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Can a Universal Mindfulness Intervention in Schools Reduce ADHD Symptoms among Adolescents? A Cluster Randomized Controlled Trial

Marianne Holopainen^{1,2}  | Mirka Hintsanen³  | Jari Lahti⁴ | Tero Vahlberg⁵ | Salla-Maarit Volanen^{2,6}

¹Doctoral Programme in Human Behaviour, University of Helsinki Doctoral School, Helsinki, Finland | ²Folkhälsan Research Center, Helsinki, Finland | ³Unit of Psychology, University of Oulu, Oulu, Finland | ⁴Department of Psychology and Logopedics, University of Helsinki, Helsinki, Finland | ⁵Department of Biostatistics, University of Turku, Turku, Finland | ⁶Clinicum, Department of Public Health, University of Helsinki, Helsinki, Finland

Correspondence: Marianne Holopainen (marianne.holopainen@helsinki.fi)

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ABSTRACT

Existing studies suggest that mindfulness-based interventions (MBIs) can reduce ADHD symptoms when delivered as targeted clinical programs to young people diagnosed with ADHD. However, there is currently a lack of research on whether MBIs are effective in reducing elevated ADHD symptoms when delivered as universal programs to whole classes in schools. This study investigated the effects of a universal nine-week MBI (*.b program*) on students' elevated ADHD symptoms using a cluster randomized controlled trial (RCT) design. The modifying effects of pupils' baseline characteristics (gender, age, and socioeconomic status) and home-practice intensity were examined. A total of 3519 adolescents aged 12 to 15 years from Finnish schools were randomized into an MBI group, a relaxation-based active-control group, and a passive-control group. ADHD symptoms were measured at baseline (T0), at nine weeks (T9), and at 26-weeks (T26, follow-up) using parent-reported assessments. The study found no positive intervention effects on parent-reported ADHD symptoms in the MBI group compared to the control groups. Neither boys nor girls benefited from the MBI. The same was true of different age groups and socioeconomic levels. Moreover, regular home practice during the follow-up period did not strengthen the intervention effects. The results do not support the use of brief, universal MBIs in whole school classes as part of the routine curriculum to reduce elevated ADHD symptoms in adolescents. Further research is essential to identify optimal content and delivery methods for MBIs in schools. Particularly among adolescents with elevated ADHD symptoms, targeted MBIs, adapted to the unique needs of this subgroup, should be examined.

Trial Registration: Healthy Learning Mind—a school-based mindfulness and relaxation program: a study protocol for a cluster randomized controlled trial (RCT) ISRCTN18642659 retrospectively registered on 13 October 2015. The full trial protocol can be accessed at <http://rdcu.be/t57S>

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Summary

- Currently, little is known about the effectiveness of mindfulness-based interventions (MBIs) in reducing elevated ADHD symptoms when delivered as whole-class universal programs in schools.
- This study investigated the effects of a 9-week universal MBI on elevated ADHD symptoms in adolescents, comparing it to a relaxation program and a routine school curriculum.
- The study found no positive intervention effects on parent-reported ADHD symptoms 9 weeks after the intervention and at the 26-week follow-up in the MBI group compared to the control groups.
- Future research is needed to determine the optimal content and implementation methods for MBIs in schools.

1 | Introduction

ADHD is one of the most common disorders in children. It is characterized by persistent symptoms of inattention and/or hyperactivity/impulsivity (American Psychiatric Association 2013). The prevalence of ADHD is approximately 5% in childhood (Polanczyk et al. 2007); an additional 5% of children have significant difficulties related to ADHD symptoms that are just below the threshold to meet the relevant diagnostic criteria (Sayal et al. 2018). Boys are diagnosed with ADHD more frequently than girls (the ratio varies 3–9:1) (Polanczyk et al. 2007; Polanczyk and Rohde 2007). In most cases, the symptoms continue into adolescence and adulthood (Faraone, Biederman, and Mick 2006; Kessler et al. 2005). One of the clinical features of ADHD is comorbidity (Biederman 2005). Coexisting impairments with behavior, emotion regulation, and learning are highly common in childhood, while psychiatric diagnoses and substance use are prevalent in adulthood (Airaksinen, Michelsson, and Jokela 2004; Erskine et al. 2016; Kadesjö and Gillberg 2001; Sobanski et al. 2007). Furthermore, children and adolescents with ADHD symptoms are more likely to exhibit reduced functioning in several areas of life (Nijmeijer et al. 2008; Wehmeier, Schacht, and Barkley 2010), including educational performance (Galéra et al. 2009; Loe and Feldman 2007).

To alleviate ADHD symptoms and associated impairments, several treatment strategies are available (Caye et al. 2019). In a clinical context, pharmacological approaches combined with psychoeducation, behavioral parent training, and social-skill training are typically considered to be the first-line treatments for children and adolescents (National Collaborating Centre for Mental Health 2009; Subcommittee on Attention-Deficit/Hyperactivity Disorder & Management 2011). Other psychosocial interventions are also shown to be useful, especially for young people, for mild symptoms, and for an add-on treatment (Caye et al. 2019). Of these interventions, mindfulness-based interventions (MBIs) have shown to be especially promising in reducing both inattention and hyperactivity/impulsivity symptoms in small observational studies ($N \leq 30$) (Haydicky et al. 2015; Valero, Cebolla, and Colomer 2022; van de Weijer-Bergsma et al. 2012; van der Oord, Bögels, and Peijnenburg 2012;

Zylowska et al. 2008) and larger RCT studies ($N \sim 100$) conducted in clinical settings (Bögels et al. 2021; Lo et al. 2020; Meppelink et al. 2024; Siebelink et al. 2022).

Theoretically, mindfulness is closely linked to attention. According to one definition (Bishop et al. 2004), it refers to the self-regulation of attention on current experience (involving the cognitive skills such as sustained attention, attention switching, and inhibiting elaborative processing), combined with an accepting attitude toward one's own experience. MBIs may be potential treatments for ADHD because they target core features of its symptoms (Gu, Zhu, and Brown 2021). Individuals with ADHD symptoms typically display impairments in several attentional processes (alerting, orienting, and/or conflict attention) and executive functions (EFs; the abilities to plan ahead, set goals, and execute based on such goals, and/or self-control/inhibition), and training self-regulation of attention via MBIs may alleviate these neurocognitive challenges (Chiesa, Calati, and Serretti 2011; Mak et al. 2018; Zylowska, Smalley, and Schwartz 2009) by influencing the associated brain-level networks (Gu, Zhu, and Brown 2021). In addition, training acceptance of one's own experience may play a role in better regulation of behavior (Klingbeil et al. 2017), which may reduce impulsivity and hyperactivity, other symptoms found in individuals with ADHD (Cairncross and Miller 2020; Oliva et al. 2021). In adolescence, MBIs for the treatment of ADHD symptoms may be especially effective and worthwhile due to the developmental plasticity of individuals' brains and related cognitive, social, and psychological systems (Blakemore and Choudhury 2006).

However, not all children and adolescents have access to clinical treatments for elevated ADHD symptoms. Instead, interventions implemented across entire classrooms in schools, known as the “universal approach” (Greenberg and Abenavoli 2017; Horowitz and Garber 2006; Payton et al. 2008) provide support not only to those meeting diagnostic criteria but also to those facing milder difficulties. Moreover, they reach all students regardless socioeconomic status and without stigma associated with individual challenges as well as may promote protective factors, such as enhance resilience and build coping skills in students (Costello and Etherington 2019; Greenberg and Abenavoli 2017). Because many pupils experience ADHD symptoms to some extent, whole-class interventions that can support students with milder difficulties may be more useful to teachers (Moore et al. 2019). Currently, school-based interventions have played a significant role in ADHD symptom management (DuPaul and Stoner 2014; Moore et al. 2019; Piffner, Barkley, and DuPaul 2015; Telford et al. 2013); however, the best evidence-based interventions and the implementation contexts in which they are most effective have not yet been fully identified (Moore et al. 2019).

MBIs in schools have become increasingly popular to support pupils' mental health (Carsley, Khoury, and Heath 2018; Felver et al. 2016; Meiklejohn et al. 2012; Renshaw, Fischer, and Klingbeil 2017; Zenner, Herrleben-Kurz, and Walach 2014). However, to the best of our knowledge, no studies have examined the effectiveness of whole-class universal MBI programs in reducing elevated ADHD symptoms among adolescents. While several studies in adolescents have found promising effects on ADHD-related specific traits, such as attention regulation,

behavior-regulation, and EFs (e.g., Black and Fernando 2014; Crooks et al. 2020; Dunning et al. 2022; Flook et al. 2015; Lassander et al. 2020; Schonert-Reichl et al. 2015), they often lack a comprehensive measure of ADHD symptoms with a cut-off for definite symptoms. Moreover, the largest population-based RCT by Kuyken et al. (2022) has showed inconsistent effects; increases in hyperactivity/inattention (no cutoff for the symptoms) after intervention and at one-year follow-up when an MBI targeted at students aged 11–14 in whole classes in 84 schools ($N=8376$) was compared to social-emotional education. Further research is essential on whether the universal MBIs are useful in reducing elevated ADHD symptoms in pupils.

1.1 | Present Study

The aim of this RCT study is to investigate whether MBIs delivered as whole-class universal programs in schools are effective in reducing elevated ADHD symptoms in adolescents as has been found with targeted MBIs in clinical settings. The study compared the effects of a universal, standardized nine-week school-based mindfulness intervention (*.b*) (Huppert and Johnson 2010) to those of a standardized nine-week relaxation program (*Relax*) (Volanen et al. 2016) and a passive-control group (a routine school curriculum) in adolescents aged 12–15 years with elevated ADHD symptoms by using a parent-rated measure with 90th percentile cutoffs. While acknowledging the limitations of using a non-clinical sample, the study aims to explore the potential benefits of the widely reachable universal MBI for a broader population of adolescents, including also individuals who may not meet the full diagnostic criteria but who exhibit definite ADHD symptoms (at-risk of ADHD). Furthermore, the study examined whether pupil baseline characteristics (gender, age (grade), and socioeconomic status (parental education level)) and mindfulness home-practice intensity moderated the effects on symptom outcomes.

Based on previous research, we hypothesized that the nine-week MBI would be effective in decreasing elevated ADHD symptoms, including both inattention and hyperactivity/impulsivity, nine weeks after the intervention and at the 26-week follow-up compared to the control groups. Moreover, we expected older students to show more benefit from the intervention, as greater improvements in EFs have been found in older adolescents (Dunning et al. 2019). We also expected that regular mindfulness training might be associated with larger effects, as found by others (Tudor et al. 2022; Zenner, Herrnleben-Kurz, and Walach 2014). Finally, we did not set any expectations regarding how gender or socioeconomic status would modify the effects (Bögels et al. 2021; Vekety, Logemann, and Takacs 2021). This study was a secondary analysis and part of the larger healthy learning mind (HLM) project (Volanen et al. 2016). The primary results have been reported in an earlier publication (Volanen et al. 2020).

2 | Methods

2.1 | Trial Design

The present study was a cluster RCT with three arms: a mindfulness-intervention group, a relaxation-based active-control group, and a passive-control group (retrospective

registration: ISRCTN18642659). School classes acted as clusters. Figure 1 illustrates the research design. The study was part of the large HLM project, and more details regarding the design, participants, and procedure are reported in the study protocol (see: Volanen et al. 2016).

2.2 | Participants

The participants were Finnish adolescents ($N=3519$) aged 12–15 years from 56 primary and secondary schools (grades 6, 7, and 8). The demographics of the participating students are shown in Table S1. Outcome data was collected from the students' parents at the baseline (T0), nine weeks after the intervention (T9), and at the six-month follow-up (T26).

2.3 | Procedure

The present study was conducted according to the Helsinki Declaration. The Ethical Review Board of the University of Helsinki reviewed and approved the study plan in January 2014. Recruitment started in 2013, and 247 schools in Southern Finland were contacted. Altogether, 56 primary and secondary schools from 14 municipalities/cities agreed to participate (24% of contacted institutions). The most frequent reasons for not participating were the following: (1) the principal could not be reached via email or telephone (25%); (2) the school was already taking part in other research or development projects (23%); (3) there were insufficient interested teachers (18%); and (4) other (11%). After recruitment and prior to commencement, written informed consent was requested from all participating students and their parents. Consent was also requested from the head teachers of the 56 participating schools.

Data was collected between March 2014 and December 2016 during four academic terms; this included four baseline measurement points (spring term 2014, autumn term 2014, spring term 2015, and spring term 2016). For practical reasons, the data from the passive-control group was collected only during two academic terms (spring term 2015 and spring term 2016). After this phase, personal details that could identify the participants were separated from the data. Data handling and analysis were performed according to the Finnish Data Protection Act.

The participating schools were randomly assigned to the MBI schools (25 schools, 94 classes), the relaxation-based control schools (24 schools, 85 classes), and the passive-control schools (seven schools, 31 classes) (Figure 1). The randomization between the MBI and control schools was conducted by an experienced statistician based on the available background information, including teaching language, grade, school location, number of classes taking part in the study, and the average apartment price per square meter near the school (Volanen et al. 2016). One of the goals was to obtain an equal number of intervention and control classes in each municipality/city. Due to practical reasons, the schools were divided into two arms (intervention and active control) in spring 2014 and autumn 2015 and into three arms (intervention, active control, and passive control) in spring 2015 and spring 2016. First, the schools were divided into three groups based on school

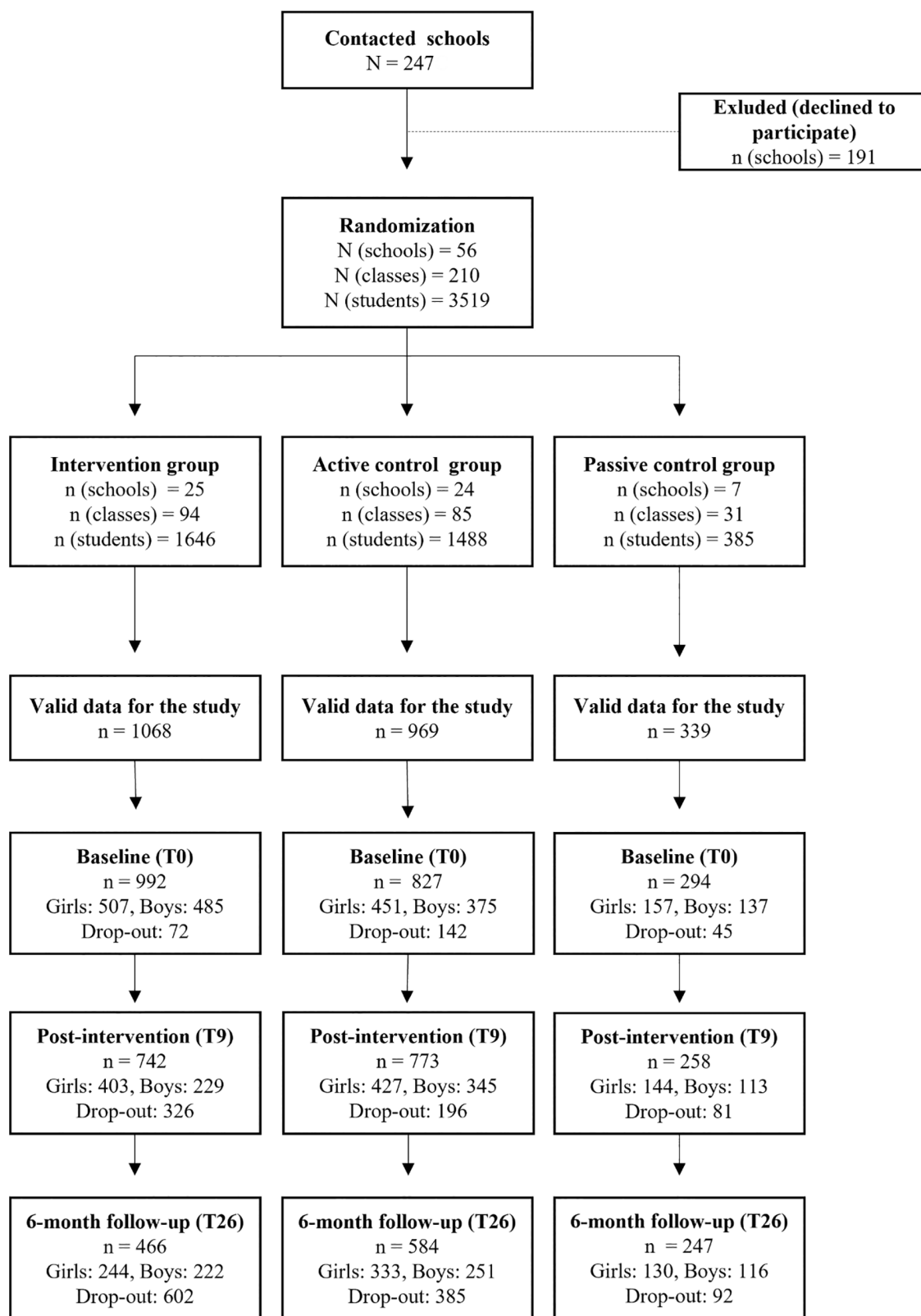


FIGURE 1 | Flowchart of participants.

location and the average apartment price per square meter to account for socioeconomic differences (the number of schools and classes varied within each group). Then, each group was divided into three subgroups with approximately the same number of classes. Students in the MBI and relaxation-based

control groups were blinded and informed about participation in a nine-week program called Skills for Well-being. Whole classes participated in the intervention/control intervention. The classes in the passive-control group followed the usual school curricula without receiving any interventions. The

study protocol describes in more detail the randomization (Volanen et al. 2016).

2.4 | .b Mindfulness Intervention

The intervention group received a nine-week standardized mindfulness intervention (Huppert and Johnson 2010). The .b program was designed to improve students' attentional and emotional regulation, sustained attention, and emotional awareness; it consisted of nine 45-min mindfulness group sessions and home practices. Each session had a distinct theme, and different mindfulness skills and exercises were taught to students (Mindfulness in Schools Project 2021). For the group sessions, the pupils received their own b. student journals, which they could also use for the home practices. The pupils were told to practice their mindfulness skills independently at home between the group sessions; this should be done five–six times a week for 3–15 min at a time. At home, the students could also listen to mindfulness exercises recorded on audio files. The .b program was conducted in the participating schools by nine certified mindfulness facilitators with years of experience. To verify the fidelity of implementation, facilitators self-assessed their performance against the core program elements and evaluated student engagement in the group sessions.

2.5 | Relaxation-Based Control Intervention and Passive-Control Group

The active-control group received a nine-week standardized relaxation intervention (Volanen et al. 2016). The *Relax* program was conducted in the participating schools by certified schoolteachers or counselors with experience working in wellness groups made up of children and adolescents. The aim of the program was to improve relaxation skills and holistic well-being. Like .b, *Relax* included nine 45-min group sessions and home practices. The program's themes focused on overall well-being (e.g., stress, screen time, sleep, and nutrition) and relaxation practices (e.g., muscle relaxation, breathing exercises, and visualization); however, they did not contain any elements of mindfulness training. In addition to the group sessions, the students were told to practice relaxation at home five–six times per week, as in the MBI group.

The pupils in the passive-control group followed their routine school curricula without receiving any interventions. The active- and passive-control groups filled in the same questionnaire as the MBI group during the same period.

2.6 | Measures

ADHD symptoms were measured using part of the Nordic five to fifteen (FTF) questionnaire for parents (Kadesjö et al. 2017). If only one parent answered the FTF, the same one filled in the questionnaire at all the data collection points. The FTF has sound psychometric properties, and it is designed to identify ADHD symptoms and comorbid difficulties among children aged 5–15 (Kadesjö et al. 2004; Lambek and Trillingsgaard 2015;

Lambek et al. 2010). It includes 181 items, which are grouped into eight scales (motor control, EFs, perception, memory, language, learning, social skills, and emotional/behavioral problems) and several subscales. We used the EF scale and its four subscales (inattention, hyperactivity/impulsivity, hypoactivity, and planning/organizing). The EFs scale consists of 25 items that are scored from 0 to 2 (does not apply, applies sometimes or to some extent, and definitely applies, respectively). The inattention and hyperactivity/impulsivity subscales are based on the list of ADHD symptoms in DSM-IV; both subscales include nine items (American Psychiatric Association 2013). The scores for the EFs scale and its subscales were calculated as the mean of the items on each scale. At least 70% of the items had to be answered in order to calculate the score. The missing values were replaced by the mean of the respondent's values. The outcome scores varied between 0 and 2, with a higher score indicating a higher number of ADHD symptoms. Based on Danish population sample, 75th, 90th, and 98th percentiles have been published for boys and girls aged 5 to 15 years (Kadesjö et al. 2017; Lambek and Trillingsgaard 2015). In research and clinical practice, FTF scores above the 90th percentile are considered as definite problems, while scores above the 98th percentile are seen as severe difficulties (Kadesjö et al. 2004, 2017; Korkman et al. 2004; Lambek et al. 2010). The 90th percentile was chosen as a cutoff point for identifying students who exhibited elevated levels of ADHD symptoms. Additionally, scores above the 98th percentile (severe difficulties) were examined in the complementary material. A formal clinical diagnosis of ADHD was not required due to the objectives of the study and the nature of the used school-based universal intervention. At baseline, the values of Cronbach's alpha for the outcome scores varied as follows: EFs 0.92, inattention 0.88, hyperactivity/impulsivity 0.82, hypoactivity 0.74, and planning/organizing 0.69.

Mindfulness home-practice intensity was measured at the 26-week follow-up. Four items containing five answer options were used to ask the participants in the MBI group about this aspect. Based on the responses, the participants were divided into the following four mindfulness-practice groups: (1) infrequent (never or few times), (2) low frequency (once or twice a month), (3) moderate frequency (at least once a week), and (4) high frequency (every day or almost every day). The moderate and high-frequency groups were combined due to the low number of participants in both groups.

Students' socioeconomic status was measured by parent educational level. Seven answer options (basic education, vocational education, upper secondary education, polytechnic degree, bachelor's degree, master's degree, licentiate/doctoral degree) were used to ask both parents about this aspect. Responses were divided into two groups (high/low SES) based on whether the mother or father had a university or polytechnic degree (higher education) or not (basic or secondary education).

2.7 | Sample Size

The sample size was estimated to anticipate an effect size of 0.2 on the main outcomes of the HLM project in the comparisons between the MBI and control groups. The estimation yielded 1200 participants in the MBI and active-control groups and 540

in the passive-control group, with 80% power, 5% two-tailed significance, and 10% dropout. The target sample size was smaller in the passive-control group as it was assumed that greater differences would be found when comparing it with the intervention group than when comparing the intervention group with the active-control group. The protocol contains a comprehensive explanation of how the sample size was determined (Volanen et al. 2016).

2.8 | Statistical Methods

All the analyses were conducted using SAS System version 9.4 for Windows (SAS Institute Inc., Cary, NC, USA). The analyses were secondary in nature and based on data from the larger HLM project (Volanen et al. 2016). Two-sided statistical tests with 5% significance levels were employed. The intervention effects on ADHD symptoms were analyzed with multilevel binary logistic regression models.

Concerning the preliminary analysis, the distributions of the FTF outcome scores were evaluated for normality by visual inspection of the histograms. The distributions were highly positively skewed (skewness = 1.21–2.32). The FTF outcome scores were dichotomized into two groups, and the 90th percentile was used as the cutoff point for indications of elevated ADHD symptoms. As currently there are no Finnish norms available (available norms are based on sample of the population of children from Denmark), 90th percentile cutoff scores (for the whole EFs scale and the four subscales) were calculated from our study sample separately for boys and girls (Kadesjö et al. 2017). The intervention effects from the multilevel binary logistic regression models were examined by comparing the groups (intervention vs. active control and intervention vs. passive control) at T9 and T26, and they were expressed as odds ratios (ORs) and 95% confidence intervals (CIs). In addition to the individual-level variation, the hierarchical structure of the data was considered in the analyses by including class- and school-level variations as random intercepts in the models, if estimable. Gender and grade were controlled for in all the analyses. Prior to these analyses, the baseline differences in the FTF outcomes were examined based on the multilevel logistic regression models by comparing the MBI group with the control groups at T0. Furthermore, the baseline differences between the three age groups (grades 6, 7, and 8) regarding the outcomes were evaluated based on the multilevel logistic regression models (main effect of grade at T0).

In addition to analyzing the intervention effects, the multilevel logistic regression models were also used to investigate pupils' baseline characteristics (gender, grade, and socioeconomic status) and mindfulness home-practice intensity as modifiers of such effects. For this purpose, gender \times group, grade \times group, and SES \times group interaction effects were entered into the model, and the analyses of the intervention effects were conducted separately for boys and girls, for grades 6, 7, and 8, as well as for students from two socioeconomic groups. The modifying effect of mindfulness home-practice intensity was examined by using three different mindfulness-practice groups (infrequent, low frequency, and moderate/high frequency), which were compared to all the students in the active-control and passive-control groups. These analyses were exploratory in nature.

Regarding the complementary analyses, intervention effects on severe ADHD symptoms were also examined using the 98th percentile cutoff points. They were performed for all the students, for boys and girls, and for grades 6, 7, and 8. The statistical methods remained otherwise consistent with the main analyses, except that if class- and school-level variations could not be estimated as random variation in the models, only the school-level variation was added to the models.

Furthermore, the intervention effects were evaluated with the continuous FTF outcomes. These analyses were conducted between the groups (intervention vs. active control and intervention vs. passive control) at T9 and T26 by using multilevel negative binomial regression models with negative binomial distribution and log link, and they were expressed as relative risks (RRs) and 95% CIs. The logarithm of the number of answered questions was used as the offset variable. The analyses were performed for all the students, for boys and girls, and for grades 6, 7, and 8. Class- and school-level variations were accounted for as random intercepts in the models, if estimable. Gender and/or grade were controlled for. Prior to these analyses, the baseline differences in the continuous FTF outcomes were investigated based on the models by comparing the MBI group with the control groups at T0.

3 | Results

3.1 | Sample Characteristics

In total, 3519 students from 56 Finnish schools participated in the study (Figure 1). The outcome data were collected from the students' parents; 2376 parents responded at least at one measurement point, and they were included in the statistical analyses (Figure 1, Table S1). The final sample consisted of 1068 participants in the MBI group, 969 in the relaxation-based active-control group, and 339 in the passive-control group. The flowchart of the participants and the dropouts at the different measurement points (T0, T9, and T26) is presented in Figure 1.

3.2 | Descriptive Statistics and Baseline Analyses

The descriptive statistics for the FTF outcomes, including the means, medians, and cutoff scores in relation to the 90% of FTF outcomes by trial arms, are displayed for all the students and by gender in Tables 1 and 2. The 90th percentile cutoff score in the EFs scale for boys was lower in our Finnish sample (0.80) compared to the available Danish norms (0.86), while for girls the cutoff scores were the same (0.52) (Kadesjö et al. 2017; Lambek and Trillingsgaard 2015). At baseline, 17% of the students exhibited no ADHD symptoms (=0 points) as rated by their parents. The descriptive statistics by grade and the 98th percentile thresholds are presented separately in Tables S2–S4.

There were no baseline differences in the FTF outcomes between the MBI and control groups among all the students as well as among the subgroups based on gender, grade, and socioeconomic status (Tables S5 and S6). There were also no differences between the students in grades 6, 7, and 8 concerning EFs (main effect of grade at T0, $p = 0.73$), inattention

TABLE 1 | Descriptive statistics (means, standard deviations, medians) for outcomes at baseline (T0), 9-week post-intervention (T9) and 26-week follow-up (T26).

	Mindfulness intervention						Active control						Passive control						
	T0		T9		T26		T0		T9		T26		T0		T9		T26		
	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	
All students																			
Executive functions	0.27 (0.29)	0.16	0.22 (0.27)	0.12	0.21 (0.27)	0.12	0.27 (0.28)	0.20	0.24 (0.28)	0.16	0.21 (0.25)	0.12	0.26 (0.31)	0.21	0.12	0.21 (0.25)	0.16	0.12	0.22 (0.27)
Inattention	0.39 (0.40)	0.22	0.31 (0.37)	0.22	0.31 (0.38)	0.22	0.40 (0.40)	0.33	0.36 (0.39)	0.22	0.31 (0.37)	0.13	0.37 (0.40)	0.29 (0.34)	0.11	0.29 (0.34)	0.22	0.11	0.31 (0.36)
Hyperactivity/impulsivity	0.17 (0.27)	0.11	0.15 (0.26)	0.00	0.14 (0.24)	0.00	0.17 (0.26)	0.11	0.16 (0.25)	0.00	0.13 (0.21)	0.00	0.19 (0.30)	0.14 (0.24)	0.00	0.14 (0.24)	0.11	0.00	0.14 (0.27)
Hypoactivity	0.25 (0.37)	0.00	0.23 (0.37)	0.00	0.21 (0.34)	0.00	0.26 (0.35)	0.00	0.23 (0.34)	0.00	0.21 (0.34)	0.00	0.25 (0.36)	0.22 (0.33)	0.00	0.22 (0.33)	0.00	0.00	0.23 (0.34)
Planning/organizing	0.21 (0.36)	0.00	0.17 (0.33)	0.00	0.15 (0.31)	0.00	0.21 (0.35)	0.00	0.18 (0.34)	0.00	0.14 (0.31)	0.00	0.18 (0.35)	0.14 (0.30)	0.00	0.14 (0.30)	0.00	0.00	0.14 (0.30)
Girls																			
Executive functions	0.20 (0.25)	0.12	0.16 (0.22)	0.08	0.15 (0.21)	0.08	0.21 (0.24)	0.13	0.18 (0.21)	0.12	0.15 (0.19)	0.08	0.21 (0.23)	0.19 (0.23)	0.10	0.19 (0.23)	0.12	0.10	0.17 (0.22)
Inattention	0.29 (0.34)	0.22	0.22 (0.30)	0.11	0.22 (0.32)	0.11	0.32 (0.35)	0.22	0.26 (0.32)	0.11	0.22 (0.29)	0.11	0.30 (0.33)	0.26 (0.33)	0.11	0.26 (0.33)	0.22	0.11	0.26 (0.32)
Hyperactivity/impulsivity	0.14 (0.25)	0.00	0.12 (0.23)	0.00	0.11 (0.18)	0.00	0.14 (0.22)	0.00	0.12 (0.20)	0.00	0.09 (0.15)	0.00	0.15 (0.24)	0.14 (0.23)	0.00	0.14 (0.23)	0.11	0.00	0.11 (0.20)
Hypoactivity	0.19 (0.32)	0.00	0.17 (0.30)	0.00	0.15 (0.29)	0.00	0.22 (0.32)	0.00	0.18 (0.29)	0.00	0.17 (0.28)	0.00	0.20 (0.30)	0.20 (0.29)	0.00	0.20 (0.29)	0.00	0.00	0.19 (0.30)
Planning/organizing	0.14 (0.29)	0.00	0.10 (0.27)	0.00	0.08 (0.22)	0.00	0.13 (0.27)	0.00	0.09 (0.22)	0.00	0.08 (0.23)	0.00	0.12 (0.29)	0.11 (0.26)	0.00	0.11 (0.26)	0.00	0.00	0.08 (0.22)

(Continues)

TABLE 1 | (Continued)

	Mindfulness intervention						Active control						Passive control						
	T0		T9		T26		T0		T9		T26		T0		T9		T26		
	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	
Boys																			
Executive functions	0.34 (0.31)	0.24	0.30 (0.30)	0.20	0.28 (0.30)	0.16	0.34 (0.31)	0.24	0.33 (0.32)	0.24	0.20	0.32 (0.36)	0.20	0.23 (0.26)	0.12	0.26 (0.31)	0.16		
Inattention	0.50 (0.43)	0.44	0.42 (0.41)	0.33	0.40 (0.41)	0.33	0.50 (0.43)	0.44	0.48 (0.44)	0.33	0.42 (0.44)	0.33	0.45 (0.46)	0.32 (0.35)	0.22	0.36 (0.39)	0.22		
Hyperactivity/impulsivity	0.21 (0.29)	0.11	0.19 (0.28)	0.11	0.18 (0.28)	0.00	0.22 (0.29)	0.11	0.21 (0.30)	0.11	0.17 (0.27)	0.11	0.23 (0.37)	0.15 (0.25)	0.00	0.18 (0.32)	0.00		
Hypoactivity	0.32 (0.41)	0.25	0.29 (0.38)	0.25	0.26 (0.38)	0.00	0.31 (0.39)	0.25	0.28 (0.38)	0.00	0.28 (0.40)	0.00	0.29 (0.41)	0.22 (0.33)	0.00	0.27 (0.37)	0.13		
Planning/organizing	0.30 (0.41)	0.00	0.26 (0.37)	0.00	0.24 (0.37)	0.00	0.31 (0.41)	0.00	0.29 (0.42)	0.00	0.22 (0.38)	0.00	0.25 (0.39)	0.17 (0.33)	0.00	0.19 (0.35)	0.00		

($p=0.74$), hyperactivity/impulsivity ($p=0.33$), hypoactivity ($p=0.72$), and planning/organizing problems ($p=0.22$). Regarding the baseline evaluations of the FTF outcomes when using 98th percentile cutoffs, the MBI group showed less inattention among 8th graders compared to active-control group ($OR=0.35$, $p=0.03$, Table S7). For the continuous FTF outcomes, no differences were found between the MBI and control groups ($p>0.15$, Table S8).

With regard to mindfulness home-practice intensity, 58.1% of the participants in the MBI group engaged in home practice infrequently ($n=621$), whereas 8% did so with low frequency ($n=85$). Moreover, 4.6% practiced with moderate frequency ($n=49$), and 3.2% did so with high frequency ($n=34$). About a quarter of the students in the MBI group (26.1%, $n=279$) lacked the answer on this measure; hence, they were excluded from the subgroup analyses. There was no association between practice intensity in the MBI group and EFs at baseline ($p=0.63$, Table S9).

3.3 | Intervention Effects among All the Students

Table 3 displays the results of the multilevel binary logistic regression models. No intervention effects were found in the EF scale and the subscales at T9 and T26 when comparing the MBI group with the active- and passive-control groups.

3.4 | Intervention Effects by Gender and Grade

Compared to the passive-control group, the MBI group showed less reduction in inattention among boys at T9 (gender \times group interaction, $p=0.03$; boys, $OR=3.65$, $p=0.047$; girls, $OR=0.57$, $p=0.10$) but not at T26 (gender \times group interaction, $p=0.13$; boys, $OR=1.26$, $p=0.73$; girls, $OR=0.79$, $p=0.55$). No other effects in the MBI group were found by gender (Table 3) and grade (Table 4) compared to the active- and passive-control groups.

3.5 | Intervention Effects by Mindfulness Home-Practice Intensity Groups

The intervention effects by mindfulness home-practice intensity groups are displayed in Table S10. At T9, no intervention effects were found in the EF scale and the subscales when comparing the three MBI home-practice intensity groups with the active-control group. However, the MBI group with infrequent home practice showed a smaller reduction in hypoactivity symptoms at T9 compared to the passive-control group ($OR=1.81$, $p<0.01$), as well as a smaller reduction in hyperactivity/impulsivity symptoms at T26 compared to the active-control group ($OR=1.68$, $p=0.04$). At T26, no differences were detected between the MBI groups and the passive-control group.

3.6 | Intervention Effects by Socioeconomic Status (Parental Education Level)

Intervention effects by SES groups are shown in Table S6. There were no intervention effects in the low or high SES groups in the

TABLE 2 | Cutoff scores for FTF outcomes in relation to 90 percentiles (%) for girls and boys and descriptive statistics (N, %) for outcomes by trial groups at T0, T9, and T26.

Outcome	Cut-off	Mindfulness intervention				Active control				Passive control					
		T0 n (%)		T9 n (%)		T0 n (%)		T9 n (%)		T0 n (%)		T9 n (%)		T26 n (%)	
		T0 n (%)	T9 n (%)	T26 n (%)	T9 n (%)	T0 n (%)	T9 n (%)	T26 n (%)	T9 n (%)	T0 n (%)	T9 n (%)	T26 n (%)	T9 n (%)	T26 n (%)	
Executive functions	All	< 90%	882 (89.0)	682 (92.0)	432 (92.7)	733 (88.8)	706 (91.6)	545 (93.5)	263 (89.8)	238 (92.6)	230 (93.5)				
		≥ 90%	109 (11.0)	59 (8.0)	34 (7.3)	92 (11.2)	65 (8.4)	38 (6.5)	30 (10.2)	19 (7.4)	16 (6.5)				
	Girls	< 90%	447 (88.3)	374 (93.0)	226 (92.6)	403 (89.4)	396 (92.7)	313 (94.3)	140 (89.7)	130 (90.3)	121 (93.1)				
Boys		≥ 90%	59 (11.7)	28 (7.0)	18 (7.4)	48 (10.6)	31 (7.3)	19 (5.7)	16 (10.3)	14 (9.7)	9 (6.9)				
		< 90%	435 (89.7)	308 (90.8)	206 (92.8)	330 (88.2)	310 (90.1)	232 (92.4)	123 (89.8)	108 (95.6)	109 (94)				
		≥ 90%	50 (10.3)	31 (9.1)	16 (7.2)	44 (11.8)	34 (9.9)	19 (7.6)	14 (10.2)	5 (4.4)	7 (6.0)				
Inattention	All	< 90%	878 (88.6)	683 (92.0)	429 (92.1)	737 (89.2)	686 (88.9)	531 (90.9)	261 (89.1)	236 (91.8)	227 (92.3)				
		≥ 90%	113 (11.4)	59 (8.0)	37 (7.9)	89 (10.8)	86 (11.1)	53 (9.1)	32 (10.9)	21 (8.2)	19 (7.7)				
	Girls	< 90%	443 (87.5)	373 (92.6)	222 (91.0)	402 (89.1)	380 (89.0)	305 (91.6)	140 (89.7)	126 (87.5)	116 (89.2)				
Boys		≥ 90%	63 (12.5)	30 (7.4)	22 (9.0)	49 (10.9)	47 (11.0)	28 (8.4)	16 (10.3)	18 (12.5)	14 (10.8)				
		< 90%	435 (89.7)	310 (91.4)	207 (93.2)	335 (89.3)	306 (88.7)	226 (90.0)	121 (88.3)	110 (97.3)	111 (95.7)				
		≥ 90%	50 (10.3)	29 (8.6)	15 (6.8)	40 (10.7)	39 (11.3)	25 (10.0)	16 (11.7)	3 (2.7)	5 (4.3)				
Hyperactivity/impulsivity	All	< 90%	881 (89.2)	678 (91.5)	424 (91.0)	742 (89.8)	693 (89.9)	547 (93.8)	261 (88.8)	239 (93.0)	225 (91.5)				
		≥ 90%	107 (10.8)	63 (8.5)	42 (9.0)	84 (10.2)	78 (10.1)	36 (6.2)	33 (11.2)	18 (7.0)	21 (8.5)				
	Girls	< 90%	447 (88.5)	371 (92.3)	221 (90.6)	405 (89.8)	390 (91.3)	314 (94.6)	137 (87.3)	131 (91.0)	118 (90.8)				
Boys		≥ 90%	58 (11.5)	31 (7.7)	23 (9.4)	46 (10.2)	37 (8.7)	18 (5.4)	20 (12.7)	13 (9.0)	12 (9.2)				
		< 90%	434 (89.9)	307 (90.6)	203 (91.4)	337 (89.9)	303 (88.1)	233 (92.8)	124 (90.5)	108 (95.6)	107 (92.2)				
		≥ 90%	49 (10.1)	32 (9.4)	19 (8.6)	38 (10.1)	41 (11.9)	18 (7.2)	13 (9.5)	5 (4.4)	9 (7.8)				
Hypoactivity	All	< 90%	883 (89.0)	668 (90.1)	430 (92.3)	730 (88.9)	706 (91.5)	539 (92.5)	265 (90.4)	242 (94.2)	221 (89.8)				
		≥ 90%	109 (11.0)	73 (9.9)	36 (7.7)	91 (11.1)	66 (8.5)	44 (7.5)	28 (9.6)	15 (5.8)	25 (10.2)				
	Girls	< 90%	459 (90.5)	366 (91.0)	227 (93.0)	394 (87.8)	394 (92.3)	308 (92.8)	140 (89.2)	134 (93.1)	116 (89.2)				
Boys		≥ 90%	48 (9.5)	36 (9.0)	17 (7.0)	55 (12.2)	33 (7.7)	24 (7.2)	17 (10.8)	10 (6.9)	14 (10.8)				
		< 90%	424 (87.4)	302 (89.1)	203 (91.4)	336 (90.3)	312 (90.4)	231 (92.0)	125 (91.9)	108 (95.6)	105 (90.5)				
		≥ 90%	61 (12.6)	37 (10.9)	19 (8.6)	36 (9.7)	33 (9.6)	20 (8.0)	11 (8.1)	5 (4.4)	11 (9.5)				

(Continues)

TABLE 2 | (Continued)

Outcome	Cut-off	Mindfulness intervention				Active control				Passive control			
		T9 n (%)		T26 n (%)		T9 n (%)		T26 n (%)		T9 n (%)		T26 n (%)	
		T0 n (%)	T9 n (%)	T26 n (%)	T0 n (%)	T9 n (%)	T26 n (%)	T0 n (%)	T9 n (%)	T26 n (%)	T0 n (%)	T9 n (%)	T26 n (%)
Planning/organizing	< 90%	890 (90.1)	678 (92.2)	428 (92.4)	735 (90.0)	702 (91.6)	535 (92.1)	261 (89.7)	237 (92.2)	230 (93.5)			
	≥ 90%	98 (9.9)	57 (7.8)	35 (7.6)	82 (10.0)	64 (8.4)	46 (7.9)	30 (10.3)	20 (7.8)	16 (6.5)			
Girls	< 90%	454 (89.9)	372 (93.5)	228 (93.8)	404 (90.8)	396 (93.2)	308 (93.1)	139 (89.7)	132 (91.7)	123 (94.6)			
	≥ 90%	51 (10.1)	26 (6.5)	15 (6.2)	41 (9.2)	29 (6.8)	23 (6.9)	16 (10.3)	12 (8.3)	7 (5.4)			
Boys	< 90%	436 (90.3)	306 (90.8)	200 (90.9)	331 (89.0)	306 (89.7)	227 (90.8)	122 (89.7)	105 (92.9)	107 (92.2)			
	≥ 90%	47 (9.7)	31 (9.2)	20 (9.1)	41 (11.0)	35 (10.3)	23 (9.2)	14 (10.3)	8 (7.1)	9 (7.8)			

outcomes at T9 and T26 when comparing the MBI group with the active- and passive-control groups.

3.7 | Complementary Analyses

The results of the multilevel binary logistic regression models with the 98th percentile cutoffs for outcomes are presented in Tables S11 and S12. In line with the main results, no intervention effects were observed among all the students, by gender, or by grade in the EFs scale and the subscales at T9 and T26 when comparing the MBI group with the active- and passive-control groups.

Moreover, the results of the multilevel negative binomial regression models for the continuous outcomes are shown in Tables S13 and S14. These results were for the most part in line with the main findings. Compared to the active-control group, the MBI group showed significant reductions in inattention at T9 among all the students ($RR=0.87, p=0.03$) and among eighth graders ($RR=0.82, p=0.05$). Among boys, however, the MBI group showed less reduction at T9 in EFs ($RR=1.32, p=0.04$) and inattention ($RR=1.31, p=0.04$) compared to the passive-control group.

4 | Discussion

The present study compared a nine-week universal MBI (.b) carried out in schools with a nine-week relaxation program and a routine school curriculum in terms of their effects on elevated ADHD symptoms among children and adolescents aged 12–15 years, as rated by parents. Furthermore, the study examined how pupil baseline characteristics (gender, age, and socioeconomic status) and mindfulness home-practice intensity moderated these effects on symptom outcomes. Previous studies conducted with targeted interventions yielded promising results in the clinical field (e.g., Bögels et al. 2021; Lo et al. 2020; Siebelink et al. 2022; Valero, Cebolla, and Colomer 2022). In contrast, our analysis, which adopted a universal approach, found that the MBI had no effect on parent-reported overall ADHD symptoms or its subcomponents (inattention, hyperactivity/impulsivity, hypoactivity or planning/organizing problems) nine weeks after the intervention and at the 26-week follow-up when compared to the active- and passive-control conditions. However, consistent with the protocol (Volanen et al. 2016), the study did not employ self- or teacher-reported assessments. As such, the absence of MBI effects must be interpreted in light of this limitation.

Our overall finding that the .b intervention was not effective in reducing elevated ADHD symptoms aligns with the largest study of universal school-based mindfulness training (the MYRIAD project, Kuyken et al. 2022). When they compared the program to teaching as usual, adolescents showed no positive benefits across several mental health and behavioral outcomes and unexpectedly, hyperactivity/inattention increased after the MBI and at one-year follow-up. Furthermore, in the MYRIAD project, Montero-Marin et al. (2022) identified harmful effects of the .b intervention on depression and well-being in students at risk of mental health problems. While research in schools is limited in adolescents who are at risk of ADHD-like behavior (or diagnosed with ADHD), our results are consistent with a study by Ramos

TABLE 3 | Results of multilevel binary logistic regression models: Between groups differences expressed as odds ratios at nine-week and 26-week follow-up for all students and for girls and boys.

Outcome	All students			Girls			Boys			Gender × Group interaction
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>	<i>p</i>
Executive functions										
Int. vs. P-cont. at T9	1.11	0.56–2.22	0.76	0.73	0.33–1.59	0.42	2.09	0.74–5.93	0.17	T9: 0.14
Int. vs. A-cont. at T9	0.96	0.61–1.51	0.87	0.95	0.53–1.71	0.87	0.93	0.53–1.60	0.78	
Int. vs. P-cont. at T26	1.11	0.53–2.34	0.78	1.12	0.44–2.83	0.81	1.05	0.37–2.96	0.92	T26: 0.69
Int. vs. A-cont. at T26	1.17	0.67–2.02	0.58	1.39	0.69–2.82	0.36	0.91	0.43–1.90	0.80	
Inattention										
Int. vs. P-cont. at T9	1.01	0.56–1.83	0.98	0.57	0.30–1.11	0.10	3.65	1.02–13.13	0.047	T9: 0.03
Int. vs. A-cont. at T9	0.70	0.47–1.03	0.07	0.65	0.40–1.07	0.09	0.76	0.44–1.31	0.32	
Int. vs. P-cont. at T26	0.95	0.45–2.00	0.89	0.79	0.38–1.68	0.55	1.26	0.34–4.65	0.73	T26: 0.13
Int. vs. A-cont. at T26	0.90	0.52–1.57	0.72	1.06	0.59–1.92	0.84	0.65	0.27–1.58	0.34	
Hyperactivity/impulsivity										
Int. vs. P-cont. at T9	1.36	0.74–2.50	0.32	0.93	0.46–1.89	0.85	2.37	0.84–6.65	0.10	T9: 0.18
Int. vs. A-cont. at T9	0.84	0.57–1.22	0.36	0.88	0.53–1.45	0.61	0.76	0.45–1.28	0.30	
Int. vs. P-cont. at T26	0.90	0.50–1.62	0.73	0.94	0.43–2.05	0.87	0.85	0.34–2.08	0.71	T26: 0.80
Int. vs. A-cont. at T26	1.44	0.91–2.30	0.12	1.80	0.94–3.44	0.08	1.13	0.57–2.25	0.73	
Hypoactivity										
Int. vs. P-cont. at T9	1.81	0.94–3.48	0.08	1.32	0.61–2.83	0.48	2.86	0.98–8.36	0.05	T9: 0.46
Int. vs. A-cont. at T9	1.19	0.80–1.77	0.39	1.17	0.70–1.93	0.55	1.25	0.71–2.20	0.44	
Int. vs. P-cont. at T26	0.76	0.41–1.40	0.37	0.66	0.30–1.48	0.32	0.83	0.29–2.38	0.72	T26: 0.80
Int. vs. A-cont. at T26	1.04	0.63–1.72	0.88	0.98	0.50–1.90	0.95	1.02	0.46–2.28	0.96	
Planning/organizing										
Int. vs. P-cont. at T9	0.95	0.52–1.72	0.85	0.71	0.32–1.58	0.40	1.31	0.55–3.14	0.54	T9: 0.53
Int. vs. A-cont. at T9	0.93	0.62–1.39	0.73	0.97	0.54–1.75	0.92	0.89	0.53–1.52	0.68	
Int. vs. P-cont. at T26	1.02	0.52–2.01	0.95	1.00	0.35–2.85	1.00	1.02	0.40–2.59	0.97	T26: 0.98
Int. vs. A-cont. at T26	0.91	0.56–1.49	0.71	0.95	0.45–2.00	0.89	0.95	0.48–1.91	0.89	

Note: Bold font indicates significant effects ($p < 0.05$), P-cont.: passive-control group, $n = 339$ (boys $n = 165$), A-cont.: active-control group, $n = 969$ (boys $n = 438$), Int.: mindfulness intervention group, $n = 1068$ (boys $n = 528$). Grade and/or gender were controlled for in the analyses, and random intercepts accounted for school class- and school level -variations if estimable.

Abbreviations: CI, confidence Interval; OR, odds ratio.

et al. (2022) that used a multi-informant method and targeted MBI (during summer treatment program in classrooms) with younger children diagnosed with ADHD. However, our results contrast to numerous findings reported by parents in clinical settings (Bögels et al. 2021; Haydicky et al. 2015; Lo et al. 2020; Meppelink et al. 2024; Siebelink et al. 2022; Valero, Cebolla, and Colomer 2022; van de Weijer-Bergsma et al. 2012; van der Oord, Bögels, and Peijnenburg 2012; Zylowska et al. 2008). These studies observed some inconsistent results across informants. A large RCT by Siebelink et al. (2022) found that an add-on family-based MBI did not outperform a standard ADHD treatment in reducing children's self-control deficit (primary outcome) as rated by parents. Nonetheless, some benefits were observed in terms of

teacher-rated self-control deficits as well as parent-rated inattentiveness and hyperactive-impulsivity (secondary outcomes). To gain a comprehensive understanding of MBI effects on ADHD symptoms in schools, future studies should include not only parent-rated measures but also teacher-rated and self-rated assessments. As our study indicated a slight trend toward the benefits of the MBI for inattention symptoms compared to the relaxation program in the main analyses (the same trend was consistently found in the complementary analyses for the continuous outcomes), the role of mindfulness training in school contexts for attention regulation is worth further investigation. This is especially the case if we consider that among adults, MBIs' highest efficacy has been found for inattention symptoms (Oliva et al. 2021).

TABLE 4 | Results of multilevel binary logistic regression models: Between group differences expressed as odds ratios at nine-week post-intervention and at 26-weeks follow-up by grades.

Outcome	6th graders			7th graders			8th graders			Grade × Group interaction
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	p
Executive functions										
Int. vs. P-cont. at T9	1.36	0.37–4.95	0.64	0.94	0.34–2.65	0.91	0.81	0.26–2.50	0.71	T9: 0.80
Int. vs. A-cont. at T9	1.28	0.62–2.63	0.51	0.88	0.32–2.44	0.81	0.68	0.34–1.36	0.28	
Int. vs. P-cont. at T26	1.99	0.55–7.18	0.30	0.61	0.11–3.35	0.57	0.47	0.06–3.45	0.45	T26: 0.23
Int. vs. A-cont. at T26	1.77	0.88–3.55	0.11	0.45	0.09–2.40	0.35	0.65	0.13–3.21	0.60	
Inattention										
Int. vs. P-cont. at T9	1.61	0.50–5.15	0.43	1.01	0.34–2.98	0.99	0.69	0.25–1.92	0.47	T9: 0.85
Int. vs. A-cont. at T9	0.78	0.44–1.38	0.39	0.71	0.25–1.98	0.51	0.63	0.33–1.18	0.15	
Int. vs. P-cont. at T26	1.09	0.32–3.69	0.89	0.66	0.17–2.66	0.56	0.75	0.13–4.44	0.75	T26: 0.96
Int. vs. A-cont. at T26	1.10	0.52–2.34	0.81	0.56	0.14–2.20	0.41	0.70	0.18–2.72	0.61	
Hyperactivity/impulsivity										
Int. vs. P-cont. at T9	2.73	0.69–10.76	0.15	1.09	0.34–3.51	0.89	0.74	0.26–2.07	0.56	T9: 0.37
Int. vs. A-cont. at T9	1.22	0.66–2.25	0.53	0.69	0.22–2.21	0.53	0.55	0.30–1.02	0.06	
Int. vs. P-cont. at T26	1.33	0.49–3.61	0.58	0.57	0.08–4.28	0.58	0.49	0.19–1.26	0.14	T26: 0.23
Int. vs. A-cont. at T26	1.71	0.93–3.13	0.08	0.52	0.07–4.12	0.54	1.65	0.63–4.32	0.31	
Hypoactivity										
Int. vs. P-cont. at T9	1.58	0.48–5.17	0.45	1.74	0.53–5.67	0.36	2.00	0.57–7.00	0.28	T9: 0.94
Int. vs. A-cont. at T9	1.42	0.74–2.75	0.29	1.00	0.34–2.92	1.00	1.04	0.58–1.87	0.90	
Int. vs. P-cont. at T26	0.61	0.24–1.54	0.30	0.33	0.07–1.64	0.17	1.05	0.23–4.79	0.95	T26: 0.65
Int. vs. A-cont. at T26	1.22	0.63–2.37	0.56	0.35	0.07–1.78	0.21	1.06	0.34–3.34	0.92	
Planning/organizing										
Int. vs. P-cont. at T9	0.81	0.30–2.20	0.68	1.13	0.34–3.79	0.84	0.88	0.29–2.68	0.82	T9: 0.85
Int. vs. A-cont. at T9	1.05	0.57–1.94	0.87	0.82	0.26–2.56	0.73	0.86	0.43–1.72	0.68	
Int. vs. P-cont. at T26	0.85	0.32–2.27	0.74	0.78	0.13–4.67	0.79	1.01	0.26–3.84	0.99	T26: 0.83
Int. vs. A-cont. at T26	1.10	0.59–2.06	0.77	0.51	0.09–2.86	0.44	0.80	0.30–2.15	0.66	

Note: P-cont.: passive-control group (6 grade $n=95$, 7 grade $n=145$, 8 grade $n=99$), A-cont.: active-control group (6 grade $n=369$, 7 grade $n=160$, 8 grade $n=440$), Int.: mindfulness intervention group (6 grade $n=421$, 7 grade $n=140$, 8 grade $n=507$). Gender was controlled for in the analyses, and random intercepts accounted for school class- and school level -variations if estimable. Abbreviations: CI, confidence interval; OR, odds ratio.

The comparison of our study with existing research, especially the kind conducted in clinical settings, is difficult. Particularly as the content and delivery aspects vary between school-based universal and targeted clinical MBIs, and differences in these factors may contribute to differential effects. Our study used the .b program, which consisted of nine weekly group sessions of 45 min each, taught by certified mindfulness facilitators in whole classrooms (the average class size in Finland is around 20 students). In addition, home practices were recommended to be conducted five–six times a week for 3–15 min at a time. Adolescents were responsible for their own home practices, and we found that very few students trained regularly after the intervention. Most clinical trials

with promising findings used the MYmind program (e.g., Bögels et al. 2021; Meppelink et al. 2024; Siebelink et al. 2022; Valero, Cebolla, and Colomer 2022; Zhang et al. 2017). It is a family-based MBI that focuses on treating ADHD problems with eight 90-min group sessions in small groups (usually < 10 children) and 15 min of home practice per day (van der Oord, Bögels, and Peijnenburg 2012). Further, the necessity of doing home practices is discussed individually before the MBI, and their completion is monitored during the program through a review and reward system (van der Oord, Bögels, and Peijnenburg 2012). When comparing the two programs, it is possible that the frequency of sessions and the dosage of home practices (including the lack of home training support)

in the .b intervention were insufficient to produce positive effects. Another difference is that MYmind program is typically implemented in small groups and in close collaboration with parents (e.g., Bögels et al. 2021; Siebelink et al. 2022; van der Oord, Bögels, and Peijnenburg 2012). Thus, in schools, a targeted small-group delivery and/or collaboration with parents may be relevant factors for more favorable effects on ADHD symptoms. For example, if MBIs were delivered in small groups in schools, teacher-student ratios would be higher (Costello and Etherington 2019; Virone 2021), which could be beneficial for pupils with multiple deficits in attentional, behavioral, and motivational regulation (see Pfiffner, Barkley, and DuPaul 2015). Currently, no guidelines exist for the optimal dosage of mindfulness training for adolescents in educational setting (Strohmaier and Bailey 2023) or for the ideal content of an MBI for adolescents with attentional and behavioral impairments (Ramos et al. 2022). Universal MBIs, such as the .b, may need to be modified when implemented for students with elevated ADHD symptoms, because it may be that standardized dosage and content may not be appropriate for all individuals (Vergara et al. 2022). Rather than using universal MBIs, a targeted approach could be used to tailor these kinds of interventions to the needs of this particular subgroup. More school-based studies are needed to gain insight into the roles of content and delivery when it comes to MBI effects.

Our second aim was to explore whether pupils' baseline characteristics and mindfulness home-practice intensity modified the intervention effects. The assumption that older students would benefit more from the MBI was not confirmed, as grade did not moderate the intervention effects on the symptom outcomes. This result is in accordance with the findings of the recent clinical RCT by Siebelink et al. (2022), but it contrasts with the meta-analysis of Carsley, Khoury, and Heath (2018), who found that later adolescence might be the developmental period in which students are most responsive to mindfulness training. One reason for these conflicting results may be that responsiveness to mindfulness training varies between children and adolescents with ADHD symptoms and their peers. ADHD may delay the development of cognitive functions (Berger et al. 2013) and brain infrastructure for EFs (Brown 2013) by a few years, which may have a negative influence on responsiveness to mindfulness. We found only a trend of a positive intervention effect on hyperactivity/impulsivity symptoms in the MBI group compared to the active-control group at the post-intervention point among older students (14–15 years, grade 8). Furthermore, our complementary analyses showed that eighth graders may benefit from mindfulness training more than from relaxation training to reduce the symptoms of inattention. This suggests the need for future studies on the moderating effect of age with a larger age gap (up to early adulthood).

Furthermore, we observed some gender differences. Boys in the passive-control group had significantly more pronounced inattention-symptom reduction as well as marginally significant hypoactivity-symptom reduction at the post-intervention point compared to the MBI group. The reason for these differences remains unclear. However, in the MBI group, a decline in ADHD symptoms among boys was also detected. Elevated inattention symptoms (over the 90th percentile) declined from 10.3% at

baseline to 8.6% at the post-intervention point and 6.8% at follow-up. Elevated hypoactivity symptoms decreased from 12.6% at baseline to 10.6% at the post-intervention point and 8.6% at follow-up (Table 2).

Regarding socioeconomic status, our findings showed no moderating effect on the impact of MBI in reducing ADHD symptoms. The current empirical evidence is scarce and non-conclusive on whether socioeconomic factors influence the effectiveness of school-based MBIs in adolescents (Tudor et al. 2022). In childhood education, a meta-analysis by Vekety, Logemann, and Takacs (2021) showed a moderate effect of MBIs in reducing inattentiveness and hyperactivity-impulsivity in children with low socioeconomic status or at-risk of/ diagnosed with ADHD (risk samples). However, they found no significant differences when compared to non-at-risk samples.

Finally, the assumption that sustained and regular home practice during the follow-up would result in more pronounced effects was also not confirmed. In previous studies, more mindfulness training was found to be associated with stronger effects on cognitive functions (Zenner, Herrnleben-Kurz, and Walach 2014). In our study, very few students regularly used mindfulness during follow-up. This is in line with many studies in the school context that have found low adherence to home-practice recommendations (Strohmaier and Bailey 2023). As ADHD symptoms can be related to multiple neurocognitive and behavioral difficulties (American Psychiatric Association 2013), developing mindfulness skills that can strengthen EFs and attentional regulation skills may require both significant motivation and time—perhaps years of mindfulness training (Verhaeghen 2021). There is no long-term research on this aspect yet.

Overall, in research on MBIs among children and adolescents, our cluster RCT study provided important findings concerning the effectiveness of universal MBIs in reducing elevated ADHD symptoms in school settings. Although we did not find any positive intervention effects, it is important to note that our study only focused on changes in symptom levels, and there were no measures of internalizing and externalizing symptoms, or academic and social impairments. Even though the core symptoms are not affected, it is possible that universal MBIs are effective for young people at risk of or diagnosed with ADHD in terms of reducing the associated impairments (e.g., Bögels et al. 2021; Haydicky et al. 2015; Siebelink et al. 2022; van de Weijer-Bergsma et al. 2012; van der Oord, Bögels, and Peijnenburg 2012) and in terms of promoting well-being by enhancing emotion regulation, emotional well-being, and stress management (e.g., Huguet et al. 2019; Virone 2021; Zylowska et al. 2008; Zylowska, Smalley, and Schwartz 2009). More research is needed on the role of MBIs in these treatment outcomes.

4.1 | Limitations and Strengths

Our RCT had some major limitations. First, there was a notable attrition, which may have affected the results. Second, the passive-control group was almost three times smaller than the MBI and active-control groups, which may have limited the sensitivity in detecting differences between the three groups.

Third, only one parent-rated scale was used to measure ADHD symptoms. Even though the parent-rated FTF questionnaire was presented in the protocol (Volanen et al. 2016) and is widely used in clinical and research contexts in Nordic countries to detect the impairments stemming from ADHD symptoms (and other developmental problems), it did not take into account the students' own or teachers views of the symptoms. The use of several measures from different perspectives (parent, student, teacher) would have strengthened the findings and minimized response bias. However, Sibley et al. (2012) showed that in adolescents parental reports of ADHD symptoms correlate moderately (0.32–0.41) with the teacher reports. Moreover, the use of parents' perceptions in our study allows for a more straightforward comparison with previous studies in clinical settings, which have usually relied on parent-rated measurements for primary outcomes, and rarely used teacher-rated assessments (Siebelink et al. 2022). As noted by Colomer, Wiener, and Varma (2020), teacher reports may also not be the most accurate indicator of adolescents' difficulties in secondary school, as there is typically a different teacher for each subject. Fourth, although the study examined the effects of the MBI on ADHD symptoms, diagnostic background information or information about ongoing treatments was not available or measured. This means that the results cannot necessarily be directly generalized to adolescents diagnosed with ADHD, and further research in schools is recommended. However, as we implemented our study in school settings, the intervention also reached children who had not been diagnosed with ADHD but who still had elevated symptoms. Fifth, the study did not include the examinations of the effects of MBIs on internalizing and externalizing symptoms, or academic and social impairment, although previous clinical studies in adolescents have shown improvements in these areas (Haydicky et al. 2015; Siebelink et al. 2022). Moreover, the study measured adherence via one measurement (practice intensity) that very few students reported. Additional measurements, such as practice quality, might have strengthened the results. Lastly, the intervention used in the study was a universal program designed to strengthen well-being among children and adolescents, without a specific focus on ADHD symptoms and the characteristics of the disorder. Thus, the mindfulness training was not adjusted to the needs of adolescents exhibiting ADHD symptoms.

Our study has also several strengths. Its use of the RCT design, extensive sample size, follow-up period of 26 weeks, standardized MBI, and comparison of active- and passive-control groups responded to recent calls to conduct high-quality studies in the treatment of ADHD symptoms (Cairncross and Miller 2020; Mak et al. 2018; Oliva et al. 2021). Studying the MBI and the relaxation intervention together offered comparative information on both psychosocial interventions. Both programs were implemented by certified facilitators. Finally, the hierarchy of the data was accounted for in the analyses by using multilevel modeling, which represents another strength.

5 | Conclusions

This study investigated the effects of a universal MBI on the treatment of elevated ADHD symptoms in school settings. The

study does not support the use of brief universal MBIs in such settings to reduce elevated ADHD symptoms in children and adolescents. More RCTs with multiple measures, including self-rating, parent-rating, and teacher-rating measures, are needed to confirm this finding and examine the moderating effect of age and the impact of MBIs on typical co-occurring problems, such as those linked to emotion regulation, social impairment, and academic performance. Further research is also needed to identify optimal content and delivery methods for MBIs in schools. Rather than using universal programs, it should be examined whether a targeted approach, delivered in small groups, and adapted to the needs of students with elevated ADHD symptoms, is beneficial for this particular subgroup.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Marianne Holopainen, Tero Vahlberg, and Salla-Maarit Volanen. The first draft of the manuscript was written by Marianne Holopainen, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Ethics Statement

The study plan of HLM project was approved by the Ethical Review Board of the University of Helsinki in January 2014.

Consent

All participating students and their parents voluntarily offered written informed consent.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the authors upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.