analyses using mixed-effects models showed no difference between the treatment arms from baseline to post treatment in primary and secondary outcomes.

Conclusions: Contrary to our hypothesis, we found no incremental treatment effect on the part of a group CBT as follow-up to psychoeducation and pharmacological treatment on ADHD symptoms and accompanying impairments. Limitations with the CBT was the large number and low dosage of treatment components, causing restricted time for practice. Unlike evidence-based, individualized targeted CBTs with parent involvement, a group CBT directed solely at the adolescents with no parent involvement does not appear effective for treating ADHD.

*Correspondence: anne-lise.j.haugan@ntnu.no

[1] Department of Mental Health, Faculty of Medicine and Health Sciences, Regional Centre for Child and Youth Mental Health and Child Welfare (RKBU), NTNU- Norwegian University of Science and Technology, Trondheim, Norway
Full list of author information is available at the end of the article

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Keywords: Attention-deficit/hyperactivity disorder,, Adolescence,, Cognitive behavioural therapy,, Group therapy,, Randomized controlled trial

Background

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterised by levels of inattention, hyperactivity and impulsivity that lead to impairment [1]. In adolescence, ADHD is often associated with a range of social and emotional sequelae, including anxiety, depression, interpersonal difficulties, low self-esteem, low academic achievement, and substance abuse [2–5]. Although medication may be effective in reducing ADHD's core symptoms [6], this treatment alone may not be sufficient to remediate ADHD and its associated conditions. Some patients experience adverse side effects or do not respond well to medical treatment [7], the long-term effect of pharmacotherapy is inconclusive [8] and many adolescents discontinue treatment in the transition to adulthood [9, 10]. Because ADHD often persists across the lifespan [11], there is a need for additional treatments to learn strategies and skills for coping with impaired executive functioning and functional impairments. This seems especially imperative for adolescents, who are at a crossroads, with expectations of parental detachment and increased independence on the one hand and a need for external structure and emotional support on the other hand. The National Institute for Health and Care Excellence (NICE) guidelines recommend multimodal treatment for children and young adults with ADHD [12]. This includes ADHD-focused support, including education and information about the causes and effects of ADHD, advice on parenting strategies and supportive measures in school. Pharmacotherapy is recommended if ADHD symptoms persist after environmental modifications. In addition, cognitive behavioural therapy (CBT) is recommended as a treatment option for young people if symptoms remain impairing after pharmacological treatment [12]. A limitation with this recommendation however, is that all CBTs are not created equal, and the guidelines do not specify which CBT programs to use for young people with ADHD [12, 13]. Systematic reviews of psychosocial interventions directed at children and adolescents show that most interventions combine components from behaviour therapy/behaviour contingency management, cognitive restructuring techniques and skills training, to reduce symptoms of ADHD and its` associated impairments [6, 14]. Compared to the childhood treatments that involve parents to a large extent, treatments directed at adolescents have a more moderate parent involvement, and they include more individualized engagement components, as well as skills training compared to the childhood treatments. According to Evans et al. [14, 15], behaviour management treatments including behavioural parent training, behaviour classroom management and behavioural peer interventions are considered well-established treatments for children with ADHD. For adolescents, only organization training has been considered well established. CBT programs directed at adolescents and their parents have so far been considered as probably efficacious [14], but preliminary results have been promising [16, 17].

The CBTs targeting adolescents with ADHD may be divided into school-based and clinic-based treatments. Evans and colleagues developed the Challenging Horizons Program (CHP), a school-based training intervention to help young adolescents with ADHD improve their inattention, social and scholastic skills [18]. In the CHP, the adolescents meet twice a week for about 2h after school, across one academic year. The program also includes three parent meetings. In a randomised trial, the participants demonstrated significant improvements in parent-rated organization and time management skills, homework completion, and ADHD inattention symptoms, but not social skills, compared to participants in two control conditions [19]. Another school-based intervention developed by Langberg and colleagues is the Homework, Organization, and Planning Skills (HOPS) program [20]. This intervention which is delivered during the school day by school mental health providers, aims to improve organizational skills and homework problems in middle school students with ADHD. It includes 16 short sessions (20 minutes) over an 11-week period. Parents are included in two of the sessions. A randomized study comparing participants receiving HOPS to a waitlist control group demonstrated significant improvements on parent-, but not on teacher- ratings of materials management, planning skills, and homework completion in favour of HOPS [21].

Sibley and colleagues developed a clinic-based skills intervention for adolescents with ADHD between the ages of 11 to 15 [22]. The Supporting Teens` Autonomy Daily (STAND) program is a modular treatment with 10 1-hour parent-teen sessions with a menu of skills that can be targeted (e.g, organization, time management, test taking and note taking) from which the family selects four to address. Parent- teen contracts are used, in which

parents provide behavioural contingencies based on the adolescents' use of the targeted skills at home and school to facilitate the skills. Motivational interviewing (MI) is integrated to enhance treatment engagement. Results from both a pilot study and a randomized trial revealed significant improvements in parent-, but not teacher-rated, ADHD symptom severity, planning and organizational skills, as well as parenting stress compared to a treatment as usual control group [17, 22]. Another promising CBT program for adolescents with ADHD was conducted by Sprich and colleagues [16]. This CBT, originally developed for adults with ADHD [23] was conducted with medicated adolescents between 14 to 18 years. The 12-session program which also involves the parents in two of the sessions, includes three modules focusing on psychoeducation, cognitive restructuring techniques and training in organisation and planning skills. A randomized trial revealed significantly reduced parent- and adolescent-rated symptom severity and reduced ADHD symptoms in the control group compared to a waitlist control group, demonstrating initial efficacy of CBT for adolescents [16]. Furthermore, two short-term CBT interventions targeting adolescents with ADHD was developed by Boyer and colleagues. Both interventions include elements from MI in combination with either planning skills (Plan My Life) or a Solution-Focused Treatment. The programs consist of eight adolescent-sessions and two parental-sessions [24]. A comparison of the programs in an ADHD population aged 12 to 17 years revealed reduced parent-rated ADHD symptoms, planning problems and improved executive functions in both treatment arms. A limitation of this study was the lack of waitlists or treatment as usual control group.

The first RCT to examine the efficacy of group CBT on a sample of late adolescents and young adults medicated for ADHD was conducted by Vidal et al. [25]. Different from the previous clinic-based CBTs that involve parents to various extent, this was a patient focused 12-session multicomponent CBT program based on psychoeducation and cognitive behavioural principles to facilitate skills related to impulsivity, emotion regulation, interpersonal skills, planning strategies and techniques to improve inattention using MI techniques. The study showed beneficial effects on both parent- and self-rated ADHD symptoms and parent rated functional impairment as compared to a waitlist control condition. One limitation of the study was the exclusion of patients with comorbid emotional disorders, which are common in this patient group [4, 26, 27]. Similar to the CBT programs of both Vidal and Sprich, the Young-Bramham program (YBP) incorporates elements from psychoeducation, structured skills training and cognitive behavioural therapy to target ADHD core symptoms as well as comorbid problems. The program is modular based, and the choice of modules and number of sessions may be adjusted to fit the needs of the individual patient or group participants [28]. In addition to cognitive restructuring techniques, the YBP includes strategies to improve attention and memory functions, it includes skills training in planning and organization and incorporates behavioural techniques such as graded task assignments, modelling and roleplay to improve social regulation and communication [28]. The YBP program has not previously been studied in an adolescent population, but Bramham and colleagues studied the effect of a short and intensive YBP group program with ADHD adults, which revealed promising preliminary results with significantly greater improvement on measures of knowledge about ADHD, self-efficacy, and self-esteem in the CBT group compared to the waitlist control group [29].

When planning a treatment study for adolescents with ADHD, we found no manual suited for the purpose in a Scandinavian language. Inspired by the positive results from the group treatment by Vidal et al. [25], we decided to develop a Norwegian research manual based on selected modules from the YBP in collaboration with one of its authors, SY. After selecting modules from the YBP thought appropriate for our adolescent population, we translated it to Norwegian and tested the manual, the feasibility and acceptability of the program in a pilot study. We refer to Novik and colleagues for the study protocol [30]. We preferred group treatment to individual treatment as the group format provides the opportunity to meet other patients with similar problems which offers normalisation, mutual understanding, and also opportunities to share strategies for coping with problems and acquire news skills in a non-judgemental environment which we consider important for adolescents with ADHD.

The NICE guideline recommends CBT as an additional treatment in ADHD patients who still present impairing symptoms after psychoeducation and pharmacological treatment [12]. To our knowledge, no published studies have examined the efficacy of CBT as follow-up treatment in a sample of ADHD adolescents with and without comorbid emotional disorders who previously received this recommended treatment. The aim of our study was thus to assess the efficacy of an age-adapted group CBT program as additional treatment to a short psychoeducational intervention and medical treatment in adolescents still presenting impairing ADHD symptoms. Based on previous CBT studies on medicated adolescent populations [16, 25] we predicted that the CBT group would be superior in terms of showing incremental improvement in ADHD symptoms, executive functions, and functional

impairment compared to a control group having received the same previous interventions as the CBT group, but no additional CBT.

Methods

Study design and procedure

This was a 12-week, RCT efficacy trial with two study arms comparing CBT group therapy as a follow-up treatment with a passive no additional CBT control condition in a clinical context. A detailed research protocol has been published elsewhere [30]. The recruitment, intervention and data collection were conducted in two outpatient child and adolescent psychiatry (CAP) university clinics in Mid-Norway. Recruitment began in February 2017, and the last follow up data were collected in January 2020. The measures included self-, parent, and teacher reports and were collected while the participants were on medication, two weeks before and two weeks after the intervention. Clinical evaluations of ADHD symptom severity using the Children's Global Assessment Scale (CGAS) [31] and Clinical Global Impression Scale for Severity (CGI-S) [32] were collected two to four weeks before the intervention and two weeks after the intervention, by clinicians (a clinical psychologist or a child and adolescents psychiatrist) blinded to the participants' group allocation. Participants were screened for eligibility and recruited from the two CAP outpatient units by the last author in cooperation with the clinicians responsible for this patient group. Participants ($N=9$) who previously received pharmacotherapy but were unable to continue treatment because of intolerable side-effects or little effect were included in the study for ethical reasons and to achieve enough participants for the study. During recruitment, we included patients with mild to moderate behavioural problems to achieve enough participants. The inclusion of patients with behaviour problems was a deviation from the trial registration but was described in the study protocol [30]. Six participants were recruited through primary care physicians after postings in a local newspaper and advertising via social media. The last author screened these participants before inclusion, and they previously underwent the same diagnostic procedures as well as received psychoeducation and pharmacological treatment in a CAP clinic similar to the other participants before being discharged. Furthermore, they followed the same inclusion criteria as the other participants. All participants and their parents were provided oral and written information about the content of the study and its treatment arms by CAP clinicians. A flowchart for the timeline for the recruitment, follow-up assessments and post-treatment analyses is presented in Fig. 1.

Participants

The sample characteristics are presented in Table 1. The participants were recruited from a group of adolescents between the ages of 14 to 18, the mean age was 15.3 (SD = 1.3), with a previous clinical diagnosis of ADHD according to the International Statistical Classification of Disease and Related Health Problems (ICD-10) [33]. A clinical psychologist or a child and adolescent psychiatrist made psychiatric diagnoses at the first intake to the CAP clinic (0–13 years). The CAP clinic's standardised procedure for the assessment and diagnosis of hyperkinetic disorder is based on the national guidelines for the assessment and treatment of ADHD [13], which are similar to the NICE ADHD guidelines [12]. This procedure requires a thorough developmental history, an examination of comorbid psychiatric disorders, a somatic assessment and the use of questionnaires filled out by the adolescents, parents, and teacher informants to obtain ADHD symptom scores (ADHD rating scale). The diagnostic criteria for hyperkinetic disorder in ICD-10 are nearly identical to those of the Diagnostic and Statistical Manual of Mental Disorder 5th edition's (DSM-5) [1] diagnosis of ADHD combined presentation. The Norwegian ADHD guidelines [13] allow for hyperkinetic disorder to be diagnosed in patients with severe inattentive symptoms only, corresponding to the DSM-5 Inattentive type. Patients receiving an ADHD diagnosis at the CAP clinic are usually offered interventions as described under the subheading "CAP standard clinical intervention" before being transferred to community care. When patients are being referred to the clinic for a follow-up medical treatment and/or associated conditions because of increased symptoms or impairments, and the patient received an ADHD diagnosis at an early time-point, the parents need to confirm ADHD symptoms and clinical impairment in a clinical interview together with the patient at readmission. All the participants received an initial ADHD diagnosis or ADHD symptoms were confirmed by a parent informant within 0 to 5 years before inclusion (Mean = 1.5 years, SD = 1.2). For 94% of the population, the ADHD symptoms were confirmed by a parent rater within the last three years of inclusion. In addition, we interviewed each participant with the Schedule for Affective Disorders and Schizophrenia for school age children-Present and Lifetime Version (Kiddie-SADS-PL) [34] at the CAP units before intake to the study to assess for the presence of ADHD symptoms and psychiatric comorbidities. In cases of diagnostic uncertainty, current comorbidities were checked with the adolescents' medical record. Ultimately, 66% of the adolescents reported symptoms above threshold for a DSM-5 ADHD diagnosis. Adolescents who reported symptoms below the threshold for ADHD according to

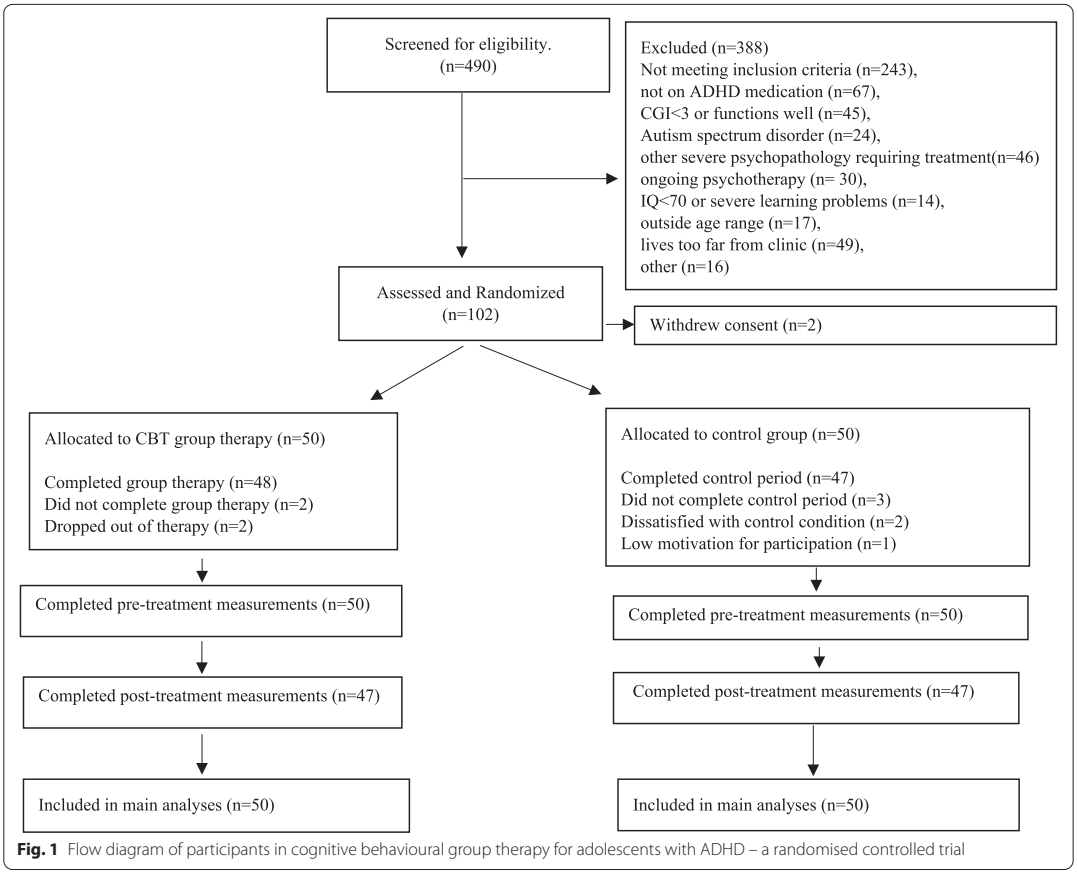

Fig. 1 Flow diagram of participants in cognitive behavioural group therapy for adolescents with ADHD – a randomised controlled trial

the DSM-5 but had impairing ADHD symptoms while on medication (34%) were allowed into the study [30] and were designated as subthreshold ADHD. The participant population's mean ADHD RS-IV parent total score at the first intake to the CAP clinic was 33.7 (SD = 8.8, $n = 75$), while the mean baseline score before the trial was 25.0 (SD = 8.8, $n = 97$). Ninety-one percent of the participants were on pharmacological treatment for ADHD. Fifty-three percent of the participants had at least one current comorbid condition according to the DSM-5 (see Table 1). Additionally, IQ scores were obtained by using the Wechsler Intelligence Scales for Children (WISC-IV) [35] or Adults (WAIS-IV) [36].

The inclusion criteria were thus a previous full diagnosis of ICD-10 ADHD, a DSM-5 diagnosis of ADHD or subthreshold ADHD, confirmed by the Kiddie-SADS-PL interview, and evidence of clinically impairing symptoms (a Clinical Global Impression Scale for Severity (CGI-S) clinician score of 3 (mildly ill) or greater at baseline). Participants with comorbid diagnosis including mild to moderate depressive disorders, anxiety disorders, bipolar disorders, tic disorders, oppositional defiant disorder and mild degree of autism spectrum disorders were included in the study. All participants needed to have been on a stable pharmacological treatment for ADHD for at least two months prior to randomisation into the study. However, participants who had previously been medicated but terminated treatment because of minimal treatment effect or having experienced intolerable side effects after at least two medication trials were included. The participants could not be seeking or engaged in parallel psychosocial interventions during the study period. A crisis involving the considerable worsening of psychiatric problems (family crisis, worsening of depressive symptoms or aggression/acting out in the home environment) could, however, necessitate a limited supplemental examination or supportive intervention with the parents or the patient. One participant received two extra hours

Table 1 Clinical characteristics of the participants at baseline (study inclusion)

Characteristics	CBT ($n=50$)	Control ($n=50$)
Mean age, years (SD)	15.9 (1.3)	15.8 (1.3)
Male patients (n [%])	21 (42.0)	22 (44.0)
Full-scale IQ (n [mean, SD])	44 (94.3[12.8])	42 (93.4[13.2])
Parent socioeconomic status (n [%])	38 (76)	37 (74)
Less than compulsory school or 1–2 years of high school (0–11 years)	13 (34.2)	6 (16.2)
Completed high school and 1 year of training after high school (12–13 years)	3 (7.9)	4 (10.8)
Academy university for up to four years (14–15 years)	15 (39.5)	15 (40.5)
Academy/ University for four years or more (16 years and more)	7 (18.4)	12 (32.4)
Previous CAP psychosocial treatments (n [%])		
Webster Stratton, Incredible years	10 (20)	6 (12)
Cognitive behavioral Therapy (CBT)	2 (4)	1 (2)
Routine Clinical Care[a]	18 (36)	24 (48)
Other[b]	4 (8)	4 (8)
CAP standard clinical intervention (n [%])		
Short psychoeducational intervention with patient and parents	33 (66)	32 (64)
Short psychoeducational intervention with patient alone	24 (48)	29 (58)
School collaborative meeting	47 (94)	48 (96)
ADHD full day lecture	35 (70)	36 (72)
ADHD presentation (Kiddie-SADS-PL) (n [%])		
Predominantly Combined	18 (36.0)	13 (26.0)
Predominantly Inattentive	17 (34.0)	18 (36.0)
Subtreshold ADHD	15 (30.0)	19 (38.0)
Medication[c] (n [%])		
ADHD medication	44 (88.0)	47 (94.0)
Sleep medication	6 (12.0)	2 (4.0)
Other psychopharmacological treatment	5 (10.0)	2 (4.0)
Psychiatric comorbidities[d] (Kidde-SADS-PL) (n [%])		
Anxiety disorders	19 (38.0)	18 (36.0)
Posttraumatic stress disorder	0 (0.0)	1 (2.0)
Depressive disorder NOS/Dysthymic disorder	8 (16.0)	3 (6.0)
Obsessive Compulsive Disorder	1 (2.0)	2 (4.0)
Tics disorder or Tourette's Disorder	4 (8.0)	5 (10.0)
ODD/Disruptive behaviour disorder NOS	6 (12.0)	5 (10.0)
Autism spectrum disorder (mild symptoms)	2 (4.0)	2 (4.0)
Learning Disorders, reading disorders or mixed (n [%])	8 (16.0)	10 (20.0)

Note: *Full-scale IQ* Wechsler Intelligence Scale for Children or Adults (WISC-IV, WAIS-IV), *SD* Standard deviation, *ADHD* Attention-deficit/hyperactivity disorder, *ODD* Oppositional Defiant Disorder

[a] *Routine clinical care* Supportive therapy for patients and/or parents for mild emotional and behavioural problems

[b] *Other* Dialectic behaviour therapy (DBT), eye movement desensitizing and reprocessing (EMDR), habit reversal training (HRT) and family therapy

[c] *Medication* ADHD medication includes methylphenidate, lisdexamfetamine, atomoxetine, and guanfacine; *sleep medication*: melatonin; *other pharmacological treatment* includes neuroleptic medication; risperidone, quetiapine; anti-epileptic medication: valproate, lamotrigine

[d] *Psychiatric comorbidities* are based on Kiddie-SADS-PL interview with the adolescents and converted to DSM-5 diagnoses

with parental support after acting out at home, and four participants received four supplemental therapy sessions related to depressive symptoms/emotional dysregulation. All of them were part of the control group.

The exclusion criteria were severe depression, suicidal behaviour, conduct disorder, psychoses, intellectual disability (IQ < 70) and current substance abuse. Patients in on-going psychotherapy or previously having received CBT for ADHD (CBT with treatment modules directed at core ADHD symptoms or executive functions as shown in Table 2), and patients not interested in psychopharmacological treatment, were also excluded.

Table 2 Contents of the group cognitive-behavioural therapy (CBT) program

	Session	Themes
Core symptom modules	1	Orienting participants to the program, including content, structure, and the basic CBT principles. Participants receive psychoeducation about ADHD and write down individual treatment goals.
	2	Attention: Various forms of attention and the impact of motivation, anxiety and stress are introduced and discussed. Various attention control strategies are presented and rehearsed in session.
	3	Memory: The various memory systems are introduced. External and internal memory strategies are presented. Memory games and exercises are practised within group meetings.
	4	Organising and time-management: Consequences of dysfunctional planning and time-management are discussed. Six steps for making a time plan, including use of daily planners and rewards are introduced and rehearsed.
	5	Impulsivity: Consequences of having low self-control are introduced and discussed. Various impulse control strategies, including self-talk and distraction techniques, are presented and rehearsed in the session.
Comorbid and associated problem modules	6	Problem solving: The participants learn how to define problems, generate solutions and evaluate them. We rehearse in session, and finally, we evaluate the level of success.
	7	Anxiety: Psychoeducation on basic CBT principles, how to cope with negative thoughts, the three- legged table, relaxation strategies and the role of exposure in changing behaviour.
	8	Depression and sleep management: Introducing the cognitive model of depression, challenging negative thoughts and the positive role of activity. Psychoeducation about sleep and sleep strategies are introduced.
	9	Interpersonal relationships and communication: Introducing and rehearsing verbal and nonverbal communication strategies.
	10	Frustration and anger management: Consequences of bad anger management are discussed. We introduce various management strategies, including self-talk, distraction techniques, reframing the situation and relaxation.
	11–12	Preparing for the future: We present and discuss the challenges of having ADHD in the transition to young adulthood. We repeat some of the highlights from the program and discuss the participants' future goals and which skills can be used to achieve them.

Note: All sessions include group activities, homework assignments and telephone coaching between sessions. The content is based on the CBT program of Young and Bramham, 2012

In all, 102 patients were randomised, and 100 participants completed the baseline assessments. The two participants who withdrew consent were not included in the analyses. Those who completed measures at baseline but not post-treatment were included in the analyses according to intention-to-treat principles.

CAP standard clinical intervention

The CAP clinical interventions are conducted shortly after receiving an initial ADHD diagnosis. Sixty-five percent of the participants received a short psychoeducational intervention (1–2 hours) together with his or her parents after receiving an ADHD diagnosis at the CAP clinic, as recommended in the ADHD guidelines [12, 13]. This psychoeducation typically consisted of information about ADHD diagnoses, symptoms, causes and treatment options. It was delivered by the patient's clinician (a psychologist, medical doctor/child and adolescent psychiatrist or clinical education specialist). Fifty-three percent of the participants received 1–2 individual psychoeducational sessions with their clinician either in addition to the meeting with parents, or as the only psychoeducational intervention received at the CAP clinic. The content of these sessions was not standardized, so the information varied across clinicians and participants. Ninety-two percent of the participants received at least one of these psychoeducational interventions. The patient's parents and schoolteachers had a collaborative meeting with the CAP clinician and/or a clinical education specialist to inform about the ADHD diagnosis and discuss individualised supportive measures in school (1 hour). Parents and a schoolteacher were also offered a standardized full-day lecture, with information about ADHD, pharmacotherapy, psychosocial interventions (help with planning and organising, supportive communication and the use of helping aids), and school interventions (regular daily routines, the use of a daily plan and week plans in school, clear communication/ short messages, and the use of rewards). These lectures are delivered by various ADHD specialists. All the families of the participants received at least one of these psychoeducational interventions. See Additional file 1 for more comprehensive information about the content.

Patients with persistent ADHD symptoms after receiving psychoeducation and a limited supportive school intervention were offered pharmacological treatment according to National clinical guidelines for ADHD [13]. Documents included in the hospital quality system (EQS) give detailed procedures for beginning and evaluating treatment. Methylphenidate is first drug of choice, while amphetamine or atomoxetine are second choices. The ADHD rating scale [37] was used as systematic

effect measure during the titration trial using both parent and teacher ratings. In addition, the patient or his or her parents completed an adverse reaction form. Clinicians mapped specific problematic ADHD symptoms before beginning medication and considered improvement in symptoms and function in everyday life and any significant side effects during the evaluation. A second or third trial was indicated if the first drug was ineffective or caused significant side-effects. See Additional file 2 for information on participant medication type and dosage.

CBT intervention

The first and last author developed the CBT treatment manual in collaboration with Dr. Susan Young. It is based on the "Young Bramham programme" which is a CBT program developed for adolescents and adults with ADHD and comorbid symptoms by Susan Young and Jessica Bramham [28]. The YBP includes information on ADHD, the principles of CBT and strategies for managing core ADHD symptoms, such as inattention and memory problems, impulsivity, and organization and time management issues. Modules with strategies for problem-solving, interpersonal problems, anxiety, depression, frustration, and anger management were also included, as these are common problem areas in our patient group. Our CBT program was adapted to fit a 12-week group format with 90-minute sessions (see Table 2 for the main contents of the program and Additional file 3 for a more detailed description of the program). Basic CBT elements including the ABC model with the triangulation of thoughts, feelings, and behaviour, identifying dysfunctional thoughts/cognitive restructuring techniques, Socratic questioning and positive reinforcement were used throughout the program. All the sessions were structured using the same format, with psychoeducation, group discussions, skills training, role-play, and individualised weekly home assignments. The language, in terms of the material and choice of modules, was adapted to fit an adolescent ADHD population with comorbid disorders. A PowerPoint presentation was developed for a visual presentation of the material, and the participants received accompanying handouts containing the main content of the modules. The groups consisted of 4–6 participants and were conducted by two clinicians recruited from the clinic (a clinical psychologist, a child and adolescent psychiatrist/and or a clinical education specialist). All the group leaders had experience with CBT, but only one was a CBT therapist. All the group leaders were trained before delivering the intervention. The training included a full day course on CBT and delivering of the research treatment manual before the intervention. They were also given a copy of the Young-Bramham textbook describing treatment strategies in CBT for ADHD. We refer to Andersen et al. for supplemental background information on the group leaders [38].

The group leaders registered the attendance of each participant. Parents were not involved in the program. A research assistant telephoned the participants every week, reminding them of their home assignment; evaluated medical adherence and verified that they did not receive any other type of psychological treatment. One routine medical follow-up was usually performed during the intervention period. This consultation involved a child and adolescent psychiatrist evaluating general health status, the side effects of medication and blood pressure, heart rate and weight. The patient was encouraged to report any difficulties related to the medication since the last consultation.

Control group

The participants in the control group continued medical treatment and received one routine medical follow-up (as in the CBT group). This was a passive control condition with no additional intervention received after the CAP standard intervention. A research assistant contacted them once a week to monitor medication adherence and verify that no other psychological treatment was received. The participants were not offered entry into a CBT group after the post-intervention assessments. They could, however, engage in other treatments according to their clinical needs after completing the post-treatment assessments.

Fidelity

Continuous CBT supervision was given to the group leaders on a nearly weekly basis by an experienced CBT supervisor (AMS), whereby the therapists could receive guidance and support for upcoming sessions to stay adherent to the method. AMS also attended some sessions as an observer.

All sessions were videotaped, and adherence to the manual and CBT core principles relevant to the study was rated based on a random selection of 20 sessions (22%) and stratified by early [2–7] and late [7–11] sessions by an external clinician experienced with group CBT. The Competence and Adherence Scale for Cognitive Behavioural Therapy (CAS-CBT) [39] covers basic CBT components, as well as specific session goals that can be adapted to fit a specific treatment. A minimum score of 3 is considered adequate for both manual adherence and therapist competence. Treatment fidelity was acceptable across all measures, including adherence related to the CBT content ($M = 3.38$, $SD = 0.75$), program adherence ($M = 3.47$, $SD = 0.69$) and the CBT competence score ($M = 3.25$, $SD = 0.87$).

Medication adherence was assessed by telephone, specifically interviewing the participants on a weekly basis during the intervention period. The participants were asked about what medication they were on, the dosage and whether they had used the medication as prescribed during the last week.

Inter-rater reliability was calculated for the CGAS scores using the intraclass correlation coefficient (ICC) at baseline. The last author (TSN) scored a random sample of 20 participants (20%) originally scored by the first author (AJH) based on the written records of the participant interviews. The ICC was 0.78 (95% CI 0.53 to 0.91). Three other child and adolescent psychiatrists experienced in the assessment of ADHD scored the CGAS post-treatment. A random sample of 18 (19%) of the participants was simultaneously scored by TSN at this time. The ICC for the CGAS ratings was 0.92 (95% CI 0.80 to 0.97).

The CGI-S scores were based on short interviews with the adolescent and a parent and set by TSN at baseline and three other child and adolescent psychiatrists post treatment. The child and adolescent psychiatrists scoring CGI-S with the adolescent and parent post-treatment scored the CGAS at the same time. A random sample of 16 (17%) of the participants was scored simultaneously by TSN. Cohen's weighted quadratic kappa for the CGI-S ratings was 0.78 (95% CI 0.54 to 1.00).

Measures

See Table 3 for an overview of the various outcome measures with different informants at different time points. All the questionnaires (except for the teacher reports) were filled out at the CAP clinic under the surveillance of a research assistant. Psychiatric diagnoses were assessed using the Schedule for Affective Disorders and Schizophrenia for school-age children-Present and Lifetime Version (Kiddie-SADS-PL) [34]. The instrument covers DSM-IV psychiatric diagnosis for school-age children (age 7–17), and the findings suggest that it generates reliable and valid child psychiatric diagnoses [34].

Primary outcomes

ADHD symptoms were assessed using parent, teacher, and self-ratings on the *ADHD Rating Scale* (ADHD RS-IV) [37, 40]. The questionnaire contains an 18-item scale corresponding to the diagnostic criteria for ADHD and rates the frequency of each item from 0 = not at all to 3 = very often, with higher scores indicating more symptoms. The scale consists of nine symptoms of inattention and nine symptoms of hyperactivity, which represents two subscales, in addition to a total score. The scale has been validated for children and adolescents (age 5–18) with ADHD, with adequate reliability and validity [40]. A pan-European study found strong evidence for cross-cultural factorial validity, internal consistency as well as convergent and divergent validity supporting use of the ADHD-RS-IV across European countries [41]. In the current study, the Cronbach alpha coefficients were 0.78 to 0.81 on the ADHD-RS IV parent report, 0.80 to 0.82 for teacher ratings, and 0.80 to 0.84 for self-ratings.

Table 3 Instruments used with various informants during time points in the trial

Instruments used in the trial	Baseline	Post-treatment
Kiddie-SADS-PL psychiatric interview (A)	x	
Primary measures		
ADHD RS-IV (ADHD symptoms) (P, S, T)	x	x
Secondary measures on functional impairment		
Children's Global Assessment Scale (CGAS) (C) (A, A + P)*	x	x
Clinical Global Impression (CGI) (C) (A + P)	x	x
Weiss Functional Impairment Rating Scale (WFIRS) (P, S, T)	x	x
Secondary measures of executive functions		
BRIEF (Executive functions) (P, S, T)	x	x
Secondary measures of emotional functions		
SCARED (Anxiety) (S)	x	x
Short Mood and Feelings Questionnaire (MFQ) (S)	x	x
General Perceived Self-Efficacy Scale (S)	x	x
Rosenberg Self-Esteem scale (S)	x	x
Adolescents Sleep Wake Scale (ASWS) (S)	x	x

Note Baseline study inclusion, *Post-treatment* 12-week assessment, *A* Adolescent participant, *C* Clinical evaluation, *P* Parent-report, *S* Self-report, *T* Teacher-report, *ADHD* Attention deficit hyperactivity disorder, *BRIEF* Behaviour Rating Inventory of Executive Function. *Only participant A at baseline and A and P post-treatment

Secondary outcomes

The *Clinical Global Impression Scale for Severity* (CGI-S) [32] was used to rate the severity of a patient's illness related to ADHD symptoms. This rating is based on observed and reported symptoms, behaviour, and function in the past seven days. It is a 7-point scale ranging from 1 = normal, meaning not at all ill, 3 = mildly ill, to 7 = among the most extremely ill patients, with 0 = not assessed. Higher scores indicate more severe ADHD symptoms. This scale is often used in psychopharmacological research and has shown to have adequate sensitivity in drug trials [32].

The *Children's Global Assessment Scale (CGAS)* [31] is a numeric scale used to measure the general psychosocial functioning of children under the age of 18 during the last month. The range is from 1 (lowest function) to 100 (excellent function). The Norwegian version has shown acceptable convergent, discriminant and predictive validity as well as acceptable interrater reliability [42].

The Weiss Functional Impairment Rating Scale parent and self-report (WFIRS-P, WFIRS-S) [43] consist of 50 and 69 items, respectively, divided into six and seven domains of impairment that are typically affected in ADHD (family, school and learning, life skills, self-concept, social activities and risky activities). Items range from 0 = not at all to 3 = very often, with 4 = not applicable, with higher scores indicating more impairment. We used the mean total score in this study, which represented the mean of all the subscales. The Norwegian version has shown acceptable psychometric properties in an adolescent ADHD population [44]. In this study, the Cronbach alpha coefficients for the WFIRS-P were 0.62 to 0.88 and 0.70 to 0.92 for the WFIRS-S.

The *Behaviour Rating Inventory of Executive Function (BRIEF)* [45] is an assessment of executive function behaviours at home and school for children and adolescents aged 5 to 18. It includes an 86-item parent and teacher report (BRIEF-P, BRIEF-T) and an 80-item self-report (BRIEF-SR). The scales range from 0 = not true to 2 = very true and converted T-scores above 65 indicate executive dysfunction. The inventories contain both a metacognitive (MI) and a behaviour regulation index score (BRI), in addition to a global executive composite score (GEC). We used the GEC index T-score in this study. The inventories have shown good psychometric properties in American and Norwegian children and adolescent populations [46–48].

The *Screen for Child Anxiety-Related Emotional Disorders* (SCARED) [49] is a 41-item self-report screening questionnaire measuring anxiety symptoms in youth. The item scale ranges from 0 = not at all to 2 = often, and a total score $\geq$ 25 may indicate the presence of an anxiety disorder. The instrument is sensitive to detecting specific and/or comorbid anxiety diagnoses in youth [50]. The Norwegian version has shown excellent internal consistency and convergent validity with other measures of anxiety in a non-clinical population [51]. The Cronbach's alpha was 0.95 in the current study.

The *Mood and Feelings Questionnaire-short version* (SMFQ) [52] is a 13-item inventory tool that measures depressive symptoms in children and adolescents from 8 to 18 years. The scale ranges from 0 = not true to 2 = true. We used the total score, with higher scores representing more depressive symptoms. In a Swedish clinical population, the SMFQ's ability to discriminate depression was fair for boys and good for girls. A Norwegian study found the measure to be a fast, practical, and feasible measure to detect depression in school adolescents [53, 54]. The Cronbach's alpha was 0.93 in the current study.

The *General Perceived Self-Efficacy Scale* [55] is a ten-item one-dimensional scale that is designed to assess belief in one's ability to cope with a broad range of stressful and challenging demands in life. The items range from 1 = all wrong to 4 = completely right, and a high score represented positive self-efficacy. Studies have found self-efficacy to be a universal construct with high internal consistency across 25 nations, and convergent validity with other similar constructs has been moderate to low [56, 57]. In this study, the Cronbach's alpha was 0.88.

The *Rosenberg Self-Esteem Scale (RSES)* [58] is a ten-item self-report instrument for evaluating one's overall sense of worthiness as a person in adolescents and adults. Responses were coded on a 4-point scale ranging from 1 = strongly disagree to 4 = strongly agree. Items 2, 5, 6, 8 and 9 were reversed to yield opposite values, and a high total score indicates positive self-esteem. The scale has exhibited high internal consistency, acceptable criterion validity and discriminant validity, as well as sensitivity to change [59]. In this study, the Cronbach's alpha was 0.93.

The *Adolescent Sleep-Wake Scale (ASWS)* [60] is a 28-item scale widely used to measure sleep quality in 12 to 18-year-old adolescents. The scale ranges from 1 = always to 6 = never. Eight of the items were reversed for opposite scores. A higher score equals a better quality of sleep. We calculated the mean score in this study. The scale is considered a reliable and valid measure of overall sleep behaviour in a young adult population, with good psychometric properties [60, 61]. The Cronbach's alpha was 0.70 in the current study.

Randomisation

A research assistant randomised the participants in a 1:1 ratio (simple randomisation) into one of the treatment arms after the baseline assessments. This was done by a randomization program supplied by the Unit for Applied Clinical Research, a centre of expertise in the Central

Norway Health Region. Codes were used to ensure participant confidentiality and anonymity. The participants were not blinded to the treatment condition.

Statistical analyses and sample size

Previous CBT programs have shown a 5- to 10-point reduction in ADHD-RS IV scale scores post-treatment [16, 25]. Sample size was calculated for a six-point difference, assuming a standard deviation of nine on the ADHD-RS IV, as recommended by Coghill and Seth [62]. With a significance level of 5%, we needed 37 participants in each group to obtain 80% power. To allow for dropouts, we aimed to include 48 participants in each group, for a total of 96. We used mixed models, with the outcome variable as the dependent variable, time point and the interaction between treatment group and time point as fixed effects, and the patient as a random effect. In this way, by not including any systematic main effect on the part of treatment group at baseline, we handled the baseline values of the outcome variable as recommended by Twisk et al. [63]. We did not adjust for any background variables in the main analyses, because we did not have a priori evidence that there are strong prognostic factors that we ought to adjust for. Analyses were based on intention-to-treat (ITT). Separate analyses were conducted for each outcome. Missing data were handled using single imputation on scales using the mean item score if 70% or more of the questions were answered. Otherwise, the outcome of that specific questionnaire for that participant was treated as missing. The normality of residuals was checked via a visual inspection of QQ plots. There were a few residuals for which we were in doubt regarding whether they should be considered outliers. We repeated the three analyses without the four, one and two observations related to these residuals. The results of the analyses were substantially the same (data not shown). Finally, post-hoc subgroup analyses were conducted to explore whether age, IQ, socioeconomic status (SES), the severity of anxiety symptoms or the severity of ADHD symptoms (ADHD-RS IV) would act as a moderator, using the parent-rated ADHD-RS IV total score. This was done by adding the potential moderator and the relevant interactions into the linear mixed models. Statistical analyses were conducted using IBM SPSS Version 25. We report 95% confidence intervals (CIs) where relevant and regard two-sided p-values ≤ 0.05 as significant.

Results

Participant attrition and adherence

See Fig. 1. for a flow diagram of the participants in the RCT. Of the 100 participants randomised into the study, 94 (94.0%) completed the post-treatment assessment. The reasons for dropping out of the control group were dissatisfaction with the control condition ($N=2$) and low motivation ($N=1$). The reasons for dropping out of the CBT group were lack of motivation to continue with the therapy ($N=2$). One participant completed the CBT treatment but contracted an illness during the study period, making a post-treatment assessment of ADHD symptom severity impossible ($N=1$).

Regarding CBT group attendance, 20 participants (43%) attended all twelve sessions, and 39 participants (83%) attended ten or more sessions. Mean attendance was 10.7 sessions (SD 1.4).

Medication adherence

A majority of the study participants reported good medical adherence (medication $\geq$ five days a week), at 80.0% in the CBT group and 86.0% in the control group, respectively. Two participants in the CBT group and three in the control group stopped taking their ADHD medication during the trial. Four participants in the CBT group and three in the control group changed their type of ADHD medication during the same period.

Primary outcomes

Between- and within-group differences are presented in Table 4. No differences were observed between the groups regarding post treatment changes in parent-rated (estimated difference -0.08, 95% CI, -2.5 to 2.32, $p=0.95$), self-rated (estimated difference 1.44, 95% CI, -1.65 to 4.52, $p=0.36$) or teacher-rated (estimated difference -1.51, 95% CI, -5.1 to 2.0, $p=0.40$) ADHD symptoms. All three informants reported reduced ADHD symptoms post treatment, with parents and teachers reporting larger symptom reductions than the adolescents. Additional interpretations of the CIs were made to distinguish between negative or inconclusive treatment effects, as recommended by Gewandter et al. [64]. None of the CIs for the ADHD RS-IV parent-, teacher and self-report total scores crossed the 6-point symptom reduction limit, considered a clinically meaningful difference, defined as a 30% symptom reduction from the baseline scores [65]. This strengthens the conclusion of no treatment effect.

Supplementary analyses excluding posttreatment data on five participants in the control group receiving extra intervention, gave substantially the same results for all the outcomes (data not shown). Post-hoc subgroup analyses exploring the potential moderating effects of age, IQ, SES, the severity of anxiety symptoms and ADHD symptoms revealed no significant effect on treatment outcome using parent-rated ADHD symptom scores.

Table 4 Primary and secondary outcome measures. Descriptive statistics at baseline and post-test, as well as estimated treatment effect (coefficient for the interaction term) from the mixed-model analyses

	CBT Group ($n=50$)			Control Group ($n=50$)				Difference (Group x Time)		
Measures	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Estimate**	**95% CI**	***P* Value**	***Standardized* effect size**
ADHD RS-IV Parent total score										
Baseline	48	24.19	9.59	49	25.71	8.09				
Post-treatment	45	19.22	8.67	46	20.74	8.52	−0.08[a]	−2.49 to 2.32	.948	−0.009
ADHD RS-IV Inattention score										
Baseline	49	15.12	5.13	49	15.96	5.07				
Post-treatment	46	12.46	4.98	46	13.22	5.45	0.04[a]	−1.50 to 1.57	.963	0.008
ADHD RS-IV Hyperactive score										
Baseline	49	8.98	5.70	50	9.90	5.35				
Post-treatment	46	6.85	5.12	47	7.62	4.79	−0.15[a]	− 1.47 to 1.16	.821	−0.027
ADHD RS-IV Self total score										
Baseline	44	21.55	9.75	47	21.49	10.15				
Post-treatment	44	19.80	9.88	45	18.67	10.21	1.44[a]	−1.65 to 4.52	.359	0.145
ADHD RS-IV Inattention score										
Baseline	47	12.32	4.99	49	11.31	6.28				
Post-treatment	47	11.09	5.50	46	10.13	6.08	0.61[a]	−1.19 to 2.41	.502	0.108
ADHD RS-IV Hyperactive score										
Baseline	46	9.35	6.10	47	9.96	5.14				
Post-treatment	44	8.82	6.17	46	8.67	5.07	0.51[a]	−1.19 to 2.21	.551	0.091
ADHD RS- IV Teacher total score										
Baseline	28	19.07	10.30	36	17.22	8.54				
Post-treatment	28	14.39	9.88	32	12.66	7.23	−1.51[a]	−5.06 to 2.04	.400	−0.160
ADHD RS- IV Inattention score										
Baseline	28	14.29	6.32	37	12.11	6.14				
Post-treatment	30	10.33	7.01	32	9.28	5.15	−1.76[a]	−3.96 to 0.43	.113	−0.283
ADHD RS- IV Hyperactive score										
Baseline	34	4.68	5.87	37	5,16	5,03				
Post-treatment	29	3.97	4.29	35	3,51	4,28	−0.31[a]	−2.09 to 1.47	.730	−0.057
Clinical Global Impression Severity										
Baseline	50	3.96	0.53	50	3.92	0.67				
Post-treatment	47	3.38	0.82	47	3.40	0.99	−0.02[a]	−0.31 to 0.26	.883	−0.033
Children's Global Assess. Scale										
Baseline	50	62.18	6.98	50	62.12	6.82				
Post-treatment	47	61.30	8.66	47	61.04	10.44	0.03[b]	−3.01 to 3.06	.985	0.004
WFIRS-Parent total mean score										
Baseline	44	0.78	0.39	44	0.80	0.38				
Post-treatment	45	0.69	0.39	46	0.73	0.41	−0.01[a]	−0.13 to 0.10	.817	−0.026
WFIRS-Self total mean score										
Baseline	44	0.83	0.49	44	0.82	0.48				
Post-treatment	43	0.70	0.44	45	0.73	0.52	−0.03[a]	−0.15 to 0.09	.599	−0.062
BRIEF-Parent GEC (T-score)										
Baseline	50	66.40	11.18	50	69.64	9.46				
Post-treatment	46	62.67	11.59	47	65.34	10.53	−0.27[a]	−2.30 to 2.46	.844	−0.026
BRIEF-Self GEC (T-score)										
Baseline	50	63.78	11.44	50	64.02	14.78				
Post-treatment	47	61.40	13.17	46	62.24	13.92	−0.02[a]	−3.35 to 3.32	.993	−0.002

Table 4 (continued)

Measures	CBT Group ($n=50$)			Control Group ($n=50$)			Difference (Group x Time)			
	n	Mean	SD	n	Mean	SD	Estimate	95% CI	*P* Value	*Standardized* effect size
BRIEF-Teacher GEC (T-score)										
Baseline	31	77.71	15.87	37	75.05	15.57				
Post-treatment	31	70.97	17.62	33	70.15	15.32	−3.21[a]	−8.10 to 1.68	.195	−0.204
SCARED										
Baseline	45	21.64	14.33	47	22.09	16.45				
Post-treatment	42	18.79	13.52	43	20.01	15.04	.97[a]	−2.92 to 4.85	.622	0.063
Short Mood and Feeling Q.										
Baseline	50	7.96	6.82	49	9.15	6.95				
Post-treatment	47	7.63	6.11	47	7.45	6.42	1.07[a]	−0.89 to 3.03	.284	0.155
General Perceived Self-Effic. Scale										
Baseline	49	27.56	5.22	49	28.04	5.05				
Post-treatment	47	29.21	4.13	47	29.12	5.84	0.46[b]	−1.13 to 2.04	.571	0.090
Rosenberg Self-Esteem Scale										
Baseline	50	28.14	6.57	49	28.64	6.87				
Post-treatment	47	29.47	5.89	47	29.15	6.80	0.70[b]	−0.74 to 2.13	.338	*0.104*
Adolescents' Sleep-Wake Scale										
Baseline	49	2.76	0.39	49	2.76	0.53				
Post-treatment	46	2.75	0.37	47	2.85	0.49	−0.06[b]	−0.21 to 0.09	.435	*−0.130*

Note: Baseline study inclusion *ADHD-RS* Attention-Deficit/Hyperactivity Disorder Rating Scale, *WFIRS* Weiss Functional Impairment Rating Scale, *BRIEF* Behaviour Rating Inventory of Executive Function, *SCARED* Screen for Child Anxiety Related Emotional Disorders, *GEC* General Executive Composite. [a] a negative difference estimate is in favour of the CBT group and a positive estimate is in favour of the control group. [b]a positive difference estimate is in favour of the CBT group and a negative estimate is in favour of the control group. The standardized effect size equals the estimate divided by the average standard deviation at baseline

Secondary outcomes

No differences were observed between the CBT group and the control group regarding symptom impairment, functional impairment, executive functions, emotional symptoms, self-efficacy, or self-esteem (see Table 4). Within-group differences revealed reduced symptom severity in both groups on the IE-rated CGI-S symptom severity scale, the parent- and self-rated WFIRS-scales and the BRIEF parent, self- and teacher reports. The IE-rated C-GAS score did not improve post treatment in either group.

Discussion

Treatment guidelines for ADHD recommend multimodal interventions, including psychoeducation and pharmacological treatment in young people with moderate to severe symptoms [12, 13]. Many patients find this combined treatment insufficient in alleviating their symptoms however, indicating a need for complementary treatments. The NICE guidelines consider CBT as a treatment option for young people with continued impairment after medication [12]. Although, behavioural interventions are considered well established for children with ADHD, this categorization has been limited to organization training for young adolescents (15 years and younger) with ADHD. CBT based interventions directed at adolescents with parent involvement were classified as probably efficacious in a review by Evans et al. [14]. Trials of CBT interventions targeting older adolescents (15 years and older) are limited, however preliminary results from a study of individualised CBT by Sprich et al. [16] and a group CBT by Vidal et al. [25] showed preliminary positive results. Our study thus aimed to assess the efficacy of a group CBT as a follow-up treatment for adolescents who still presented ADHD symptoms and functional impairments, after previously having received a psychoeducational intervention and medication.

In contrast to our hypothesis, the additional group CBT program could not demonstrate an incremental treatment effect as compared to the control condition. Indeed, previous studies of CBT with adolescents found larger post-treatment reductions in ADHD symptoms and improved functional impairment as compared with medicated waitlist controls [16, 25]. In our study, the participants received psychoeducation and pharmacological treatment, interventions recommended by ADHD treatment guidelines, prior to additional CBT. The ADHD symptoms at baseline were thus somewhat lower than in comparable studies [16, 25]. Another reason for the lower baseline scores could be an actual difference in

populations (more females, less hyperactivity symptoms and few participants with comorbid ODD). Although our CAP standard intervention may in part explain a lack of treatment effect regarding ADHD symptoms compared to studies including participants with more severe symptoms, it cannot explain the nonsignificant effect of group CBT as compared to the control condition. However, the result is consistent with findings from other studies of youth directed psychosocial treatments without parent involvement [66, 67]. These findings suggest that a more focused and/or individually targeted intervention with the inclusion of parents, similar to the evidence-based treatment programs by Sprich et al. [16], and Sibley et al. [17], could be more effective for this patient group.

However, several questions remain. First, the mean age of our study population was 15.8 years (SD = 1.3), and somewhat younger than the mean age of 17.2 (SD = 1.8) years in a comparable CBT group study by Vidal et al. [25]. Perhaps, the group format is more appropriate for older adolescents or young adults, who are more mature and thus more able to incorporate CBT principles and strategic tools into their daily lives. Second, our treatment program contains eleven modules, with new concepts and skills being introduced over a brief period. Although we consider all the modules relevant when treating adolescents with ADHD and comorbid conditions, such a comprehensive program leaves little time to practice new skills. Based on the adolescents` own report, only one third of the homework assignments was completed. This lower-than-expected completion rate may be explained by too little time to practice new strategies in and between sessions. Because practising new skills is considered a prerequisite for change, this may have contributed to lack of treatment effect. Another hypothesis explaining the low homework adherence may be a more general "lack of motivation" to work between sessions. This pattern was observed across themes and participants and was reported by both group-leaders in checklists and by descriptions from the research assistants talking to the participants between session. These observations suggests a particular challenge working with adolescents with ADHD who often struggle with poor decision making and poor insight into own functioning [68]. The inclusion of more engagement-focused components such as a more systematic exploration of goals and values, a stronger emphasis on motivational interviewing techniques [69] to target out-of-session skills application, and an even stronger emphasis on rewards to improve homework adherence using contingencies based treatment (with the help of parents), could have enhanced treatment engagement [70, 71]. Following this, parent involvement is considered an important treatment component in other programs focusing on helping adolescents with ADHD who struggle with organization, time management and planning for homework assignments [16, 24, 72]. As such, the inclusion of parents in the CBT program could have improved treatment outcome. Third, the parents`- and teachers` BRIEF scores indicated executive dysfunction (T > 65) across groups at baseline. The adolescents reported symptoms just below this cut-off. Although these scores were reduced post-treatment, they still indicated ongoing impairment in both groups. This result pinpoints a need for more extensive training in planning, organisation, and time management over several sessions, as suggested in both school-based behaviour studies [19, 21] and clinic-based CBT studies [17, 24]. Fourth, a structured group format makes it harder to follow up on each participant and individual treatment goals. This could be addressed with the inclusion of an early parallel individual session, working on a case formulation in agreement with the adolescent and thereafter gradually openly sharing each one's problems in the group. Fifth, our CBT program did not alleviate symptoms of anxiety. This was similar in the study by Vidal and colleagues [25] and suggests a need for more extensive treatment to reduce these symptoms. An RCT by Emilsson et al. [73] found an integrated group and individual CBT program to alleviate both ADHD symptoms and comorbid conditions in adults with ADHD. Such a combined model should be studied in future studies of adolescents with comorbid emotional and behavioural conditions.

This study is to the best of our knowledge, the first RCT to explore the efficacy of a group CBT as follow-up treatment for adolescents with impairing ADHD symptoms who previously received medication and psychoeducational interventions. Strengths of this study include the use of a control condition, the use of blinded evaluators and treatment fidelity ratings. In addition, the use of multiple informants, with self-, parent- and teacher ratings, is considered a strength in terms of the evaluation of the treatment effect. Furthermore, the inclusion of diverse outcome measures covering functional impairment, executive functions, and psychiatric symptoms paints a broader picture of areas in which CBT may have potential treatment effects. Finally, the study was delivered in a real-world setting using clinical staff and covering a total catchment area.

This study has several limitations. First, the large number and low dosage of treatment components caused restricted time to practice each module, which may have affected the treatment outcome. Second, 91% of the population was on pharmacological treatment for ADHD, limiting the study's generalisability to non-medicated patients. Third, although most study participants fulfilled the diagnostic criteria for an ADHD

diagnosis at inclusion, 34% of the participants presented subthreshold ADHD symptoms prior to study inclusion, thus limiting the room for further improvement. Fourth, although the treatment fidelity and deliverance of the CBT program was acceptable, the CBT experience and background of the group leaders varied, which may have affected treatment outcome. Fifth, the socioeconomic status (SES) of the participants was higher than in a typical ADHD population [74, 75], which limits the generalisability of the results to populations with lower SES. Sixth, even though more boys than girls receive an ADHD diagnosis at the CAP clinics [76, 77], girls were easier to recruit for this study, and represented 57% of the population. Boys with comorbid behaviour disorders were particularly hard to recruit, which may suggest that individual- or family-based interventions are more appropriate for this patient group [14]. Seventh, data on homework completion was incomplete, leaving little room for analyses on its impact on treatment effect. Also, there were substantially fewer teacher ratings than self- and parent ratings. This is considered a limitation since their ratings may represent unbiased observations that add to the more proximate and potentially biased parent observations.

Even though our CBT program revealed no overall incremental treatment effect as compared to the control condition, the participants receiving group CBT were positive about joining the program, and dropout rates were low [38]. Future research should examine whether CBT-based treatment programs with parent involvement, focusing on core ADHD symptoms and executive functions that include individualised skills training, contingency management and MI components would be even more effective for this patient group, similar to the clinic-based programs by Sprich [16], Sibley [17] and Boyer [24]. These components are included in an evidence-based psychosocial treatment model for younger adolescent with ADHD [14, 17], but were not included in the current treatment model.

Although treatment guidelines recommend CBT as additional treatment for ADHD in adolescents who still experience functionally impairing symptoms after receiving psychoeducation and medical treatment [12], more research is needed to support the effect of CBT as an adjunct to medication and a historic previous psychoeducation (mean years = 1.8). The guidelines might be clarified to highlight that not all CBT is created equal and that behavioral and cognitive behavioral interventions that include individualized skills training coupled with parent involvement rather than a group program without parent involvement, is the primary evidence-based model for this adolescent age group [16, 17, 21].

Conclusions

To our knowledge, this RCT is the first study to assess the efficacy of a group CBT as addition to pharmacological treatment and psychoeducational intervention in adolescents with ADHD symptoms and related impairments. In this study the group CBT did not show an incremental effect as a follow-up treatment after a CAP standard clinical intervention. Further studies are warranted to explore the efficacy or effectiveness of a more focused group CBT intervention as addition to medication and psychosocial interventions, and preferably with parents involved. It is also relevant to explore whether more individualised CBT treatment, in a group or individual setting, may be more effective than a standardised program intended to fit all.

Abbreviations

ADHD: Attention-Deficit/Hyperactivity-Disorder; ADHDRS- IV: ADHD Rating Scale IV; BRIEF-P/—S: The Behaviour Rating Inventory of Executive Function parent report and self-report; CBT: Cognitive Behavioural Therapy; CAP: Child and Adolescent Psychiatry; CAS-CBT: The Competence and Adherence Scale for Cognitive Behavioural Therapy; CGAS: Children's Global Assessment Scale; CGI-S: Clinical Global Impression Scale for Severity; CI: Confidence Intervals; CONSORT: Consolidated Standards of Reporting Trials; DSM-5: the Diagnostic and Statistical Manual of Mental Disorder 5th edition; ICC: Intraclass Correlation Coefficient; ICD-10: The International Statistical Classification of Disease and Related Health Problems 10th version; IE: Independent evaluator; ITT: Intention-to-treat; Kiddie-SADS-PL: the Schedule for Affective Disorders and Schizophrenia for school age children-Present and Lifetime Version; MI: Motivational interviewing; NICE: National Institute for Health and Care Excellence; RCT: Randomised Controlled Trial; WAIS-IV: the Wechsler Adult Intelligence Scale IV; WISC-IV: the Wechsler Intelligence Scales for Children IV; YBP: Young Bramham programme.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12888-022-04019-6.

Additional file 1.

Additional file 2.

Additional file 3.

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Authors' contributions

The main research team undertook the research design: TSN, AMS, PHT and SL. AJH, TSN and SY contributed to the CBT treatment manual, and AJH and TSN participated in the gathering of the data. AMS supervised the therapists in the study, while TSN, PHT and SL supervised the first author. SL was the statistical expert in this study; AJH performed the statistical analyses with the supervision of SL. All authors read and provided substantial contributions to the paper and approved of the final version of the manuscript.

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Availability of data and materials
The datasets used in the current study are not publicly available due to privacy policy, but they will be made available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Written informed consent was obtained from adolescents and parents before enrolment into the study (parents signed the forms for participants under 16 years). In the case of dropouts, the participants were asked to consent to the use of the baseline data. The study was approved by the Regional Committee for Medical and Health Research Ethics in Southeast Norway (2015/2115). The study was conducted according to the principles set forth in the Declaration of Helsinki from 1964 and later amendments. The study was also performed and reported according to CONSORT guidelines [78] (see checklist in supplemental material).

Consent for publication
Not applicable.

Competing interests
PHT has received speaker's fees from Medice and Shire in the last three years. TSN has received a speaker's fee from Medice during the last three years. SY has received honoraria for consultation and/or educational talks in the last 5 years from Janssen, HB Pharma, Shire and Medice. AMS has received travel support and a congress fee from Medice in the last three years. AJH has received travel support and a speaker's fee from Medice in the last year, SL declares no conflicts of interest.

Author details
[1]Department of Mental Health, Faculty of Medicine and Health Sciences, Regional Centre for Child and Youth Mental Health and Child Welfare (RKBU), NTNU- Norwegian University of Science and Technology, Trondheim, Norway. [2]Department of Child and Adolescent Psychiatry, St. Olav University Hospital, Trondheim, Norway. [3]Psychology Services Limited, London, UK. [4]Department of Psychology, University of Reykjavik, Reykjavik, Iceland. [5]Department of Child and Adolescent Psychiatry, Aarhus University Hospital, Aarhus, Denmark.

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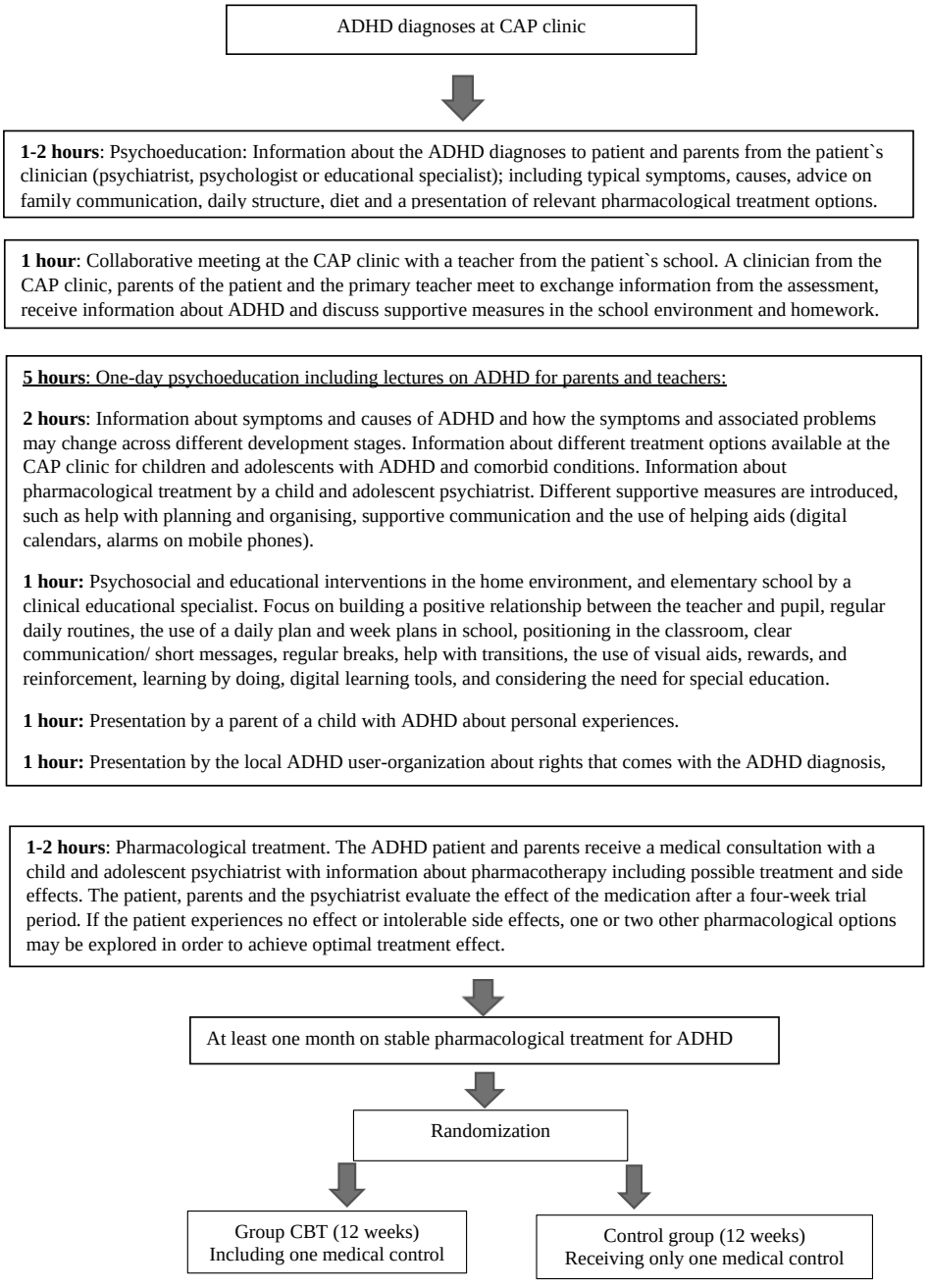
Supplementary material: Paper II

Additional file 1

Description of the CAP Clinic intervention program before randomization to CBT group treatment or the control condition.



Additional file 2

Mean daily doses of medication among participants

ADHD medication and treatment group	Daily dose (mg) Mean	(SD)	Daily dose (mg) Range
Methylphenidate			
CBT group n= 29	43.0	10.3	20-65
Control group n= 30	48.7	10.0	27-63
Lisdexamfetamine			
CBT group n= 8	53.8	18.5	30-80
Control group n=11	42.7	16.2	30-70
Atomoxetine			
CBT group n=6	66.7	15.1	40-80
Control group n=2	57.5	10.6	50-65
Guanfacine			
CBT group n= 1	1.0	--	1.0
Control group n=3	3.7	1.5	2-5

Note: ADHD = attention-deficit hyperactivity disorder

Additional file 3

Background of the CBT group program

The CBT program was an adaptation of the CBT program of Young and Bramham (2012), which was developed to treat adolescents and adults with ADHD by providing cognitive behavioural therapy (CBT) to treat core symptoms of the condition and its associated problems. The program consists of stand-alone modules that can be delivered in individual, or a group format. We developed the CBT program in collaboration with Dr Susan Young to fit an adolescent population in a group format (90-minute sessions for 12 weeks).

The CBT program has two primary aims; to encourage people with ADHD to change their environment and optimize functioning (to change from the outside in), and to develop psychological strategies for adaptive functioning (to change from the inside out).

The program includes psychoeducation to inform the client about the diagnosis, treatment and prognosis of the disorder and therapeutic techniques (cognitive behavioural therapy, cognitive remediation, restructuring and reframing, rationalization) to address core symptoms, comorbid and associated problems.

Each module (or session in this RCT) follows a standard format providing a general introduction to the topic, followed by a group discussion, where the adolescents present their experienced difficulties or functional impairment related to this theme. The group leaders use handouts to assess the individual problems of the participants (self-ratings), and different treatment strategies including specific cognitive behavioural strategies and techniques that address the problems are presented for the group. Next, strategies are rehearsed either individually or in pairs, and then shared and discussed with the group. At the end of each session, all participants get home assignments related to the session`s topic. They write down their targeted assignment to rehearse and practice new skills until the next session. The next session starts with a follow-up of the weeks` assignments, where each participant presents their experience practicing the new skills with the group. Potential obstacles to practice or achieve the new goal are addressed.

Coaching: Each week a research assistant telephoned the participants to check if they had done their week assignment or experienced any difficulties with the assignment. The “coach`s” role was to motivate the participant and address ambivalence.

The content of the CBT group program

Background and treatment

Session 1: Orienting participants to the program, including content, structure, and the basic CBT principles. Participants receive psychoeducation about ADHD and write down individual treatment goals.

Core symptom modules

Session 2: Attention: Various forms of attention and the impact of motivation, anxiety and stress are introduced and discussed. Various attention control strategies are presented and rehearsed in session. We introduce external strategies that may be applied to adapt to the environment to minimize distraction and introduce strategies to optimize performance such as goalsetting, breaks, incentives, and rewards.

Session 3: Memory: The various memory systems are introduced, and individual memory problems are identified (handouts). External memory strategies (such as the use of diaries, electronic devices

and alarms) and internal memory strategies (such as repetition, rehearsal, visual cue and use of mnemonics) are presented. Memory games and exercises are practiced within the group.

Session 4: Organizing and time-management: Consequences of dysfunctional planning and time-management are discussed. A methodical approach to make plans is presented by reviewing goals for a set time period (short and long-term), listing activities, devising a schedule, prioritizing activities, and planning breaks and rewards. We also include methods for avoiding pitfalls, such as ways of maintaining attention on task, advice regarding reviewing priorities and avoiding procrastination.

Session 5: Impulsivity: We address behaviours that are often closely linked to a low tolerance of boredom, feelings of frustration, a preference for short-term rewards and an inability to delay gratification. Consequences of having low self-control are introduced and discussed. Self-monitoring techniques are introduced to identify situations in which adolescents are vulnerable to responding in an impulsive way. Various impulse control strategies are introduced (including stop-and-think techniques, self-talk and distraction techniques) and rehearsed in roleplays.

Comorbid and associated problem modules

Session 6: Problem solving: The participants learn how to define problems, generate solutions, evaluate solutions, and consider alternatives. A methodology for choosing solutions is introduced through the rehearsal of solution to evaluate consequences. We rehearse in session, and finally, we evaluate the level of success.

Session 7: Anxiety: We address the generalized and social anxiety problems commonly seen in adolescents with ADHD. The CBT principles from session 1 are repeated (the three-legged table is reintroduced) and we present methods to re-interpret common responses to anxiety by evaluating thoughts, feelings, behaviors, and bodily reactions. A version of the cognitive behaviour model of panic (Clark, 1986) is presented and strategies for intervention, including relaxation and breathing exercises. We suggest ways to overcome avoidance and increase confidence by applying techniques of graded exposure, systematic desensitization, and behavioural experiments.

Session 8: Low mood and depression/ sleep management: We introduce a cognitive model of depression (Beck 1976) that incorporates negative thinking and thinking errors common to adolescents with ADHD. We suggest how to break the negative cycle and introduce strategies that include activity scheduling, techniques to challenge negative automatic thoughts and introduce positive self-talk. Psychoeducation about sleep and sleep strategies including advice on sleep hygiene and relaxations techniques are introduced.

Session 9: Interpersonal relationships and communication: We address disruption to interpersonal relationships that may be a problem for adolescents with ADHD. We focus and rehearse verbal and nonverbal communication strategies, and how to modify and regulate social behavior in different social settings.

Session 10: Frustration and anger management: Consequences of bad anger management are discussed. We introduce various management strategies, including self-talk, distraction techniques, reframing the situation and relaxation.

The future module

Session 11-12: Preparing for the future: We present and discuss the challenges of having ADHD in the transition to young adulthood. We summarize some of the techniques introduced in the previous modules, and each participant sum up those strategies they found the most helpful. We discuss the participants' future goals and which skills and support networks that can be used to achieve them.

Each participant receives positive feedback on their achievements related to individual treatment goals and their contribution in the group by the group members and the group leaders.

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EDITED BY
Kerstin Jessica von Plessen,
Centre Hospitalier Universitaire Vaudois (CHUV), Switzerland

REVIEWED BY
Javier Fenollar Cortés,
Loyola University Andalusia, Spain
Yulia Solovieva,
Meritorious Autonomous University of Puebla, Mexico

*CORRESPONDENCE
Anne-Lise Juul Haugan
anne-lise.j.haugan@ntnu.no

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Executive functions mediate the association between ADHD symptoms and anxiety in a clinical adolescent population

Anne-Lise Juul Haugan[1]*, Anne Mari Sund[1,2], Per Hove Thomsen [1,3] Stian Lydersen[1] and Torunn Stene Nøvik [1,2]

[1]Department of Mental Health, Regional Centre for Child and Youth Mental Health and Child Welfare (RKBU), Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology (NTNU), Trondheim, Norway, [2]Department of Child and Adolescent Psychiatry, St. Olav University Hospital, Trondheim, Norway, [3]Department of Child and Adolescent Psychiatry, Aarhus University Hospital, Aarhus, Denmark

Objective: Attention-deficit/hyperactivity disorder (ADHD) is associated with a high prevalence of anxiety disorders in children and adolescents. The reasons for this association are poorly understood. Preliminary findings with young adults have suggested that executive functions and functional impairment may mediate the relationship between symptoms of ADHD and mixed anxiety and depressive symptoms. The objective of this study was to explore whether ADHD symptoms, executive functions and functional impairment predict anxiety in a clinical adolescent population. In addition, we investigated the possible mediating role of executive functions and functional impairment in this relationship.

Method: One hundred adolescents with ADHD and their parents completed the ADHD Rating Scale IV (ADHD RS-IV), the Behavior Rating Inventory of Executive Function (BRIEF), and the Weiss Functional Impairment Rating Scale (WFIRS) in relation to an RCT study. The adolescents also completed the Screen for Child Anxiety-Related Emotional Disorders (SCARED). Analyses were conducted using regression and a serial multiple mediator model.

Results: In the regression analyses, parent-rated ADHD symptoms were unable to predict anxiety, but ADHD inattention symptoms predicted anxiety in the self-ratings. Executive dysfunction and functional impairment predicted anxiety in both the parent- and self-reports. In the mediation analyses ADHD symptoms alone did not predict anxiety, but executive dysfunction mediated this relationship as expected. Functional impairment mediated this relationship indirectly through executive functions. The results were similar in the parent- and self- reports.

Conclusion: The results pinpoint executive dysfunction as an important treatment target for alleviating anxiety in adolescents with impairing ADHD symptoms.

KEYWORDS

attention-deficit/hyperactivity disorder, executive functions, functional impairment, adolescents, anxiety

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders in childhood (1) and is characterized by developmentally inappropriate levels of inattention, hyperactivity and impulsivity that lead to impairment in at least one life domain (2). Through adolescence, symptoms of ADHD typically impair functioning in various contexts, such as school, social settings, and emotional wellbeing. Comorbid psychiatric conditions are common in this patient group, and anxiety, depression, conduct disorders and substance misuse are among the most common disorders (3–5). Although pharmacological treatment for ADHD has shown beneficial effects on core ADHD symptoms as well as improvements in functional impairment and health-related quality of life (6, 7), the lack of data on longer-term treatment effects makes it unclear whether the changes in health-related quality of life are mediated by symptom changes, changes in functional impairment or other factors.

Anxiety disorders (ADs) are among the most prevalent disorders in child and adolescent populations, and ADHD and AD are comorbid with each other in 25–50% of cases (8–10). This comorbidity rate is greater than chance and is still present after controlling for overlapping symptoms, such as difficulty concentrating and restlessness (11, 12). The presence of both disorders is associated with more attentional problems, school fears and lower social competence than the presence of either ADHD or anxiety alone (8). While there is evidence of a prospective relationship between ADHD and AD across development, the reasons for this association are still unclear. Previous studies have suggested a specific relationship between the ADHD inattentive type and anxiety (9, 13, 14). Similarly, ADHD patients with sluggish (slow) cognitive speed have shown more internalizing symptoms, such as anxiety and depression, than patients with the hyperactive or combined subtype of ADHD (15, 16). Jensen et al. (17) found that anxiety reported in ADHD populations may differ from anxiety in non-ADHD populations, with concerns about competency and performance being the more common components rather than specific phobias *per se*. This form of anxiety has been suggested to arise primarily when one's cognitive processing abilities are overwhelmed by the demands of the environment (18). Following from this, two possible factors linking ADHD and anxiety are executive functions (EFs) and functional impairment. EFs represent higher-order cognitive processes that help us achieve our daily goals (19–21). EFs are mainly supported by the prefrontal cortex and typically include planning skills, response inhibition, mental flexibility, working memory, initiation and set shifting (22). Dysfunctional EFs may prevent the acquisition and implementation of skills, leading to difficulties handling everyday challenges related to academic functioning (23), interpersonal problems (24), and mental health (25–27). Although dysfunctional EFs are common in ADHD and have been hypothesized to underlie the functional impairments related to this disorder (28, 29), these cognitive dysfunctions are not restricted to ADHD but are rather common in various psychiatric disorders, including mood disorders and ADs (30, 31).

Previous research with university students with ADHD has demonstrated that executive functions may predict functional impairments. Dvorsky and Langberg (32) showed that executive functions, including motivation and emotional regulation skills mediated the association between ADHD symptoms and overall daily functioning. They also found organizational skills to mediate the association between ADHD symptoms and academic achievement rated by grade point average. Dorr and Armstrong (33) found that high executive functions were related to lower levels of functional impairment in patients with low ADHD symptoms, but high EF was not associated with low functional impairment in a sample of university students with a high level of ADHD symptoms. Research conducted with adolescents with ADHD has demonstrated that dysfunctional EFs are related to multiple domains of impairment even after controlling for symptoms of ADHD (23, 34). In particular, the metacognitive aspects of EFs (e.g., mental flexibility, planning and organization) have proven salient for school functioning and homework completion in this age group (34, 35). As children and adolescents with ADHD experience functional impairment in multiple domains, including school, the social arena and family life, they are also more vulnerable to developing low self-esteem. In addition, they are more often involved in risky behavior than their non-ADHD peers (36). Since functional impairment and the accompanying feeling of incompetence may trigger stress and anxiousness, it is important to explore the role of functional impairment in the ADHD-anxiety relationship, as this may guide our understanding of underlying mechanisms for this association and help us develop more targeted treatment interventions for this patient group.

To our knowledge, only one published study has explored the relationship between symptoms of ADHD and mixed anxiety and depressive symptoms with a particular emphasis on EFs and functional impairment. In this study, EFs and functional problems explained 42 to 53% of the variance in mixed anxiety and depressive symptoms in a population of university students (37). A limitation of this study was the lack of a systematic diagnostic assessment in the population.

The aim of the present study was thus to explore whether ADHD symptoms, executive dysfunction and functional

Abbreviations: ADHD, Attention-deficit/hyperactivity disorder; ADHD-RS IV, ADHD Rating Scale IV; BRIEF, The Behavior Rating Inventory of Executive Function; CAP, Child and Adolescent Psychiatry; CI, Confidence Intervals; EF, Executive Functions; GAD, Generalized Anxiety Disorder; SCARED, The Screen for Child Anxiety-Related Emotional Disorders; WFIRS-P/-S, Weiss Functional Impairment Rating Scale parent-report/self-report versions.

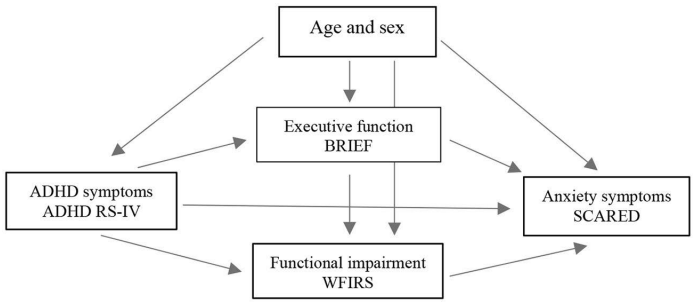

FIGURE 1
Hypothetic relationships among ADHD symptoms, functional impairment, executive dysfunction, and anxiety symptoms with the accompanying measurements. Age and sex are potential confounders.

impairment predict anxiety in a clinical adolescent population. Specifically, we hypothesize that the effect of ADHD symptoms on anxiety is to some extent mediated through EF or functional impairment (see Figure 1). Based on previous results (37), we expected both EFs and functional impairment to have a mediating effect on the ADHD-anxiety relationship.

Method

Study design and procedure

This observational study was conducted in Mid-Norway. The data were derived from a randomized controlled trial (RCT) examining the efficacy of cognitive behavioral group therapy as a follow-up treatment in a sample of adolescents with ADHD who previously received a short psychoeducational intervention and were medicated but still presented impairing ADHD symptoms (38). We refer readers to this published study and the study protocol for more details about the procedures (38, 39). Recruitment and data collection began in February 2017, and the last data were collected in September 2019. Written informed consent was obtained from the adolescents and from parents for participants under 16 years of age. The questionnaires were completed under the surveillance of a research assistant. Parent-rated questionnaires were completed by the primary caregiver, usually the mother. The study was approved by the Regional Committee for Medical and Health Research Ethics in Southeast Norway (2015/2115). The present study uses baseline data from the RCT.

TABLE 1 Characteristics of the participants ($n = 100$).

Characteristic	M (SD)
Age, years	15.8 (1.3)
Full-scale IQ ($n = 86$)	93.9 (13.0)
Characteristic	***n* = %**
Male patients	43
ADHD presentation (Kiddies-SADS-PL)	
ADHD-Predominantly inattentive	35
ADHD-Predominantly combined	31
Subtreshold ADHD	34
Medication	
[a]ADHD medication	91
[b] Other pharmacological treatment	7
[c] **Psychiatric comorbidities**	
Anxiety disorders	37
Posttraumatic stress disorder	1
Depressive disorder NOS/ Dysthymic disorder	11
Obsessive compulsive disorder	3
Tics disorder or Tourette's disorder	9
ODD/ Disruptive behavior disorder NOS	11
Learning Disorders, reading disorders or mixed	18

M mean, SD, standard deviation; Full scale IQ Wechsler Intelligence Scale for Children or Adults (WISC-IV, WAIS-IV), ADHD attention deficit/hyperactivity disorder, [a]ADHD medication includes methylphenidate, lisdexamfetamine, atomoxetine, and guanfacine. [b]Other pharmacological treatment includes neuroleptic medication; risperidone, quetiapine; anti-epileptic medication: valproate, lamotrigine. [c]Psychiatric comorbidities are based on Kiddie-SADS-PL interview with the adolescents and converted to DSM-5 diagnoses. ODD, Oppositional Defiant Disorder; NOS, Not Otherwise Specified.

Participants

See Table 1 for the participant characteristics. The participants were between the ages of 14 and 18 years and were recruited from two outpatient child and adolescent psychiatry (CAP) units at St. Olavs Hospital. The participants had received a prior diagnosis of hyperkinetic disorder by

a certified psychologist or a psychiatrist according to the International Statistical Classification of Disease and Related Health Problems (ICD-10) criteria (40). The assessment and diagnosis of hyperkinetic disorder requires a thorough clinical assessment, including a developmental history, a somatic assessment, and an examination of comorbid psychiatric disorders, and the use of questionnaires to assess ADHD symptoms (ADHD rating scale), which were completed by adolescents, parents, and teachers. The diagnostic criteria for hyperkinetic disorder in ICD-10 resemble the criteria for ADHD combined presentation in the Diagnostic and Statistical Manual of Mental Disorder 5th edition (DSM-5). According to Norwegian ADHD guidelines (41), hyperkinetic disorder may also be diagnosed in patients with severe inattention symptoms, similar to the DSM-5 ADHD inattentive type. At study enrolment, each participant was interviewed with the Schedule for Affective Disorders and Schizophrenia for School Age Children-Present and Lifetime Version (Kiddie-SADS-PL) at the CAP units to confirm the ADHD symptoms and assess psychiatric comorbidity. The ADHD symptoms were confirmed by a parent rater within the last 3 years of inclusion for 94% of the population. Ninety-one percent of the participants were receiving pharmacological treatment for ADHD. Ninety-two percent had previously received a short psychoeducational intervention of 1–5 h, which typically consisted of information about ADHD diagnosis, symptoms, causes, and treatment options delivered by the patient's clinician to the patient with and/or without parents. Parents and a schoolteacher of each participant were also offered a standardized full-day lecture, with information about ADHD, pharmacotherapy, psychosocial interventions, and school interventions. Seventy-two percent of the participants attended this lecture. All the participants had previously had a collaborative meeting with the patient's parents and a schoolteacher to discuss supportive measures in school. These interventions were all completed before the baseline collection of data used in the present study.

The socioeconomic status (SES) of the participants refers to the highest level of education reported by one or both parents (n = 75, 75%). This information was retrieved from the participants' medical records. Nineteen percent reported that they had an education lower than elementary school or 1–2 years of high school (0–11 years), seven percent completed high school and/or 1 year of training after high school (12–13 years), thirty percent had an academy or university degree for up to 4 years (14–15 years), and nineteen percent confirmed an academy/university degree for 4 years or more (16 years and more).

Measures

ADHD symptoms

The ADHD Rating Scale IV (ADHD RS-IV) (42) was used to measure the ADHD symptoms of the participants. We used the parent and self-report versions in this study. The ADHD RS-IV is an 18-item scale that assesses nine symptoms of inattention and nine symptoms of hyperactivity. The items correspond to the DSM-5 ADHD diagnostic criteria, including the combined and predominantly inattentive and hyperactive presentations. Item responses are scored from 0 = not at all to 3 = very often, with higher scores indicating more symptoms. The questionnaire has been validated for patients with ADHD aged 6–18 years across several European countries, including Norway, with impressive evidence for cross-factorial cultural validity, internal consistency, and convergent and divergent validity (43). Cronbach's $\alpha = 0.78$ to 0.81 on the ADHD RS-IV parent version and 0.80 to 0.84 on the self-report version were reported in the present study.

Anxiety symptoms

The Screen for Child Anxiety-Related Emotional Disorders (SCARED) (44) was used to measure anxiety symptoms. The SCARED is a 41-item self-report screening instrument that measures anxiety symptoms in children and adolescents aged 8 to 18 years. In addition to a total scale score, the instrument contains five subscales representing diagnostic symptoms of panic disorder, generalized anxiety, separation anxiety, social phobia, and school phobia. Item responses are scored from 0 = not at all to 2 = often, and a total score $\geq$ 25 may indicate the presence of an anxiety disorder (45). The SCARED has shown good internal consistency and moderate parent-child correlations. The instrument is sensitive to detecting specific and/or comorbid anxiety diagnoses in children and adolescents (45). A study among Norwegian high school students found acceptable internal consistency (Cronbach's $\alpha = 0.62$ to 0.87) for the SCARED subscales (46). Cronbach's $\alpha = 0.95$ for the SCARED total score was reported in the current study.

Executive functions

The Behavior Rating Inventory of Executive Function (BRIEF) (22) assesses EF behaviors in children and adolescents at home and at school. The BRIEF includes an 86-item parent version (BRIEF-P) for children and adolescents aged 6–18 years and an 80-item self-report (BRIEF-SR) for children and adolescents aged 11–18 years (47). Both questionnaires contain a metacognitive index (MI), a behavior regulation index (BRI) and a global executive composite (GEC) score that represents the total scale score. The BRIEF-P and BRIEF-SR contain the following MI subscales: working memory, planning/organizing, organization of material and task completion. The BRI includes the following subscales: inhibit, shift and emotional control. Item responses are scored from 0 = not true to 2 = very true, with higher scores representing more severe dysfunction. According to the BRIEF manual, a total T-score above 65 indicates executive dysfunction. In this study, we used the

MI, BRI and GEC scores. The BRIEF-P has shown good psychometric properties in a Norwegian child and adolescent population (48). Fallmyr and Egeland (48) found the Norwegian and American norms to be compatible, the questionnaire showed a good ability to discriminate between a normative population and a clinical ADHD population, and the internal consistency was acceptable (Cronbach's $\alpha = 0.76$ to 0.92). The BRIEF-SR has shown acceptable psychometric properties in an American adolescent population, with $\alpha = 0.96$ for the GEC and $\alpha = 0.72$ to 0.96 for the clinical scales. Interrater reliability between the GEC of the BRIEF-P and the GEC of the BRIEF-SR was strong ($r = 0.56$) (47).

Functional impairment

The Weiss Functional Impairment Rating Scale parent-report (WFIRS-P) and self-report (WFIRS-S) versions (49) assess functional impairment in different domains typically affected in ADHD. The WFIRS-P and WFIRS-S consist of 50 and 69 items, respectively, divided into six and seven domains of impairment. The domains include family, school and learning, life skills, self-concept, social activities, and risky activities. The WFIRS-P and WFIRS-S are not parallel forms, but there are many parallel items. Item responses are scored from 0 = not at all to 3 = very often and 4 = not applicable, with higher scores indicating more impairment. In this study, a total mean score was calculated, representing the sum of the mean domain scores. Items with a missing or "not applicable" response were omitted. Any domain with a mean score > 1.5, two items with a score ≥ 2, or one item with a score $= 3$ is considered clinically impaired. The WFIRS scales have shown acceptable psychometric properties in a Norwegian adolescent ADHD population (50). In the present study, Cronbach's α was $r = 0.62$ to 0.88 for the WFIRS-P subscales and 0.70 to 0.92 for the WFIRS-S subscales.

Statistical analyses

We conducted regression analyses to analyse the individual contributions of parent-rated and self-rated ADHD symptoms, executive dysfunction, and functional impairment to the severity of adolescent-rated anxiety symptoms in separate analyses. First, the ADHD RS-IV total score; the ADHD RS inattentive and the hyperactivity subscale scores; the BRIEF GEC, BRI and MI indices; and the WFIRS total score were entered one by one as independent variables, with the SCARED total score as the dependent variable. Second, to explore which of the subscales or indices from the ADHD RS-IV and the BRIEF questionnaire that predict anxiety the most while controlling for the other questionnaire subscale, we carried out two separate regression analyses: first with the two ADHD RS-IV subscales simultaneously and second with the two BRIEF indices simultaneously. Multicollinearity was checked to avoid high correlations ($r = 0.70$ and above) between the independent variables, as recommended by Dormann et al. (51). The normality of residuals was checked by visual inspection of QQ plots.

To explore whether EFs and functional impairment act as mediators in the association between ADHD symptoms and anxiety, we conducted a serial multiple mediator model recommended by Hayes (52) using the PROCESS macro for IBM SPSS (www.processmacro.org). The PROCESS command generates bootstrap confidence intervals (CIs) for all indirect effects as well as possible pairwise comparisons between indirect effects. We used 5,000 bootstrap samples. The ADHD RS total score was entered as the predictor variable (X), the BRIEF GEC score was entered as the first mediator (M^1), and the WFIRS total score was entered as the second parallel mediator (M^2) (see Figures 2, 3). The adolescent- rated SCARED total score was the outcome variable in both mediation analyses. The analyses were conducted using parent- and self-report questionnaires in separate analyses. Age and sex were considered confounders and entered as covariates in all the analyses. In addition, we carried out supplementary analyses also adjusting for IQ and SES. These analyses were restricted to the 62 participants in the regression analyses and 58 and 52 participants in the mediation analyses using parent- and self-reports, respectively, with available data on these variables. The estimated effects were essentially the same (data not shown). Missing data were handled using single imputation on scales using the mean score if 70% or more of the questions were answered. Otherwise, the outcome of that specific questionnaire for that participant was treated as missing. For the rest, we handled missing data using available case analyses, including in each analysis the cases with data on the variables in the analysis. We report 95% CIs where relevant. To reduce the risk of false-positive findings due to multiple hypotheses, two-sided p-values ≤ 0.01 are regarded as significant. This approach is suggested by Lydersen (53). Statistical analyses were conducted using SPSS 26.

Results

Clinical characteristics of the participants

The 100 participants included 57 females and 43 males; the mean age was 15.8 years (SD = 1.3). When collecting the data, ninety-one percent of the participants were stably taking ADHD medication. Nevertheless, sixty-six percent of participants met the DSM-5 criteria for an ADHD diagnosis (35% predominantly inattentive presentation and 31% combined presentation), and 33% presented subthreshold symptoms of ADHD (all ADHD medicated). Fifty-three percent of the participants had at least one current comorbid condition; among them, 37% had an AD according to the DSM-5 criteria (see Table 1).

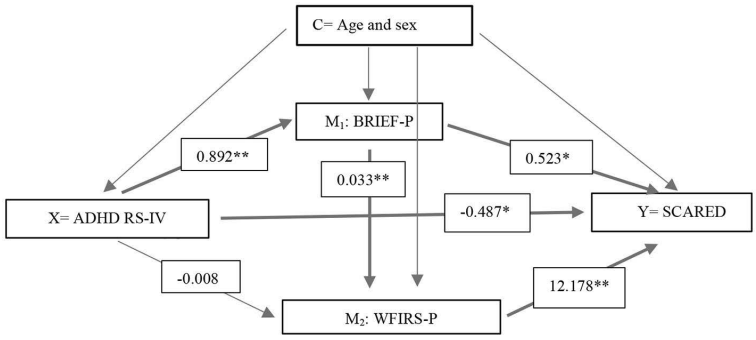

FIGURE 2
Regression coefficients for the associations between parent-report measures of ADHD RS-IV and SCARED (self-report) with BRIEF and WFIRS as possible mediators. Age and sex were considered confounders ($n = 90$). *X* predictor, *Y* dependent variable, *C* confounder, M_1 mediator 1, M_2 mediator 2. *ADHD RS-IV* Attention-Deficit/Hyperactivity Disorder Rating Scale, *BRIEF-P* Behavior Rating Inventory of Executive Function Parent version, *WFIRS* Weiss Functional Impairment Rating Scale. ** $p < 0.005$, * $p < 0.05$.

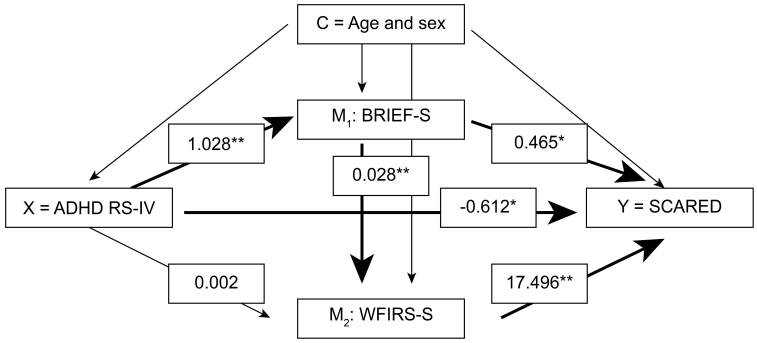

FIGURE 3
Regression coefficients for the associations between self-report measures of ADHD RS-IV and SCARED with BRIEF and WFIRS as possible mediators. Age and sex were considered confounders ($n = 81$). *X* predictor, *Y* dependent variable, *C* confounder, M_1 mediator 1, M_2 mediator 2, *ADHD RS-IV* Attention-Deficit/Hyperactivity Disorder Rating Scale, *BRIEF-S* Behavior Rating Inventory of Executive Function Self-report, *WFIRS* Weiss Functional Impairment Rating Scale Self-report. ** $p < 0.005$, * $p < 0.05$.

Results from the regression analyses

The results from the regression analyses using parent-ratings of the ADHD RS-IV, the BRIEF and the WFIRS to predict anxiety symptoms measured with the SCARED self-report, controlling for age and sex, are presented in Table 2. In step 1, neither the ADHD total score, nor the subscale scores were able to predict anxiety. All the BRIEF indices, including the GEC ($p = 0.002$), the BRI ($p = 0.010$) and the MI ($p = 0.003$) significantly predicted anxiety, as did the WFIRS total score ($p < 0.001$).

In step 2 of Table 2, we examined the ability of the ADHD RS-IV subscale scores and the BRIEF indices to predict anxiety when controlling for age, sex, and the companion subscale or index score. The results showed that neither the ADHD subscales nor the BRIEF indices were able to predict anxiety when controlling for age, sex, and the companion subscale.

The results from the regression analyses using self-ratings of the ADHD RS-IV, the BRIEF and the WFIRS to predict anxiety symptoms measured with SCARED, controlling for age and sex, are presented in Table 3. In step 1, the ADHD inattentive subscale score was significantly able to predict anxiety ($p = 0.002$). Among the BRIEF indices, the GEC, MI, and BRI predicted anxiety ($p \leq 0.001$), as did the total score of the WFIRS ($p < 0.001$).

In step 2 of Table 3, we examined the ability of the ADHD RS-IV subscale scores and the BRIEF indices to predict anxiety when controlling for age, sex, and the companion subscale or

TABLE 2 Results from regression analysis using the parent-rated ADHD RS-IV, BRIEF and WFIRS measures as independent variables entered in two steps.

Measures	Step 1				Step 2			
	Regression coefficient B	95% confidence interval			Regression coefficient B	95% confidence interval		
		Lower	Upper	*p*-value		Lower	Upper	*p*-value
ADHD RS-IV parent total	0.181	−0.157	0.518	0.290				
Inattentive subscale	0.606	0.020	1.191	0.043	0.715	0.079	1.351	0.028
Hyperactivity subscale	−0.005	−0.539	0.528	0.984	−0.253	−0.822	0.316	0.379
BRIEF parent GEC	0.440	0.167	0.712	0.002*				
BRI	0.321	0.078	0.564	0.010*	0.153	−0.153	0.459	0.323
MI	0.429	0.147	0.711	0.003*	0.318	0.040	0.677	0.081

SCARED self-report is the dependent variable in all the analyses. All analyses were adjusted for age and sex (n = 92). Step 1 only one single independent variable is entered in the analyses, step 2 the subscales in the same questionnaire are entered simultaneously as independent variables. The Screen for Children Anxiety Related Emotional Disorders (SCARED) is the dependent variable in all the analyses. ADHD-RS-IV Attention- Deficit/Hyperactivity Disorder Rating Scale, BRIEF Behavior Rating Inventory of Executive Function, WFIRS Weiss Functional Impairment Rating Scale, GEC Global Executive Composite, BRI Behavior Regulation Index, MI Metacognitive Index. **p < 0.001, *p < 0.01.

TABLE 3 Results from regression analyses using self-report measures of the ADHD RS-IV, BRIEF and WFIRS measures entered as independent variables in two steps.

Measures	Step 1				Step 2			
	Regression coefficient B	95% confidence interval			Regression coefficient B	95% confidence interval		
		Lower	Upper	*p*-value		Lower	Upper	*p*-value
ADHD RS-IV self total	0.342	0.036	0.649	0.029				
Inattentive subscale	0.818	0.315	1.321	0.002*	0.985	0.380	1.590	0.002*
Hyperactivity subscale	0.211	−0.337	0.760	0.445	−0.318	−0.931	0.294	0.304
BRIEF self GEC	0.484	0.271	0.697	<0.001**				
BRI	0.371	0.166	0.575	0.001**	0.161	−0.098	0.419	0.220
MI	0.481	0.259	0.704	<0.001**	0.366	0.078	0.655	0.013
WFIRS self-report total	16.929	11.738	22.121	<0.001**				

SCARED self-report is the dependent variable in all the analyses. All analyses were adjusted for age and sex (n = 92). Step 1 only one single independent variable is entered in the analyses, step 2 the subscales in the same questionnaire are entered simultaneously as independent variables. The Screen for Children Anxiety Related Emotional Disorders (SCARED) is the dependent variable in all the analyses. ADHD-RS-IV Attention- Deficit/Hyperactivity Disorder Rating Scale, BRIEF Behavior Rating Inventory of Executive Function, WFIRS Weiss Functional Impairment Rating Scale, GEC Global Executive Composite, BRI, Behavior Regulation Index; MI, Metacognitive Index. **p < 0.001, *p < 0.01.

index score. The results showed that the ADHD inattention score was able to predict anxiety when controlling for the hyperactive subscale score. The BRIEF indices were unable to predict anxiety when controlling for each other.

The role of EFs and functional impairment in mediating the association between ADHD symptoms and anxiety

Regression coefficients presenting the direct effects between the parent-rated variables are presented in Figure 2. The total direct and indirect effects between the variables are presented in Supplementary Table S4. The direct effect of ADHD symptoms predicting anxiety was negative but significant (coefficient = −0.487, $p = 0.048$); thus, a low ADHD symptom score significantly predicted more severe symptoms of anxiety when EFs and functional impairment were controlled for. The first indirect effect of only EF mediating the association between ADHD symptoms and anxiety was significantly positive (coefficient = 0.466, CI 0.013 to 1.024). Thus, levels of ADHD symptoms predicted levels of executive dysfunction, which again mediated the severity of anxiety symptoms. The second indirect effect was through levels

of functional impairment only, which was negative and non-significant (coefficient = −0.101, CI:−0.275 to 0.0241). The third indirect effect of executive dysfunction and functional impairment in serial (X- M^1- M^2-Y) was positive and significant (coefficient = 0.362, CI: 0.087 to 0.665); thus, the association between ADHD symptoms and anxiety seems to be mediated by EFs affecting functional impairment, which in turn mediates symptoms of anxiety. This was found regardless of age, sex, IQ, and SES.

Regression coefficients presenting the direct effects between the self-rated variables are presented in Figure 3. The total direct and indirect effects between the variables are presented in Supplementary Table S5. The results from the self-report measures were similar to the results from the parent reports, showing a negative but significant direct effect of ADHD symptoms predicting anxiety (coefficient = −0.612, p = 0.007). The first indirect effect *via* executive dysfunction alone was positive and significant (coefficient = 0.478, CI: 0.025 to 0.947), while the second indirect effect *via* functional impairment alone was non-significant (coefficient = 0.035, CI:−0.199 to 0.261). The serial indirect effect of executive dysfunction and functional impairment on the association between ADHD and anxiety was positive and significant (coefficient = 0.501, CI: 0.203 to 0.889), and the results were similar to the analyses with the parent reports.

Discussion

Children and adolescents with ADHD have an increased risk of comorbid ADs compared to their non-ADHD peers. In addition, anxiety symptoms tend to have an earlier onset, be more severe and be frequently associated with other psychiatric conditions (54, 55). Although the comorbidity rates of ADHD and ADs are well documented, the etiology of these associations is poorly understood. As such, the first aim of the current study was to examine whether parent- and self-rated ADHD symptoms, executive dysfunction and functional impairment were able to predict anxiety in a clinical population of adolescents with symptoms of ADHD. Overall, the main patterns were similar in the adolescent and parent reports, with stronger associations in the self-reports. This finding was as expected, considering that anxiety is an internalizing disorder and that only the adolescents reported anxiety symptoms. Among the self-rated ADHD symptom scores, only the inattention domain predicted anxiety, while hyperactivity symptoms were unable to predict anxiety. This was found regardless of age and sex and is in line with previous studies showing inattention symptoms to be more strongly associated with anxiety than hyperactivity (14, 56). On the other hand, none of the parent-rated ADHD symptom scores were able to predict anxiety. This was somewhat surprising and might suggest that parents are less sensitive in capturing this symptom association, perhaps because of the less overt nature of both inattention symptoms and anxiety symptoms. On the other hand, only including a self-report measure of anxiety could have affected this finding.

Among the EFs, both the global executive composite (GEC), the behavioral regulation index (BRI) and the metacognitive index (MI) were able to predict anxiety in both self- and parent-reports. Neither the BRI nor the MI index was significantly able to predict anxiety over and above the other BRIEF index when controlling for age and sex. The behavioral regulation index reflects both emotional dysregulation, mental inflexibility and impulsivity. An association between emotional dysregulation and anxiety would be expected. In addition, an association between mental inflexibility and anxiousness has previously been found in studies examining measures of shifting and updating using neurocognitive measures on clinical and non-clinical samples of anxious children and adolescents (57–59). Impulsivity, on the other hand, has previously been shown to be inversely associated with anxiety, with studies showing less inhibited children and adolescents presenting lower symptoms of anxiety than more inhibited children (60, 61). More detailed subgroup analyses are recommended to explore these associations further.

The metacognitive index includes cognitive functions such as working memory, task completion, planning and organization, and organization of materials, all skills strongly related to school performance and the attainment of future goals. As such, it is reasonable to link experienced difficulties in these areas with both low self-esteem and lack of control, which again may increase anxiousness. Finally, the functional impairment score, representing self-concept, social activities, school functioning, life skills and risky activities, predicted anxiety in both the parent- and self-reports. In sum, both executive dysfunction related to behavior regulation and metacognitive functions and functional impairment may be important to assess when working with adolescents with ADHD and comorbid anxiety.

The second aim of this study was to explore the roles of executive dysfunction and functional impairment as possible mediators in the ADHD-anxiety relationship. The results from the mediation analyses showed that ADHD symptoms alone were unable to predict anxiety when controlling for executive dysfunction and functional impairment. Executive dysfunction mediated the ADHD-anxiety pathway, as expected; thus, more ADHD symptoms significantly predicted more severe executive dysfunction, which mediated the severity of anxiety symptoms. This pattern was found when controlling for age and sex and was similar in both parent- and self-reports, strengthening the validity of the result. This result was similar to a previous study (37) where EFs and functional impairment explained most of the variance in combined anxiety and depressive symptoms in college students with ADHD.

Another recent study found that EFs and anxiety/depression significantly mediate the relationship between ADHD and quality of life (62). Together, these results suggest that executive dysfunctions rather than ADHD symptoms *per se* may lead to comorbid anxiety or mood disorders and difficulties in daily life. In the current study, ADHD symptoms alone were unable to predict functional impairment, but functional impairment predicted anxiety. Functional impairment was thus unable to mediate the ADHD-anxiety relationship by itself but acted as a mediator through EFs. Executive dysfunction has previously been linked to functional impairment in both school and social settings in children and adolescents with ADHD (63, 64). Roselló et al. (65) found impulsivity/emotional lability as well as planning and organizing to be significant predictors of functional impairment in family, social, academic, and risky activity areas in young adults with ADHD. Shift and working memory marginally predicted impairment in the same areas. These findings suggest executive dysfunction to be an important target in the prevention of functional impairment across several life domains.

This study has several strengths. First, this was the first study to explore the mediating effect of EFs and functional impairment on the ADHD-anxiety relationship in a clinical adolescent population. Second, we included ADHD patients with common psychiatric comorbidities, which increases the generalizability of the results to a clinical CAP setting. Third, the use of both parent- and self-report measures improves the validity of the results. Finally, males and females were equally represented among the participants, which is positive when controlling for the possible moderating effect of sex on the ADHD-anxiety relationship. This study also has several limitations. First, most of the participants (91.0%) were on ADHD medication when completing the questionnaires; thus, the results may not be representative of adolescents with ADHD who are not on medication. Second, the participants showed subthreshold ADHD symptoms, which may limit the generalizability to participants with more severe symptoms. Third, data on ADHD symptoms, executive functions and functional impairments were restricted to parent- and self-report questionnaires. The additional use of neurocognitive measures and computer tests to assess inattention symptoms and executive functions could have added valuable supplemental information in this study. Fourth, a high correlation between the main index scores (see Supplementary Table S6) indicates some conceptual overlap between the EF and functional impairment questionnaires. The two measures, however, also represent distinct, non-overlapping problem areas, making each questionnaire valuable as a clinical assessment instrument. Fifth, since this is a cross-sectional observational study, we have no longitudinal data to explore different developmental pathways related to the included variables. Moreover, the inclusion of only quantitative data limits an in-depth understanding of the origin and consequence of the different associations between cognitive functions/ADHD symptoms, functional impairments, and anxiety in this adolescent population. The inclusion of qualitative methods, such as interviewing parents and adolescents about life conditions, symptom development, psychosocial treatment and medication effects, could improve our knowledge of these associations for different patient groups and is recommended for use in future studies.

Conclusion and relevance

In this study, ADHD inattention symptoms, executive functions and functional impairment predicted anxiety in a clinical adolescent population with ADHD symptoms. ADHD core symptoms were, however, not able to predict anxiety when controlling for executive functions and functional impairment in a mediation analysis. Executive dysfunction acted as a substantial mediator in this relationship, while functional impairment mediated this relationship only through EFs. This result pinpoints executive dysfunction as an important treatment target in alleviating anxiety in adolescents with impairing ADHD symptoms. Thus, the additional assessment of EFs using a broadband questionnaire such as the BRIEF parent- and self-report versions is recommended when assessing ADHD and comorbid disorders in adolescent populations. The results also suggest that adolescents with ADHD with normal EFs may have a lower risk of experiencing anxiety. These results improve our knowledge of the association between ADHD and anxiety in a clinical ADHD population. More studies are needed to replicate these findings across different age groups.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Regional Committee for Medical and Health Research Ethics in Southeast Norway (2015/2115). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

TN, PT, and SL supervised A-LH. A-LH drafted the paper and performed the statistical analyses with the supervision of SL. All authors contributed to the research design, provided substantial contributions to the paper, and read and approved the final version of the manuscript.

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Conflict of interest

Authors A-LH, AS, and TN have received a speaker's fee and a travel honorarium from Medice during the last 3 years. Author PT has received speakers fee from Medice and Takeda within last 3 years. Author PT has received royalties from several publishers for books on ADHD and related disorders.

The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.834356/full#supplementary-material

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Supplementary material: Paper III

Supplemental Table 1 Scale scores on measures of ADHD RS-IV, BRIEF, WFIRS and SCARED

Measures	Scores			
	min-max	Mean	SD	N
ADHD RS- IV Parent Total	4 -84	25.0	8.8	97
Inattentive symptoms	3-27	15.5	5.1	98
Hyperactive/Impulsive symptoms	0-21	9.4	5.5	99
ADHD-RS IV Self Total	1-41	21.5	9.9	91
Inattentive symptoms	0-23	11.8	5.7	96
Hyperactive/Impulsive symptoms	0-23	9.7	5.6	93
BRIEF-Parent General Executive Composite (GEC) T-score	41-91	68.0	10.4	100
BRIEF Parent Behavior Regulation Index (BRI) T-score	39-94	63.6	11.9	100
BRIEF Parent Metacognitive index (MI) T-score	41-90	68.9	10.2	100
Inhibit	41-94	61.0	13.8	100
Shift	38-98	63.0	11.5	100
Emotional Control	40-87	62.0	11.7	100
Initiate	36-86	63.7	10.8	100
Working Memory	46-92	72.7	10.4	100
Plan Organize	43-91	69.6	10.3	100
Organization of Materials	34-72	57.4	10.4	100
Monitor	36-91	63.6	11.4	100
BRIEF-Self General Executive Composite (GEC)	30-94	63.9	13.1	100
BRIEF Self Behavior Regulation Index (BRI)	31-91	59.7	14.0	100
BRIEF Self Metacognitive index (MI)	31-91	65.6	12.7	100
Inhibit	34-93	59.1	14.0	100
Shift	32-83	58.5	13.1	100
Emotional Control	34-84	57.1	13.5	100
Monitor	36-83	55.3	12.2	100
Working Memory	34-87	66.3	12.1	100
Plan/ Organize	31-86	61.0	12.3	100
Organization of Materials	33-84	58.0	12.3	100
Task Completion	35-88	66.8	12.4	100
WFIRS-Parent total mean score	0.0-2.6	0.8	0.4	96
Family	0.0-2.6	0.8	0.6	99
School and Learning	0.0-3.0	0.9	0.6	98
Life skills	0.0-3.0	1.1	0.5	100
Self esteem	0.0-3.0	1.1	0.8	99
Social	0.0-5.7	0.7	0.8	100
Risky Activitites	0.0-2.0	0.2	0.3	99
WFIRS-Self total mean score	0.0-2.0	0.8	0.5	98
Family	0.0-2.3	0.8	0.6	96
School and Learning	0.0-2.5	1.0	0.6	98
Life skills	0.0-2.6	1.0	0.6	99
Self esteem	0.0-3.0	1.1	0.9	98
Social	0.0-2.3	0.6	0.5	99
Risky Activities	0.0-2.5	0.3	0.4	89
Screen for Child Anxiety Related Emotional Disorders Total	0-64	21.9	15.5	92

Note: *ADHD RS-IV* Attention Deficit/Hyperactivity Disorder Rating Scale IV, *WFIRS* Weiss Functional Impairment Rating Scale, *BRIEF* Behavior Rating Inventory of Executive Function

Supplemental Table 2. Regression coefficients, Standard Errors and model summary information for the mediator model using the parent-report of ADHD RS-IV, BRIEF, WFIRS and SCARED (n=90).

Consequent									
	M_1 (BRIEF)			M_2 (WFIRS)			Y (SCARED)		
Antecedent	Coeff.	SE	p	Coeff.	SE	p	Coeff.	SE	p
X (ADHD RS-IV)	0.892	0.077	<.001	-0.008	0.006	.186	-0.487	0.243	.048
M_1 BRIEF (GEC)	--	--	--	0.033	0.005	<.001	0.523	0.253	.041
M_2 WFIRS total	--	--	--	--	--	--	12.178	4.186	.005
SEX	0.301	1.364	.826	-0.001	0.069	.991	13.628	2.664	<.001
AGE	-0.583	0.518	.264	< 0.001	0.026	.996	-0.206	1.019	.840
Constant	54.185	8.683	<.001	-1.235	.529	.022	-29.718	21.073	.162

Note: *ADHD RS-IV* Attention Deficit Hyperactivity Disorder Rating Scale IV, *BRIEF* Behaviour Rating Inventory of Executive Functions, *WFIRS* The Weiss Functional Impairment Rating Scale, *SCARED* Screen for Child Anxiety-Related Emotional Disorders. Sex and age were confounders, *M* Mediator.

Supplemental Table 3. Regression coefficients, Standard Errors and model summary information for the mediator model using self-report of the ADHD RS-IV, BRIEF, WFIRS and SCARED (n=81).

Consequent									
	M_1 (BRIEF)			M_2 (WFIRS)			Y (SCARED)		
Antecedent	Coeff.	SE	p	Coeff.	SE	p	Coeff.	SE	p
X (ADHD RS-IV)	1.028	0.081	<.001	0.002	0.006	.753	-0.612	0.22	.007
M_1 BRIEF (GEC)	--	--	--	0.028	0.005	<.001	0.465	0.207	.028
M_2 WFIRS total	--	--	--	--	--	--	17.496	3.937	<.001
SEX	5.124	1.655	.003	-0.184	0.079	0.023	11.019	2.805	<.001
AGE	0.018	0.629	.978	-0.011	0.028	0.695	-1.191	0.973	.225
Constant	33.806	9.784	<.001	-0.496	.473	.298	-8.069	16.352	.623

Note: *ADHD RS-IV* Attention Deficit Hyperactivity Disorder Rating Scale IV, *BRIEF* Behaviour Rating Inventory of Executive Functions, *WFIRS* The Weiss Functional Impairment Rating Scale, *SCARED* Screen for Child Anxiety-Related Emotional Disorders. Sex and age were confounders, *M* Mediator.

Supplemental Table 4 Regression coefficients with total-, and indirect effects of the association between parent-reports of ADHD-RS-IV (X) and SCARED (Y), with BRIEF and WFIRS as mediators (M) (n=90).

Associations between variables	Coefficient/ effect	Standard error	CI	p
Total effect of X on Y	0.240	0.171	-0.101 to 0.581	0.165
Indirect effect of X on Y	Coefficient/ effect	Bootstrap Standard error	CI	
Total indirect effect (a+b+c)	0.727*	0.251	0.283 to 1.268	
[a]ADHD RS-BRIEF-SCARED	0.466*	0.261	0.013 to 1.024	
[b]ADHD RS-WFIRS-SCARED	-0.101	0.078	-0.275 to 0.024	
[c]ADHD RS-BRIEF-WFIRS-SCARED	0.362*	0.150	0.087 to 0.665	

Note Results from PROCESS procedure for SPSS (Hayes, 2018.www.guilford.com/p/hayes3) [the] first indirect effect, [b] The second indirect effect, [c] The third indirect effect *CI* Confidence Intervals (95%).

Supplemental Table 5. Regression coefficients with total-, and indirect effects of the association between self-reports of ADHD RS-IV (X) and SCARED (Y), with BRIEF and WFIRS as mediators (M) (n=81).

Associations between variables	Coefficient/ effect	Standard error	CI	p
Total effect of X on Y	0.402	0.159	0.087 to 0.718	0.132
Indirect effect of X on Y	Coefficient/ effect	Bootstrap Standard error	CI	
Total indirect effect (a+b+c)	1.015*	0.220	0.598 to 1.471	
[a]ADHD RS-BRIEF-SCARED	0.478*	0.234	0.025 to 0.947	
[b]ADHD RS-WFIRS-SCARED	0.035	0.115	-0.200 to 0.261	
[c]ADHD RS-BRIEF-WFIRS-SCARED	0.501*	0.177	0.203 to 0.889	

Note Results from PROCESS procedure for SPSS (Hayes, 2018.www.guilford.com/p/hayes3), [a] The first indirect effect, [b] The second indirect effect, [c] The third indirect effect. *CI* Confidence Intervals (95%) with 5000 bootstrap samples.

Supplemental Table 6. Correlation matrix between the WFIRS total score and BRIEF GEC, MI and BRI indexes using parent- and self-reports

Measures	WFIRS-P total score (n)	Measures	WFIRS-S total score (n)
BRIEF-P GEC	0.648** (99)	BRIEF-S GEC	0.707** (98)
BRIEF-P BRI	0.580** (99)	BRIEF-S BRI	0.645** (98)
BRIEF-P MI	0.585** (99)	BRIEF-S MI	0.653** (98)

Note *WFIRS* Weiss Functional Impairment Rating Scale, *BRIEF* Behavior Rating Inventory of Executive Function, *GEC* General executive composite, *BRI* Behaviour regulation index, *MI* Metacognitive Index. **. Pearson correlation is significant at 0.01 level (2-tailed)

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