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ORIGINAL PAPER

A School-Based Mindfulness Intervention for Adolescent Mental Health: The Moderating Effect of Personality Traits

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Abstract

Objectives There is currently a lack of empirical studies investigating whether specific personality traits moderate the effects of mindfulness-based interventions (MBIs) on distinct adolescent mental health outcomes. This study examined how personality traits from a five-factor model (agreeableness, conscientiousness, emotional stability, extraversion, and openness to experience) moderate the effects of an MBI in schools on adolescents' depression, socio-emotional functioning, and resilience.

Method A total of 2773 Finnish students aged 12–15 years participated in a cluster randomized controlled trial with three arms: a 9-week MBI (the.b program), a 9-week active control condition (a relaxation program), and an inactive control condition (the routine school curriculum). Personality traits were assessed before the MBI (T0). Mental health was evaluated before (T0) and after (T9) the intervention, as well as at a 26-week follow-up (T26), using scores for depressive symptoms, socio-emotional functioning difficulties, and resilience.

Results When compared with both control groups, personality traits did not moderate the effects of the MBI on resilience or socio-emotional functioning. Most of the moderation analyses were also nonsignificant on depressive symptoms. Only, at the 26-week follow-up, the analyses indicated a small moderating effect on the change in depressive symptoms between the MBI and active control groups ($\beta = 0.31$, 95% CI [0.002 to 0.63], $p = 0.048$), with adolescents in the MBI group scoring low in extraversion showing the greatest improvement. The results did not differ by gender.

Conclusions These preliminary findings suggest that the moderation effects were largely nonsignificant across personality traits and mental health outcomes, with only a small, exploratory interaction for extraversion observed at the follow-up. Further research is warranted to replicate these findings and to investigate their generalizability across diverse populations.

Preregistration A study protocol for a cluster randomized controlled trial was preregistered in the UK's Clinical Study Registry, ISRCTN18642659. The full trial protocol can be accessed at http://rdcu.be/t57S.

Keywords Mindfulness · Adolescence · Personality · School · Mental health

Adolescence marks a peak period for the onset of many common mental health problems, including depression, anxiety, and behavioral disorders (Kessler et al., 2005; Paus et al., 2008), affecting 10–20% of young people worldwide (Kieling et al., 2011). These challenges can impair adolescents' social and academic functioning (Christiansen et al., 2021) and increase the risk of mental health difficulties in adulthood (Kessler et al., 2005). Given that school-based interventions reach many students with a low threshold, educational settings are increasingly recognized as an ideal context for mental health promotion and early intervention (Green et al., 2013). For this purpose, various school-based interventions have been developed and tested with promising results (Cipriano et al., 2024; O'Reilly et al., 2018; van de Sande et al., 2019). Yet, there is a need for a broader evidence base regarding which interventions and practices work best for whom, why, and under what implementation contexts (Durlak et al., 2022).

Within educational settings, mindfulness-based interventions (MBIs) have long been acknowledged as particularly promising (Carsley et al., 2018; Felver et al., 2016). Aiming to enhance students' present-moment awareness by training them to focus attention on internal (e.g., thoughts, emotions, body sensations) and/or external (e.g., sounds) experiences moment by moment in an accepting and non-judgmental way (Bishop et al., 2004), dozens of MBIs have been developed worldwide for students across all grade levels (Meiklejohn et al., 2012; Roeser et al., 2022). A comprehensive

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meta-analysis of 66 RCTs in children and adolescents found that MBIs led to small improvements in anxiety/stress, attention, executive functioning, and negative and social behavior compared to inactive controls and in anxiety/stress and mindfulness compared to active controls (Dunning et al., 2022). Another meta-analysis of 22 RCTs, focusing particularly on school-based MBIs in adolescents as well as interventions that were delivered universally across entire classrooms or schools, found that the programs improved stress/anxiety and well-being relative to active controls, but reduced trait mindfulness compared with inactive controls (Galla et al., 2024). Moreover, no intervention effects on any outcome were revealed at follow-up assessment, or in the analyses where passive and active control groups were combined (Galla et al., 2024). Likewise, several school-based studies of universal MBIs have found no significant differences relative to control groups on a range of mental health outcomes, including socio-emotional functioning, depression, anxiety, attention/executive functioning, and overall well-being (Holopainen et al., 2025; Johnson et al., 2016, 2017; Kuyken et al., 2022; Lassander et al., 2020).

These inconsistent findings may derive from individual variability in the responses to MBIs (Carsley et al., 2018; Kuyken et al., 2022; Tang & Braver, 2020a, 2020b). Scholars who have worked on school-based MBIs have suggested that some student subgroups may benefit more than others, with meta-analyses showing larger effects on mental health outcomes (anxiety, depression, stress) in late adolescents (ages 15 to 18 years) (Carsley et al., 2018). Additionally, recent school-based studies indicate greater reductions in depression and anxiety, as well as greater improvements in resilience and positive affect among female students (Galvez Tan & Alampay, 2022; Kang et al., 2018; Volanen et al., 2020). Similarly, students with high motivation to practice at home (Volanen et al., 2020) and students with elevated baseline symptoms (Fung et al., 2019) have demonstrated larger reductions in depressive and stress symptoms. Moreover, individual dispositional traits of high catastrophizing and high acceptance, which are dimensions of cognitive emotion regulation (Garnefski et al., 2001), may increase the effectiveness of school-based mindfulness training against depressive symptoms (Saarinen et al., 2022). Beyond these tentative findings, evidence on the individual of factors that modify the effectiveness MBIs on mental health outcomes is scarce, highlighting a need for more investigation (Dunning et al., 2022; Tang & Braver, 2020b; Tudor et al., 2022).

Personality traits are among the possible characteristics that could moderate the effects of MBIs on mental health outcomes. Personality refers to relatively consistent and temporally stable patterns of affect, cognitions, and behaviors, and particularly, those traits described in the five-factor model (FFM, agreeableness, conscientiousness, emotional stability, extraversion, and openness to experience) are the most widely accepted trait structure description in the literature (Goldberg, 1993; McCrae & Costa, 2008). From a theoretical perspective, these traits might predict person-activity fit in psychological interventions (Lyubomirsky & Layous, 2013; Schueller, 2014). This means that the most effective intervention strategies should be those that are consistent with an individual's characteristics (strengths-based perspectives) or those that aim to work on one's deficits (weaknesses-based perspectives) (Schueller, 2014). On the one hand, intervention activities that resonate with an individual's natural strengths are typically more enjoyable and rewarding, which can enhance intrinsic motivation and increase the likelihood of sustained engagement over time (Lyubomirsky & Layous, 2013; Schueller, 2010, 2014). On the other hand, interventions could benefit participants by targeting their deficits (Schueller, 2014). Although this approach can help individuals develop new skills more quickly, such as coping strategies to deal with life's stressors, practices that conflict with one's own tendencies may also feel frustrating or less rewarding, reducing motivation for long-term commitment (Biswas-Diener et al., 2011; Schueller, 2014).

Although current literature links personality traits of the FFM to trait mindfulness (Banfi & Randall, 2022; Giluk, 2009; Hanley & Garland, 2017), empirical research examining how the traits moderate the effects of MBIs on adolescent mental health outcomes, particularly in school-based settings, is almost non-existent. To the best of our knowledge, only one non-randomized controlled trial with a small sample size ($N = 155$) has examined whether the improvements in psychological well-being, resilience, and mindfulness are related to the FFM traits (Huppert & Johnson, 2010). Most scholars have focused on university/college students (de Vibe et al., 2015; Halland et al., 2015; Küchler et al., 2022) or various adult populations, such as athletes and employees (Gan et al., 2024; Krick & Felfe, 2020; Nyklíček & Irrmischer, 2017). Given that adolescence is characterized by heightened neural plasticity of the brain and the ongoing maturation of psychosocial and cognitive systems, including changes in personality, shifts in emotion regulation (a normative decline), growth in metacognitive skills, and rising autonomy needs (Blakemore & Choudhury, 2006; Costa et al., 2019; Johnson et al., 2024; Soto & Tackett, 2015), it is possible that personality traits in children and adolescents influence the effects of MBIs on mental health outcomes in different ways compared to what happens in adults. Furthermore, although most of the studies conducted in adults used the RCT design, none of them involved an active control group. This undermines the ability to draw causal inferences as the very fact of being subjected to an intervention can generate changes regardless of the content of the intervention (Boot et al., 2013). Thus, the lack of an active control group makes it difficult to isolate specific

processes that underlie the effects of mindfulness training. Our study included both inactive and active control groups, and it examined all five traits of the FFM. In the next section, we briefly discussed the potential moderating role of personality traits in MBI effects on adolescent mental health outcomes, taking into account the theoretical perspectives of person-activity fit.

The most consistent evidence on personality traits as MBI moderators pertains to emotional stability. Low emotional stability (i.e., neuroticism) is defined by individual tendencies to worry, insecurity, self-consciousness, and the experience of various negative affects (Costa & McCrae, 1992; McCrae & Costa, 1987). In adolescents with low levels of emotional stability, MBI can have pronounced effects on psychological well-being (Huppert & Johnson, 2010). Similarly, scholars studying adults have shown that individuals with lower emotional stability experience greater benefits from MBIs in terms of mental distress, subjective well-being (de Vibe et al., 2015), adoption of healthy coping strategies (Halland et al., 2015), anxiety, depressive symptoms (Nyklíček & Irrmischer, 2017), mindfulness, self-care, psychological strain, and negative affects (Krick & Felfe, 2020). Since individuals with low emotional stability typically exhibit lower trait mindfulness and poorer emotion regulation skills (Banfi & Randall, 2022; Barańczuk, 2019), it is possible that improving these deficits is key to the observed well-being benefits. However, not all studies have produced consistent results. For example, Küchler et al. (2022) failed to find a moderating role for emotional stability in the effect of an MBI on mindfulness, whereas Gan et al. (2024) showed that athletes with higher levels of emotional stability experienced greater improvements after mindfulness training in self-confidence. The findings from adult samples cannot be directly generalized to adolescents, particularly because individuals generally experience lower emotional stability and a normative decline in emotion regulation during puberty (Costa et al., 2019; Cracco et al., 2017; Soto & Tackett, 2015). For example, these developmental changes may cause mindfulness practices to feel overly challenging for some adolescents, thereby reducing their motivation to engage with or sustain the practice over time.

The evidence on the moderation effects of conscientiousness and openness to experience lacks consistency. A study conducted in adolescents found that these traits were not significantly related to the effects of an MBI on resilience, psychological well-being, or mindfulness (Huppert & Johnson, 2010). Regarding higher *conscientiousness*, which implies socially determined self-control and goal-oriented behavior (John et al., 2008; McCrae & Costa, 2008), de Vibe et al. (2015) showed an increased effect of mindfulness training on the reduction of study stress among university students. Because mindfulness training requires self-regulation and disciplined practice, conscientious individuals may find the training more enjoyable and maintaining mindfulness skills easier (Banfi & Randall, 2022). However, beyond stress symptoms, studies in adults have found no modifying effects of conscientiousness on other socio-emotional outcomes, such as mood symptoms, coping, self-care, psychological strain, and negative affects (Halland et al., 2015; Krick & Felfe, 2020; Küchler et al., 2022; Nyklíček & Irrmischer, 2017). In terms of higher *openness to experience*, which covers curiosity, imagination, and an exploratory tendency towards the outer world and inner experiences (John et al., 2008; McCrae & Costa, 2008), a more pronounced effect of an MBI has been reported on improving physiological health (heart rate variability) (Krick & Felfe, 2020). Given that openness to experience is closely related to mindfulness (e.g., curiosity and openness to different experiences; Banfi & Randall, 2022), it is likely that individuals with higher levels of this trait are more interested in starting mindfulness practice and remain motivated over the long term (van den Hurk et al., 2011) and thus achieve greater benefits. From a developmental perspective, openness to experience typically increases during adolescence (Costa et al., 2019), suggesting that its moderating impact on the effectiveness of MBIs may be particularly pronounced in younger populations. However, the findings from adult samples are mixed. One study found that lower openness was associated with a greater MBI effect on increasing mindfulness (Küchler et al., 2022), while other studies found no modifying effects regarding psychological well-being, as indicated by mood symptoms or negative affects (Krick & Felfe, 2020; Nyklíček & Irrmischer, 2017).

Regarding the role of *extraversion*, which pertains to traits such as activity, excitement seeking, sociability, and positive emotionality (Barrick et al., 2001; John et al., 2008), researchers have found mostly null effects, including in adolescence (de Vibe et al., 2015; Halland et al., 2015; Huppert & Johnson, 2010; Küchler et al., 2022; Nyklíček & Irrmischer, 2017). Only adult athletes with higher levels of extraversion showed an increased MBI effect on improving mindfulness and alleviating anxiety (Gan et al., 2024). It is possible that extraverted individuals benefit from intervention approaches that include group-based practices and interpersonal interactions (Tang & Braver, 2020b). However, a need for activity and stimulation may also make formal mindfulness training difficult for these individuals (Giluk, 2009). This may be particularly true among adolescents, as research indicates that activity/extraversion declines in most individuals as they transition from adolescence to adulthood (Costa et al., 2019; Soto & Tackett, 2015).

Finally, only a few scholars have examined *agreeableness*, which concerns characteristics such as altruism, honesty, tendermindedness, and cooperative and empathetic behavior towards others (Graziano & Eisenberg, 1997; John et al., 2008; McCrae & Costa, 2008), and

their results have been inconclusive. Huppert and Johnson (2010) found that a higher level of agreeableness in adolescents was associated with a greater MBI effect on increasing psychological well-being, while Küchler et al. (2022) were unable to confirm this trait as a significant MBI moderator on mindfulness in adults. Furthermore, Mongrain et al. (2018) found that compassion training, a practice closely linked to mindfulness training (Wilson et al., 2019), was more effective in reducing depressive symptoms in individuals with lower levels of agreeableness. Given that mindfulness is positively associated with agreeableness (Banfi & Randall, 2022), individuals high in this trait may find mindfulness training more rewarding and practice more intensively (Barkan et al., 2016). However, those with lower agreeableness may also benefit from the training by developing new self-regulation skills, such as an acceptive attitude.

To date, research assessing personality traits as moderators of the effects of MBIs on adolescent mental health outcomes is almost non-existent, particularly in school-based settings. The present study sought to address this gap by examining the following research questions: (1) Did the FFM personality traits (agreeableness, conscientiousness, emotional stability, extraversion, and openness to experience) moderate the effects of a school-based MBI on adolescent mental health outcomes? and (2) Did these moderation effects vary by gender? Given the limited relevant research on adolescents (Huppert & Johnson, 2010), we made no assumptions about the direction of moderating effects, and the analyses were exploratory and hypothesis-generating in nature.

The participating schools were randomized to a 9-week standardized MBI (*the.b program*), a 9-week standardized relaxation-based active control group, and an inactive control group that followed a routine school curriculum. Mental health was assessed at baseline (T0), 9 weeks after baseline (T9, immediately after the intervention), and 26 weeks after baseline (T26, follow-up) using resilience, socio-emotional functioning difficulties, and depressive symptoms as outcomes. The mental health outcomes were chosen for this study because they are the primary outcomes in our extensive Finnish Healthy Learning Mind (HLM) research project (Volanen et al., 2016). The effectiveness of the MBI in question on the outcomes has been reported in a previous publication (Volanen et al., 2020). The results showed a positive effect of the MBI on resilience in all the participants at T9 compared to the active control group, whereas no effects on depressive symptoms and socio-emotional functioning were found at T9 and T26 compared to both control groups. Moreover, the gender-stratified analyses showed no intervention effects in boys. In girls, a positive intervention effect was found only for depressive symptoms at T26.

Method

Participants

There were 1646 students in the MBI group, 1488 in the active control group, and 385 in the inactive control group. Figure 1 shows the flow of participants. After the follow-up period, 746 students (21.2%) were excluded because they lacked the baseline personality trait measure or did not complete the outcome measures at any of the measurement points. Overall, 2773 students were included in the analysis: 1228 in the MBI group, 1192 in the active control group, and 353 in the inactive control group.

Table 1 presents the descriptive statistics. The participants were in Grades 6, 7, and 8, and they were aged between 12 and 15. There were no differences between the groups in terms of personality traits, mental health outcomes, or gender at baseline (Table 1). Most of the students were in eighth grade ($n = 1241$; 44.8%), and half of them were girls ($n = 1413$; 51.0%). At baseline, girls had higher depressive symptoms ($p < 0.001$), agreeableness ($p < 0.001$), conscientiousness ($p < 0.001$), and openness to experience ($p < 0.001$) compared to boys, while the latter had higher levels of emotional stability ($p < 0.001$) (Table 2).

Procedure

A total of 3519 Finnish adolescents enrolled in this cluster RCT, which consisted of an MBI group, an active control group, and an inactive control group (retrospective registration: ISRCTN18642659). Approval was granted by the ethical review board of the University of Helsinki (approval 1/2014). Initially, the recruitment started by contacting all 247 schools located in the southern part of Finland (in 14 municipalities/cities), of which 56 (23%) were interested and consented to participate. Schools cited several reasons for non-participation: principal unavailable during recruitment (25%), already involved in other research (23%), insufficient teacher interest (18%), and other reasons (11%). Before baseline data collection, the schools that consented to participate were randomized to either the MBI (25 schools, 94 classes, $n = 1646$), active control (24 schools, 85 classes, $n = 1488$), or inactive control conditions (7 schools, 31 classes, $n = 385$). The stratified randomization was performed using computer-generated sequences via R (version 3.0.2). For stratification, several background variables were taken into account including the teaching language (Finnish, Swedish, or English), the grade, the school location, the total number of participating classes, and the average apartment price

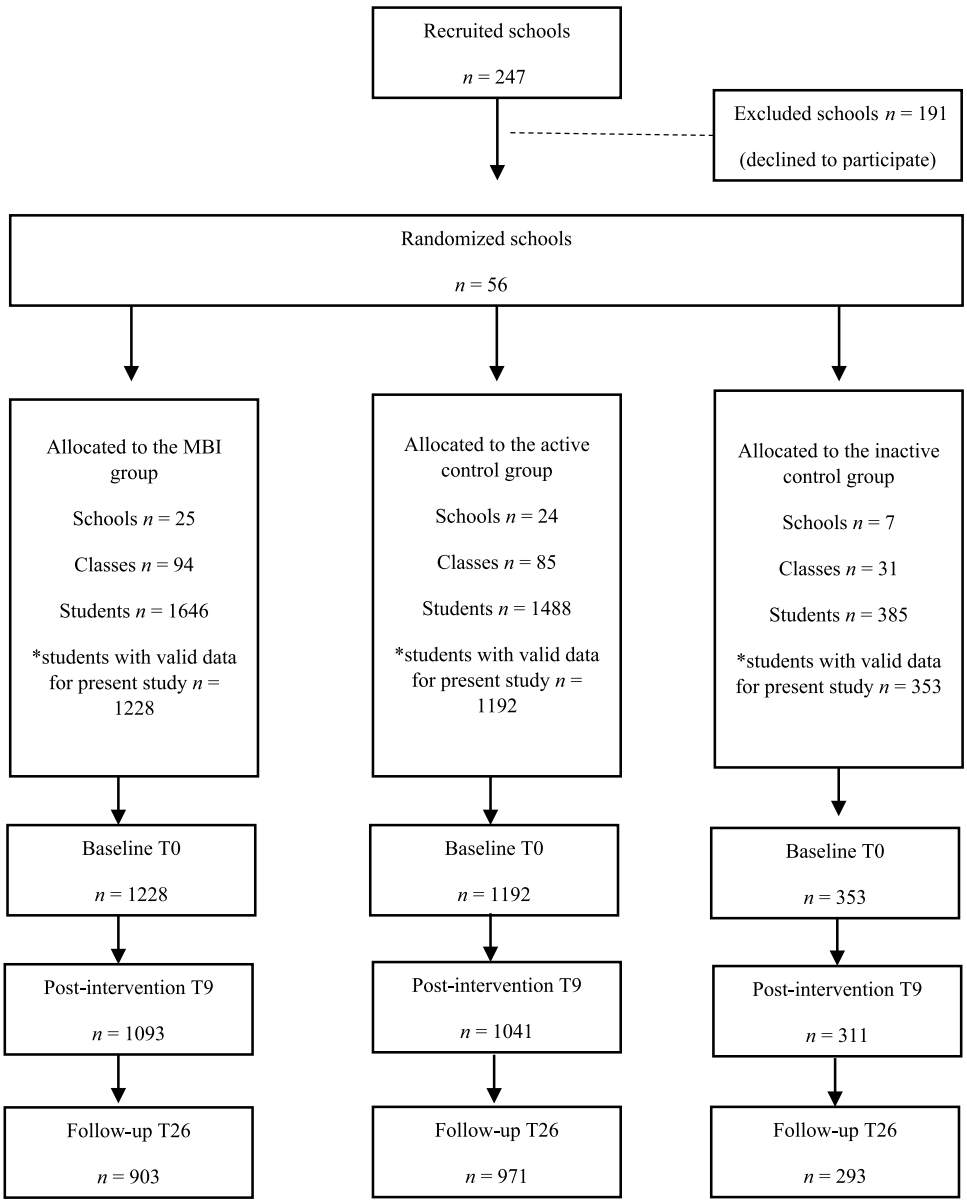

Fig. 1 Study design

per square meter in the school's neighborhood. The goal was to achieve equal numbers of intervention and control classes in each municipality. Due to practical reasons, randomization was implemented in separate phases, dividing classes into either two (intervention/control: Spring 2014, Autumn 2015) or three arms (intervention/active control/inactive control: Spring 2015, Spring 2016). A statistician outside the research group performed the randomization. In Finland, the school system is characterized by a high degree of consistency. This means that private schools are rare, and the majority of pupils attend the nearest school in their neighborhood. Additionally, all schools follow the national curriculum set by the Finnish National Agency for Education, ensuring consistency in educational content. Compared to many countries, regional segregation in education remains relatively low.

Data collection occurred between March 2014 and December 2016, and it covered four semesters (including four baseline measurement periods): the spring semester in 2014, the fall semester in 2014, the spring semester in 2015, and the spring semester in 2016. For practical reasons, the data from the inactive control group was collected in only two semesters (spring 2015 and spring 2016), which led to a smaller sample for this group. Whole classes participated in the MBI and active control conditions. The participants in these groups were blinded and briefed about their participation in a 9-week program called Skills for Well-Being. The classes in the inactive control group followed the normal school curriculum and did not receive any intervention

Table 1 The descriptive statistics of the study variables (predictors, moderators, and outcomes) by groups

	Total		MBI group		Active control group		Inactive control group		
	N (%)	*Mean (SD)*	*n* (%)	*Mean (SD)*	*n* (%)	*Mean (SD)*	*n* (%)	*Mean (SD)*	*p*
Demographic characteristics at T0									
N	2773		1228 (44.3)		1192 (43.0)		353 (12.7)		
Gender									0.51
Boys	1360 (49.0)		617 (50.2)		571 (47.9)		172 (51.3)		
Girls	1413 (51.0)		611 (49.8)		621 (52.1)		181 (48.7)		
School grade									< 0.001
6th grade	1030 (37.1)		488 (39.7)		429 (36.0)		113 (32.0)		
7th grade	502 (18.1)		163 (13.3)		192 (16.1)		147 (41.6)		
8th grade	1241 (44.8)		577 (47.0)		571 (47.9)		93 (26.3)		
Personality traits at T0									
Agreeableness	2716	5.43 (1.04)	1203	5.44 (1.03)	1175	5.45 (1.04)	338	5.36 (1.04)	0.41
Conscientiousness	2706	5.34 (1.12)	1191	5.32 (1.11)	1171	5.32 (1.15)	344	5.43 (1.05)	0.38
Extraversion	2737	4.67 (1.25)	1213	4.66 (1.27)	1175	4.68 (1.24)	349	´4.66 (1.22)	0.95
Emotional stability	2715	4.62 (1.19)	1201	4.63 (1.19)	1166	4.63 (1.22)	348	4.58 (1.10)	0.58
Openness	2739	5.01 (1.11)	1212	5.00 (1.12)	1180	5.04 (1.08)	347	4.97 (1.16)	0.85
Outcome variables at T0, T9, and T26									
Depressive symptoms									
T0	2627	2.12 (3.88)	1159	2.18 (4.03)	1132	2.10 (3.73)	336	2.04 (3.89)	0.85
T9	2322	1.93 (3.77)	1040	1.93 (3.88)	977	1.95 (3.58)	305	1.88 (4.00)	
T26	2070	1.92 (4.06)	868	1.83 (3.74)	912	1.98 (4.29)	290	2.00 (4.24)	
Resilience									
T0	2765	77.02 (11.17)	1224	77.05 (11.34)	1188	77.04 (11.12)	353	76.87 (10.77)	0.84
T9	2433	76.45 (12.32)	1091	76.90 (12.06)	1032	75.69 (12.29)	310	77.42 (13.19)	
T26	2160	77.24 (13.08)	901	77.32 (13.30)	967	77.23 (13.24)	292	77.04 (11.83)	
Socio-emotional functioning									
T0	2723	10.27 (5.43)	1216	10.39 (5.44)	1160	10.18 (5.43)	347	10.20 (5.38)	0.81
T9	2399	10.15 (5.93)	1073	10.11 (5.87)	1020	10.26 (6.02)	306	9.93 (5.87)	
T26	2124	9.66 (5.94)	882	9.73 (5.87)	955	9.61 (6.03)	287	9.62 (5.90)	

p-values: χ^2-test was used for gender, and school grade, and linear mixed models (LMMs) for outcomes, and personality traits at T0. The LMMs included random intercepts of classroom- and school-level variances. Gender and grade were adjusted for in the analyses

during the data collection period. Written informed consent was obtained from all the participants and their parents (or legal guardians). Consent was also requested from the head teachers at the schools. Participants were informed that the participation was voluntary, with the option to withdraw at any time. The teachers were at the classrooms during questionnaire completion and group sessions. After data collection, personal details that could identify the participants were separated from the data. The more comprehensive details of the procedure are available in the RCT protocol (Volanen et al., 2016).

Mindfulness Intervention

The participants in the MBI group received a manualized 9-week intervention called *.b* (Huppert & Johnson, 2010; Mindfulness in Schools Project, 2021). The program was developed to improve emotional awareness, emotion regulation, and attention regulation of children and adolescents

Table 2 The descriptive statistics of the study variables for girls and boys by groups, and baseline comparisons between the genders

	Girls								**Boys**								**Girls vs. Boys**
	MBI group		Active control group		Inactive control group		Total		MBI group		Active control group		Inactive control group		Total		
Variables	*n*	*Mean (SD)*	*n*	*Mean (SD)*	*n*	*Mean (SD)*	*n*	*Mean (SD)*	*n*	*Mean (SD)*	*n*	*Mean (SD)*	*n*	*Mean (SD)*	*n*	*Mean (SD)*	*p*-value
Outcomes																	
Depressive symptoms																	
T0	592	2.63 (4.32)	605	2.55 (4.03)	175	2.96 (4.86)	1372	2.63 (4.27)	567	1.71 (3.65)	527	1.58 (3.27)	161	1.05 (2.03)	1255	1.57 (3.33)	< 0.001
T9	544	2.35 (4.15)	537	2.43 (4.10)	163	2.55 (4.72)	1244	2.41 (4.20)	496	1.47 (3.51)	440	1.35 (2.71)	142	1.11 (2.80)	1078	1.38 (3.11)	
T26	456	1.96 (3.44)	489	2.43 (4.49)	148	2.71 (4.61)	1093	2.27 (4.12)	412	1.70 (4.05)	423	1.46 (3.99)	142	1.26 (3.67)	977	1.53 (3.97)	
Resilience																	
T0	607	76.72 (11.57)	618	77.09 (11.28)	181	76.93 (11.26)	1406	76.91 (11.39)	617	77.38 (11.11)	570	76.99 (10.95)	172	76.80 (10.25)	1359	77.14 (10.93)	0.74
T9	560	76.90 (11.22)	550	75.94 (11.55)	162	76.62 (13.24)	1272	76.45 (11.64)	531	76.91 (12.89)	482	75.40 (13.09)	148	78.30 (13.13)	1161	76.46 (13.03)	
T26	467	78.29 (11.64)	508	77.49 (12.96)	149	76.81 (12.36)	1124	77.74 (12.35)	434	76.27 (14.83)	459	76.94 (13.55)	143	77.27 (11.29)	1036	76.70 (13.82)	
Socio-emotional functioning																	
T0	603	10.45 (5.26)	608	10.15 (5.26)	177	10.63 (5.19)	1388	10.34 (5.25)	613	10.33 (5.61)	552	10.21 (5.62)	170	9.76 (5.56)	1335	10.21 (5.60)	0.58
T9	551	9.80 (5.45)	548	9.79 (5.50)	160	10.50 (5.78)	1259	9.89 (5.51)	522	10.44 (6.27)	472	10.80 (6.54)	146	9.31 (5.93)	1140	10.45 (6.35)	
T26	460	9.16 (5.20)	503	9.33 (5.80)	146	9.91 (5.76)	1109	9.34 (5.56)	422	10.35 (6.47)	452	9.92 (6.27)	141	9.32 (6.04)	1015	10.02 (6.32)	
Moderators at T0																	
Agreeableness	598	5.58 (0.99)	611	5.63 (0.99)	174	5.35 (1.02)	1383	5.58 (1.00)	605	5.30 (1.04)	564	5.25 (1.05)	164	5.37 (1.07)	1333	5.29 (1.05)	< 0.001
Conscientiousness	592	5.49 (1.08)	609	5.49 (1.13)	176	5.56 (0.97)	1377	5.50 (1.09)	599	5.16 (1.12)	562	5.14 (1.15)	168	5.30 (1.11)	1329	5.17 (1.13)	< 0.001

Table 2 (continued)

	Girls					Boys					Girls vs. Boys
Extraversion	605	4.71 (1.29)	615	4.69 (1.25)	178	1398	4.58 (1.29)	608	4.61 (1.24)	560	0.47
Emotional stability	598	4.47 (1.17)	608	4.47 (1.23)	178	1384	4.34 (1.18)	603	4.79 (1.19)	558	<0.001
Openness	604	5.07 (1.07)	618	5.16 (1.04)	179	1401	5.04 (1.18)	608	4.94 (1.16)	562	<0.001

Extraversion	171	4.74 (1.14)	1339	4.65 (1.23)	
Emotional stability	170	4.84 (0.94)	1331	4.80 (1.16)	
Openness	168	4.89 (1.15)	1338	4.92 (1.14)	

p-values: linear mixed models were used for baseline comparisons by gender. Grade and group were controlled for in the analyses, and random intercepts accounted for school classroom- and school-level variations

in a classroom context based on mindfulness-based stress reduction (MBSR, Kabat-Zinn, 2003b) and mindfulness-based cognitive therapy (MBCT, Segal et al., 2013). It was implemented during school hours as a series of nine group sessions (45 min each, once per week) and short home practices. The group sessions were designed to teach a variety of mindfulness skills through short, informal and formal mindfulness practices and psychoeducation (Mindfulness in Schools Project, 2021). The formal practices involved awareness of the body, mindfulness of breathing and finding an anchor point, awareness of sounds, awareness of thoughts and understanding their transient nature, and walking meditation (Huppert & Johnson, 2010). The informal practices, such as mindful eating, were aimed at teaching how mindfulness can be embedded in daily routines. Standardized teacher notes, PowerPoint presentations, and animations were used in each group lesson. The structure of the weekly session was as follows: (1) introducing what mindfulness is, (2) paying attention and training the muscle of the mind, (3) mind states and anchoring attention to the body, (4) recognizing worry, (5) how to respond rather than react, (6) moving mindfully, (7) how we relate to our thoughts, (8) dealing with difficult emotions, and (9) key techniques and future inspirations. A more comprehensive structure of the sessions is provided in Online Resource 1. The participants received *.b* student workbooks for the course, which they could also use for home exercises. After each class, they were advised to practice independently at home five to six times a week for 3–15 min at a time. At home, the participants also had the opportunity to listen to the mindfulness exercises using audio files. The program was conducted by nine certified mindfulness facilitators with years of experience. Most of them had backgrounds in education or health and welfare. All of them had previously attended an 8-week MBSR course (Kabat-Zinn, 2003b) and received training in delivering the *.b* program. The training included each instructor delivering one randomly selected *.b* session, which was evaluated by members of the research team and colleagues who were not part of the current research group but had participated in the MBSR course. The students in the MBI group exhibited high participation: 90% of them took part in seven to nine lessons, 5% in six lessons, and 5% in one to five lessons. Adherence to home practice recommendations was not assessed during the 9-week intervention. At the follow-up, the intensity of home practice was evaluated, and most of the students had practiced only a couple of times (78.3%, Online Resource 2).

Relaxation Program

The students in the active control group participated in a standardized 9-week relaxation program called *Relax*. This program was developed in collaboration with Folkhälsan

Förbundet (based on a program called *Chilla*), and it aimed to improve the participants' relaxation skills and overall well-being. The program took the form of nine group sessions (45 min each, once per week) during school hours and short home exercises (the recommended amount: 5–6 times a week). The classes were held by Relax-certified schoolteachers or experienced wellness group leaders specializing in the age group in question. Each class included training in relaxation techniques and psychoeducation/discussions on various wellness topics. The relaxation practices lasted from 3 to 15 min. These exercises included progressive muscle relaxation, breathing relaxation, relaxation through visualization, movement relaxation, choosing an emotion for the rest of the day, and a short pause for regaining energy. The discussion part involved several topics, such as stress in adolescence, how to recognize stress responses, stress management and relaxation, the role of lifestyle factors for well-being (including sleeping, nutrition, physical activity, and supportive friends), and digital media use and its effects on well-being.

Measures

Depressive Symptoms

The 13-item short questionnaire of the revised Beck Depression Inventory (RBDI) was used to measure depressive symptoms (Beck et al., 1988; Raitasalo, 2007). The RBDI is a self-report measure that assesses the depth of depression across its cognitive, affective, behavioral, and somatic aspects. The Finnish version of this instrument has been validated in a Finnish adolescent population with good psychometric properties (Kaltiala-Heino et al., 1999). For ethical reasons, the item on suicidal ideation was removed. The 12-item scale corresponds to the original scale in terms of psychometric properties (Kosunen et al., 2003). Each item is scored on a 4-point scale ranging from 0 to 4. The outcome score of the RBDI was calculated as the sum of the 12 items (range 0–36), with higher scores indicating more severe symptoms. The observed internal consistency of the RBDI (McDonald's Omega coefficient at baseline) was 0.86 (Hayes & Coutts, 2020).

Resilience

The short version of the Resilience Scale (RS14) was used to assess the participants' degree of resilience, which describes a personality trait that enhances an individual's ability to adapt and recover from difficult life events (Wagnild & Young, 1993). The Finnish version of the RS14 has shown good internal consistency and reliability (Losoi et al., 2013). The RS14 consists of 14 items scored on a 7-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The outcome score of the scale was calculated as the sum of the 14 items (range 7–98), with higher scores indicating higher resilience. The scale's observed internal consistency (McDonald's Omega coefficient at baseline) was 0.87.

Socio-emotional Functioning

The self-rated Strengths and Difficulties Questionnaire (SDQ) was used to measure socio-emotional functioning difficulties (Goodman, 1997). This questionnaire is a brief screening tool for mental health problems in children and adolescents (Goodman, 2001). The Finnish version of the SDQ has shown good psychometric properties (Koskelainen et al., 2000). The SDQ consists of 25 items divided into five subscales, each with five items: emotional symptoms, conduct problems, hyperactivity, peer problems, and pro-sociality. Each item is scored on a scale of 0 (*not true*) to 2 (*certainly true*). Five items are scored in the opposite direction because they are formulated positively. The total difficulties score (range 0–40) is generated by summing all the items except those in the pro-sociality scale (Goodman, 2001). As our study used only the total score, the pro-sociality scale was excluded. Higher difficulties scores indicated higher socio-emotional functioning problems. The scale's observed internal consistency (McDonald's Omega coefficient at baseline) was 0.79.

Personality Traits

The Ten Item Personality Inventory (TIPI) was used to assess the FFM personality dimensions (agreeableness, conscientiousness, emotional stability, extraversion, and openness to experience) (Gosling et al., 2003). It is a brief measure designed for contexts where survey length must be minimized. In the inventory, each dimension contains two items representing its positive and negative poles (e.g., extraversion: "I see myself as extraverted and enthusiastic" and "I see myself as reserved and quiet"). The responses were scored on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). The outcome scores of the subscales were calculated as the sums of the items (range 2–14). The TIPI demonstrates adequate convergent and discriminant validity, test–retest reliability, and patterns of external correlates (Gosling et al., 2003). However, as each TIPI scale has only two items, internal consistency is typically lower than in longer measures (Gosling et al., 2003). This is in line with psychometric research showing that the number of items in a scale has a significant influence on internal consistency (Streiner, 2003; Tavakol & Dennick, 2011). In our study, to assess the scale's internal consistency, Spearman–Brown coefficients were calculated (Eisinga et al., 2013). For two-item measures, the Spearman–Brown coefficient is typically less biased than, for example, Cronbach's α (Eisinga et al.,

2013). The coefficients can be considered good if they are above 0.80 (Ellis & Sijtsma, 2024; Nunnally, 1978). The results were 0.40 for agreeableness, 0.46 for conscientiousness, 0.31 for emotional stability, 0.38 for extraversion, and 0.19 for openness to experience. Similar internal consistency findings for each dimension (Cronbach's $\alpha = 0.11–0.57$) were observed in a study of MBI among adolescents by Huppert and Johnson (2010).

Data Analyses

Data analyses were performed using SAS System version 9.4 for Windows (SAS Institute Inc., Cary, NC, USA). Linear mixed models (LMMs) were used to compare the outcomes and personality traits at baseline by group (MBI, active control, and inactive control) and gender. LMMs were also performed to analyze the modifying impacts of personality traits on the effectiveness of the MBI in terms of changes in the outcomes at T9 and T26. LMMs can account for the correlation of repeated measurements within individuals over time and for intra-group dependencies arising from the nested structure of the data (e.g., students within classes or within schools) (Hox, 1998). In addition, they enable participants with incomplete information to be included in the analyses. Therefore, all the participants with available outcome data from at least one measurement point and personality traits measured at baseline were included in our analysis (an intention-to-treat analysis). Cases with partially missing outcome data were handled using maximum likelihood estimation. In the LMMs, group was treated as a between-subjects factor, and time was considered a repeated factor. To specify the within-individual error covariance structure, four types of structures (compound symmetry (CS), heterogeneous compound symmetry (HCS), unstructured (UN), and first-order autoregressive covariance structures (AR(1))) were tested. These are commonly examined in longitudinal studies (Shek & Ma, 2011; Wolfinger, 1996), representing a range of common assumptions from the simplest (CS) to the most complex/flexible structure (UN), and one that is specific to time-series data (AR(1)). The Bayesian information criterion (BIC) was used to select the model that provided a good fit to the data without being unnecessarily complex. Generally, a lower BIC value indicates a better model to the data (Shek & Ma, 2011). To account for the clustered nature of the data, the LMMs included random intercepts of classroom- and school-level variances (the variance components covariance structure was used). In the analyses, gender and grade were adjusted for (included as covariates in the analyses) based on prior literature indicating their potential influence on the outcome variables (Carsley et al., 2018; Dunning et al., 2022; Volanen et al., 2020). The analyses were conducted separately for each personality trait without adjusting for the other traits.

The LMMs of the intervention effects consisted of the main effects of time, group, gender, grade, and personality trait; the two-way interaction effects of group × time, personality trait × time, personality trait × group; and the three-way interaction effect of personality trait × group × time. The modifying effects of each personality trait were examined based on the three-way interaction effects and between-group and within-group comparisons. For each group, regression coefficients were calculated for the moderating effect of each personality trait on the change in the three outcomes at T9 and T26. A positive estimate meant that a higher value in the modifying personality trait predicted a greater increase in the outcomes (depressive symptoms, socio-emotional functioning difficulties, or resilience) at T9 or T26. A negative estimate meant that a higher value in the modifying variable predicted a greater decrease in the outcomes at T9 or T26. Between-group estimates (MBI vs. inactive control and MBI vs. active control) were calculated as the difference in the regression coefficients between the MBI and control groups. The Bonferroni adjustment was used in these pairwise group comparisons to control for type I error. The effect sizes were calculated as a standardized difference in regression coefficients for the moderating effects between groups. An effect size of 0.10–0.29 is considered small, 0.30–0.49 as medium, and 0.50 or greater as a large effect (Cohen, 1988). All the regression coefficients were estimated from the LMMs. A two-tailed statistical test was used at a level of significance of 5%. No multiple testing adjustments were made due to the exploratory and hypothesis-generating nature of analyses of the study. Analyses were conducted for all the participants, and each personality trait was tested as a continuous variable against all three outcomes. Furthermore, the modifying effect of gender was examined by entering a four-way interaction term (gender × personality trait × group × time) into the LMMs (and all the lower-order interaction terms). Grade was adjusted for in the gender-related analyses. The effect sizes for these interactions were calculated as a standardized difference in regression coefficients for the moderating effect of each personality trait for the gender difference (girls vs. boys) in the intervention effectiveness.

Results

The findings of the LMMs for the personality traits moderating intervention effects are shown in Table 3. The table presents the moderating effect of each personality trait on the change in the three outcomes at T9 and T26 for each group, as well as the moderating effect of each personality trait on the effectiveness of the intervention (MBI vs. inactive control and MBI vs. active control) for all the students. Table 4 displays the effect sizes. Overall, the moderation analyses yielded predominantly null results, with a single

Table 3 The results of the LMMs: modifying effects of personality traits on the effectiveness of MBI on depressive symptoms, resilience, and socio-emotional functioning difficulties

		Depressive symptoms			Resilience			Socio-emotional functioning		
Personality traits		Estimate	95% CI	*p*	Estimate	95% CI	*p*	Estimate	95% CI	*p*
Agreeableness										
9-week change	Inact	0.20	−0.15; 0.55	0.26	−0.45	−1.62; 0.72	0.45	0.14	−0.37; 0.64	0.59
	Act	0.13	−0.05; 0.31	0.17	**−0.82**	**−1.43; −0.21**	**0.01**	−0.01	−0.28; 0.25	0.92
	MBI	−0.02	−0.20; 0.17	0.87	−0.19	−0.81; 0.42	0.54	−0.02	−0.28; 0.25	0.91
	MBI vs. Inact	−0.22	−0.67; 0.24	0.57	0.26	−1.25; 1.77	1.00	−0.15	−0.81; 0.50	1.00
	MBI vs. Act	−0.14	−0.44; 0.15	0.55	0.63	−0.37; 1.62	0.32	0.00	−0.43; 0.43	1.00
26-week change	Inact	−0.26	−0.68; 0.17	0.24	−0.90	−2.23; 0.42	0.18	−0.12	−0.68; 0.44	0.68
	Act	**0.32**	**0.09; 0.55**	**0.01**	**−0.88**	**−1.59; −0.17**	**0.02**	−0.01	−0.32; 0.29	0.93
	MBI	**0.27**	**0.03; 0.52**	**0.03**	−0.69	−1.45; 0.08	0.08	**0.38**	**0.06; 0.71**	**0.02**
	MBI vs. Inact	0.53	−0.04; 1.09	0.07	0.22	−1.53; 1.96	1.00	0.50	−0.24; 1.25	0.26
	MBI vs. Act	−0.05	−0.44; 0.34	1.00	0.20	−1.00; 1.39	1.00	0.40	−0.11; 0.90	0.16
Conscientiousness										
9-week change	Inact	−0.13	−0.47; 0.20	0.43	−0.36	−1.49; 0.77	0.54	−0.04	−0.53; 0.46	0.89
	Act	0.02	−0.15; 0.19	0.82	**−0.78**	**−1.34; −0.23**	**0.01**	0.04	−0.20; 0.28	0.73
	MBI	0.11	−0.06; 0.28	0.21	**−0.75**	**−1.31; −0.18**	**0.01**	−0.02	−0.26; 0.23	0.90
	MBI vs. Inact	0.24	−0.18; 0.67	0.41	−0.39	−1.84; 1.06	1.00	0.02	−0.61; 0.65	1.00
	MBI vs. Act	0.09	−0.18; 0.36	0.93	0.04	−0.87; 0.94	1.00	−0.06	−0.45; 0.34	1.00
26-week change	Inact	−0.14	−0.56; 0.28	0.51	−0.52	−1.82; 0.78	0.43	0.37	−0.19; 0.92	0.20
	Act	**0.23**	**0.02; 0.44**	**0.03**	**−0.67**	**−1.32; −0.02**	**0.04**	0.17	−0.11; 0.44	0.23
	MBI	**0.31**	**0.09; 0.54**	**0.01**	**−1.37**	**−2.07; −0.67**	**< 0.001**	0.22	−0.08; 0.51	0.15
	MBI vs. Inact	0.45	−0.09; 1.00	0.13	−0.85	−2.53; 0.84	0.52	−0.15	−0.86; 0.57	1.00
	MBI vs. Act	0.08	−0.28; 0.43	1.00	−0.70	−1.79; 0.39	0.30	0.05	−0.41; 0.51	1.00
Emotional stability										
9-week change	Inact	0.29	−0.02; 0.59	0.07	−0.19	−1.25; 0.87	0.73	0.39	−0.07; 0.84	0.09
	Act	**0.22**	**0.06; 0.37**	**0.01**	**−0.81**	**−1.34; −0.29**	**< 0.01**	**0.44**	**0.21; 0.67**	**< 0.001**
	MBI	**0.19**	**0.03; 0.35**	**0.02**	−0.45	−0.98; 0.09	0.10	**0.33**	**0.11; 0.56**	**< 0.01**
	MBI vs. Inact	−0.10	−0.50; 0.30	1.00	−0.26	−1.62; 1.10	1.00	−0.06	−0.64; 0.53	1.00
	MBI vs. Act	−0.03	−0.29; 0.22	1.00	0.37	−0.49; 1.23	0.67	−0.10	−0.47; 0.27	1.00
26-week change	Inact	0.11	−0.27; 0.50	0.57	−0.50	−1.71; 0.72	0.42	0.20	−0.31; 0.71	0.45
	Act	0.18	−0.01; 0.38	0.07	−0.40	−1.00; 0.20	0.19	**0.42**	**0.17; 0.67**	**< 0.01**
	MBI	**0.37**	**0.16; 0.58**	**< 0.01**	**−0.74**	**−1.40; −0.09**	**0.03**	**0.49**	**0.21; 0.76**	**< 0.01**
	MBI vs. Inact	0.26	−0.25; 0.76	0.50	−0.25	−1.82; 1.33	1.00	0.29	−0.38; 0.95	0.66
	MBI vs. Act	0.19	−0.14; 0.52	0.38	−0.34	−1.35; 0.68	0.91	0.07	−0.36; 0.49	1.00
Extraversion										
9-week change	Inact	0.15	−0.13; 0.43	0.28	−0.35	−1.31; 0.62	0.48	0.06	−0.36; 0.47	0.79
	Act	−0.02	−0.18; 0.13	0.78	**−0.58**	**−1.10; −0.07**	**0.03**	**0.26**	**0.04; 0.49**	**0.02**
	MBI	**0.15**	**0.01; 0.30**	**0.04**	−0.50	−0.99; 0.004	0.05	0.08	−0.14; 0.29	0.47
	MBI vs. Inact	0.00	−0.36; 0.36	1.00	−0.15	−1.39; 1.09	1.00	0.02	−0.51; 0.56	1.00
	MBI vs. Act	0.17	−0.07: 0.42	0.22	0.09	−0.74; 0.91	1.00	−0.18	−0.54; 0.17	0.49
26-week change	Inact	0.18	−0.17; 0.52	0.31	**−1.41**	**−2.50; −0.32**	**0.01**	0.31	−0.15; 0.77	0.19
	Act	−0.02	−0.22; 0.17	0.80	−0.42	−1.01; 0.17	0.17	**0.32**	**0.07; 0.56**	**0.01**
	MBI	**0.29**	**0.10; 0.48**	**< 0.01**	**−0.85**	**−1.46; −0.25**	**0.01**	**0.30**	**0.05; 0.55**	**0.02**
	MBI vs. Inact	0.11	−0.34; 0.56	1.00	0.56	−0.87; 1.98	0.77	−0.01	−0.61; 0.59	1.00
	MBI vs. Act	**0.31**	**0.002; 0.63**	**0.048**	−0.44	−1.40; 0.53	0.62	−0.02	−0.42; 0.39	1.00
Openness										

Table 3 (continued)

		Depressive symptoms			Resilience			Socio-emotional functioning		
9-week change	Inact	0.25	−0.06; 0.55	0.11	−0.10	−1.12; 0.91	0.84	−0.06	−0.51; 0.38	0.78
	Act	**0.18**	**0.01; 0.36**	**0.04**	−0.46	−1.04; 0.12	0.12	0.02	−0.24; 0.27	0.90
	MBI	0.00	−0.17; 0.17	0.98	**−0.58**	**−1.14; −0.02**	**0.04**	0.06	−0.18; 0.31	0.62
	MBI vs. Inact	0.25	−0.64; 0.15	0.32	−0.47	−1.80; 0.85	0.85	0.13	−0.45; 0.70	1.00
	MBI vs. Act	−0.19	−0.46; 0.09	0.27	−0.12	−1.04; 0.80	1.00	0.05	−0.36; 0.45	1.00
26-week change	Inact	0.10	−0.26; 0.47	0.57	**−1.48**	**−2.61; −0.36**	**0.01**	0.30	−0.18; 0.78	0.23
	Act	**0.27**	**0.05; 0.48**	**0.02**	−0.54	−1.20; 0.12	0.11	0.07	−0.21; 0.35	0.63
	MBI	0.10	−0.11; 0.32	0.35	**−0.96**	**−1.63; −0.29**	**0.01**	0.01	−0.27; 0.30	0.93
	MBI vs. Inact	0.00	−0.48; 0.48	1.00	0.53	−0.97; 2.02	0.86	−0.28	−0.92; 0.36	0.64
	MBI vs. Act	−0.16	−0.51; 0.19	0.62	−0.42	−1.49; 0.66	0.77	−0.06	−0.52; 0.40	1.00

The within-group estimates (rows Inact, Act, MBI) correspond to the regression coefficient for the personality traits modifying the effect. They are interpreted as when the modifying factor increases by 1 point, how many points is the average change in the outcome variable at T9 and T26. Thus, if estimate is positive, it refers that a higher value in the modifying personality trait predicted a greater increase in outcomes (depressive symptoms, difficulties of socio-emotional functioning, or resilience) at T9 or T26. While if the estimate is negative, it refers that having a higher value in the modifying variable predicted a greater decrease in outcomes at T9 or T26. Between-group estimates (rows MBI vs. Inact and MBI vs. Act) refers to the differences in the effect of each personality trait as modifying factor on the change in outcomes between the MBI and control groups. These estimates were calculated as the difference in regression coefficients between the MBI and control groups. Bonferroni adjustment was used in these group comparisons

Abbreviations: *LMMs* linear mixed models, *Inact* the inactive control group, *Act* the active control group, *MBI* the mindfulness-based intervention group, *CI* confidence intervals

statistically significant but small interaction appearing at T26 for extraversion.

Moderation Effects of Agreeableness

Agreeableness did not moderate the effect of the MBI on depressive symptoms at T9 when compared with the inactive control group ($\beta = -0.22$, 95% CI [−0.67, 0.24], $p = 0.57$) and active control group ($\beta = -0.14$, 95% CI [−0.44, 0.15], $p = 0.55$). At T26, this held true when the MBI group was compared to the active control group ($\beta = -0.05$, 95% CI [−0.44, 0.34], $p = 1.00$). The analyses indicated a trend towards a small moderating effect on the change in depressive symptoms between the MBI and inactive control groups ($\beta = 0.53$, 95% CI [−0.04, 1.09], $p = 0.07$). Lower agreeableness was associated with reduced depressive symptoms in the MBI group ($\beta = 0.27$, 95% CI [0.03, 0.52], $p = 0.03$), while no significant relationship was found in the inactive control group ($\beta = -0.26$, 95% CI [−0.68, 0.17], $p = 0.24$).

Agreeableness did not moderate the effect of the MBI on resilience at T9 (MBI vs. inactive control: $\beta = 0.26$, 95% CI [−1.25, 1.77], $p = 1.00$; MBI vs. active control: $\beta = 0.63$, 95% CI [−0.37, 1.62], $p = 0.32$) or at T26 (MBI vs. inactive control: $\beta = 0.22$, 95% CI [−1.53, 1.96], $p = 1.00$; MBI vs. active control: $\beta = 0.20$, 95% CI [−1.00, 1.39], $p = 1.00$). A similar finding was observed for the outcome of socio-emotional functioning at T9 (MBI vs. inactive control: $\beta = -0.15$, 95% CI [−0.81, 0.50], $p = 1.00$; MBI vs. active control: $\beta = 0.00$, 95% CI [−0.43, 0.43], $p = 1.00$) and T26 (MBI vs. inactive control: $\beta = 0.50$, 95% CI [−0.24, 1.25], $p = 0.26$; MBI vs. active control: $\beta = 0.40$, 95% CI [−0.11, 0.90], $p = 0.16$).

Moderation Effects of Conscientiousness

Conscientiousness did not moderate the effect of the MBI on depressive symptoms at T9 (MBI vs. inactive control: $\beta = 0.24$, 95% CI [−0.18, 0.67], $p = 0.41$; MBI vs. active control group: $\beta = 0.09$, 95% CI [−0.18, 0.36], $p = 0.93$) or T26 (MBI vs. inactive control: $\beta = 0.45$, 95% CI [−0.09, 1.00], $p = 0.13$; MBI vs. active control: $\beta = 0.08$, 95% CI [−0.28, 0.43], $p = 1.00$). Likewise, there was no evidence that conscientiousness had a moderating effect on the impact of the MBI on resilience at T9 (MBI vs. inactive control: $\beta = -0.39$, 95% CI [−1.84, 1.06], $p = 1.00$; MBI vs. active control: $\beta = -0.04$, 95% CI [−0.87, 0.94], $p = 1.00$) or at T26 (MBI vs. inactive control: $\beta = -0.85$, 95% CI [−2.53, 0.84], $p = 0.52$; MBI vs. active control: $\beta = -0.70$, 95% CI [−1.79, 0.39], $p = 0.30$). This lack of moderation also held true for socio-emotional functioning at T9 (MBI vs. inactive control: $\beta = 0.02$, 95% CI [−0.61, 0.65], $p = 1.00$; MBI vs. active control: $\beta = -0.06$, 95% CI [−0.45, 0.34], $p = 1.00$) and T26 (MBI vs. inactive control: $\beta = -0.15$, 95% CI [−0.86, 0.57], $p = 1.00$; MBI vs. active control: $\beta = 0.05$, 95% CI [−0.41, 0.51], $p = 1.00$).

Table 4 Effect sizes

		Depressive symptoms		Resilience		Socio-emotional functioning	
Personality traits		Effect size	95% CI	Effect size	95% CI	Effect size	95% CI
Agreeableness							
9-week change	MBI vs. Inact	−0.06	−0.18; 0.06	0.02	−0.11; 0.15	−0.03	−0.14; 0.09
	MBI vs. Act	−0.04	−0.11; 0.04	0.05	−0.03; 0.14	0.00	−0.08; 0.08
26-week change	MBI vs. Inact	0.14	−0.01; 0.29	0.02	−0.13; 0.17	0.09	−0.04; 0.22
	MBI vs. Act	−0.01	−0.12; 0.09	0.02	−0.08; 0.12	0.07	−0.02; 0.16
Conscientiousness							
9-week change	MBI vs. Inact	0.06	−0.05; 0.19	−0.04	−0.17; 0.10	0.00	−0.12; 0.13
	MBI vs. Act	0.03	−0.05; 0.10	0.00	−0.08; 0.09	−0.01	−0.09; 0.07
26-week change	MBI vs. Inact	0.13	−0.03; 0.29	−0.08	−0.23; 0.08	−0.03	−0.17; 0.11
	MBI vs. Act	0.02	−0.08; 0.12	−0.06	−0.16; 0.04	0.01	−0.08; 0.10
Emotional stability							
9-week change	MBI vs. Inact	−0.03	−0.15; 0.09	−0.03	−0.16; 0.11	−0.01	−0.13; 0.11
	MBI vs. Act	−0.01	−0.09; 0.07	0.04	−0.05; 0.12	−0.02	−0.10; 0.05
26-week change	MBI vs. Inact	0.08	−0.07; 0.23	−0.02	−0.18; 0.13	0.06	−0.08; 0.20
	MBI vs. Act	0.06	−0.04; 0.16	−0.03	−0.13; 0.07	0.01	−0.07; 0.10
Extraversion							
9-week change	MBI vs. Inact	0.00	−0.12; 0.12	−0.02	−0.14; 0.11	0.01	−0.11; 0.12
	MBI vs. Act	0.06	−0.02; 0.13	0.01	−0.07; 0.09	−0.04	−0.12; 0.04
26-week change	MBI vs. Inact	0.04	−0.11; 0.18	0.06	−0.09; 0.20	0.00	−0.13; 0.13
	MBI vs. Act	0.10	0.00; 0.20	−0.04	−0.14; 0.05	0.00	−0.09; 0.08
Openness							
9-week change	MBI vs. Inact	−0.07	−0.18; 0.04	−0.04	−0.16; 0.08	0.02	−0.09; 0.13
	MBI vs. Act	−0.05	−0.13; 0.03	−0.01	−0.09; 0.07	0.01	−0.07; 0.09
26-week change	MBI vs. Inact	0.00	−0.14; 0.14	0.05	−0.09; 0.18	−0.05	−0.18; 0.07
	MBI vs. Act	−0.05	−0.15; 0.05	−0.04	−0.14; 0.06	−0.01	−0.10; 0.08

The effect sizes were calculated as a standardized difference in regression coefficients for the moderating effect of each personality trait on the effectiveness of the intervention. The standardized regression coefficients were estimated using linear mixed models. Effect size of 0.10–0.29 is considered as small, 0.30–0.49 as medium, and 0.50 or greater as large effect

Moderation Effects of Emotional Stability

When compared with both control groups, emotional stability did not moderate the effect of the MBI on depressive symptoms at T9 (MBI vs. inactive control: $\beta = -0.10$, 95% CI [−0.50, 0.30], $p = 1.00$; MBI vs. active control: $\beta = -0.03$, 95% CI [−0.29, 0.22], $p = 1.00$) or at T26 (MBI vs. inactive control: $\beta = 0.26$, 95% CI [−0.25, 0.76], $p = 0.50$; MBI vs. active control: $\beta = 0.19$, 95% CI [−0.14, 0.52], $p = 0.38$). Likewise, the results indicated that emotional stability had no moderating effect on the impact of the MBI on resilience at T9 (MBI vs. inactive control: $\beta = -0.26$, 95% CI [−1.62, 1.10], $p = 1.00$; MBI vs. active control: $\beta = 0.37$, 95% CI [−0.49, 1.23], $p = 0.67$) or at T26 (MBI vs. inactive control: $\beta = -0.25$, 95% CI [−1.82, 1.33], $p = 1.00$; MBI vs. active control: $\beta = -0.34$, 95% CI [−1.35, 0.68], $p = 0.91$). A similar lack of moderation held true for socio-emotional functioning at T9 (MBI vs. inactive control: $\beta = -0.06$, 95% CI [−0.64, 0.53], $p = 1.00$; MBI vs. active control: $\beta = -0.10$, 95% CI [−0.47, 0.27], $p = 1.00$) and T26 (MBI vs. inactive control: $\beta = 0.29$, 95% CI [−0.38, 0.95], $p = 0.66$; MBI vs. active control: $\beta = 0.07$, 95% CI [−0.36, 0.49], $p = 1.00$).

Moderation Effects of Extraversion

The results indicated that extraversion had no moderating effect on the impact of the MBI on depressive symptoms at T9 (MBI vs. inactive control: $\beta = 0.00$, 95% CI [−0.36, 0.36], $p = 1.00$; MBI vs. active control: $\beta = 0.17$, 95% CI [−0.07, 0.42], $p = 0.22$). At T26, a significant difference in the effect of extraversion on the change in the symptoms was found between the MBI and active control groups ($\beta = 0.31$, 95% CI [0.002, 0.63], $p = 0.048$). The effect size was small (Table 4). Lower extraversion was associated with a greater reduction in depressive symptoms at T26 ($\beta = 0.29$, 95% CI [0.10, 0.48], $p < 0.01$) in the MBI group, while no relationship was observed at T26 in the active control group

($\beta = -0.02$, 95% CI [−0.22, 0.17], $p = 0.80$). No significant effect was observed between the MBI and inactive control groups at T26 ($\beta = 0.11$, 95% CI [−0.34, 0.56], $p = 1.00$). An additional analysis was conducted to assess whether extraversion was associated with mindfulness home practice intensity (Online Resource 3).

Extraversion did not moderate the effects of the MBI on resilience at T9 (MBI vs. inactive control: $\beta = -0.15$, 95% CI [−1.39, 1.09], $p = 1.00$; MBI vs. active control: $\beta = 0.09$, 95% CI [−0.74, 0.91], $p = 1.00$) or at T26 (MBI vs. inactive control: $\beta = 0.56$, 95% CI [−0.87, 1.98], $p = 0.77$; MBI vs. active control: $\beta = -0.44$, 95% CI [−1.40, 0.53], $p = 0.62$). A similar lack of moderation was found for socio-emotional functioning at T9 (MBI vs. inactive control: $\beta = 0.02$, 95% CI [−0.51, 0.56], $p = 1.00$; MBI vs. active control: $\beta = -0.18$, 95% CI [−0.54, 0.17], $p = 0.49$) and at T26 (MBI vs. inactive control: $\beta = -0.01$, 95% CI [−0.61, 0.59], $p = 1.00$; MBI vs. active control: $\beta = -0.02$, 95% CI [−0.42, 0.39], $p = 1.00$).

Moderation Effects of Openness to Experience

Openness to experience did not moderate the effect of the MBI on depressive symptoms at T9 (MBI vs. inactive control: $\beta = 0.25$, 95% CI [−0.64, 0.15], $p = 0.32$; MBI vs. active control: $\beta = -0.19$, 95% CI [−0.46, 0.09], $p = 0.27$) or at T26 (MBI vs. inactive control: $\beta = 0.00$, 95% CI [−0.48, 0.48], $p = 1.00$; MBI vs. active control: $\beta = -0.16$, 95% CI [−0.51, 0.19], $p = 0.62$). Similar findings were found for outcomes of resilience at T9 (MBI vs. inactive control: $\beta = -0.47$, 95% CI [−1.80, 0.85], $p = 0.85$; MBI vs. active control: $\beta = -0.12$, 95% CI [−1.04, 0.80], $p = 1.00$) and at T26 (MBI vs. inactive control: $\beta = 0.53$, 95% CI [−0.97, 2.02], $p = 0.86$; MBI vs. active control: $\beta = -0.42$, 95% CI [−1.49, 0.66], $p = 0.77$) and socio-emotional functioning at T9 (MBI vs. inactive control: $\beta = 0.13$, 95% CI [−0.45, 0.70], $p = 1.00$; MBI vs. active control: $\beta = -0.05$, 95% CI [−0.36, 0.45], $p = 1.00$) and at T26 (MBI vs. inactive control: $\beta = -0.28$, 95% CI [−0.92, 0.36], $p = 0.64$; MBI vs. active control: $\beta = -0.06$, 95% CI [−0.52, 0.40], $p = 1.00$).

Gender Differences in Moderation Effects

To test whether the moderating effects of each personality trait on the intervention's effectiveness differed by gender, four-way interaction terms (gender × personality trait × group × time) were included in the LMMs. The results for these interactions are detailed in Online Resources 4, 5, 6, 7, 8 and the effect sizes in Online Resource 9. The analysis consistently revealed an absence of gender-based differences. Specifically, for depressive symptoms, the interactions were nonsignificant for agreeableness ($p = 0.10$), conscientiousness ($p = 0.92$), emotional stability ($p = 0.31$), extraversion ($p = 0.91$), and openness to experience ($p = 0.71$). Similarly, no significant four-way interactions were found for the outcomes of resilience (agreeableness $p = 0.20$, conscientiousness $p = 0.55$, emotional stability $p = 0.15$, extraversion $p = 0.84$, and openness to experience $p = 0.92$) and socio-emotional functioning (agreeableness $p = 0.41$, conscientiousness $p = 0.37$, emotional stability $p = 0.69$, extraversion $p = 0.74$, and openness to experience $p = 0.20$). Because the interactions lacked statistical significance, we did not perform separate analyses for girls and boys.

Discussion

This exploratory cluster RCT investigated whether the FFM personality traits (agreeableness, conscientiousness, emotional stability, extraversion, and openness to experience) moderated the effects of a school-based MBI on adolescent mental health (depressive symptoms, resilience, and socio-emotional functioning difficulties) compared to a relaxation program and a regular school curriculum. Most of the moderation analyses were not significant. At the follow-up point, extraversion had a small moderating effect on the effectiveness of the MBI for depressive symptoms compared to the active control group, with those exhibiting low extraversion benefiting the most from the intervention. The results did not differ by gender.

The literature suggests that universal MBIs in schools have small (Dunning et al., 2022) and inconsistent (Kuyken et al., 2022) effects on mental health outcomes in adolescence. Individual differences may contribute to these varying findings (Tang & Braver, 2020b). For this reason, it is important to investigate the factors that may moderate the effectiveness of these interventions. Currently, the FFM personality traits have received little attention in mindfulness research, particularly on adolescents, despite the fact that all five traits have been empirically shown to predict the well-being outcomes of various mental health treatments (Bucher et al., 2019; Chapman et al., 2014). Furthermore, from a theoretical perspective, the traits play relevant roles in the effectiveness of mindfulness training (Tang & Braver, 2020b).

Our preliminary findings suggested that extraversion and possibly agreeableness moderated the effects of the MBI on depressive symptoms. Regarding extraversion, when compared to the active control group at the follow-up, the participants with low levels of the trait gained the most benefits. This is contrary to previous studies in various populations, including adolescents, that have found mostly null effects (de Vibe et al., 2015; Halland et al., 2015; Huppert & Johnson, 2010; Küchler et al., 2022; Nyklíček & Irrmischer, 2017). With one exception (Nyklíček & Irrmischer, 2017), these scholars did not use long-term follow-ups. In the present

study, we did not observe effects immediately after the intervention (T9). Even though the risk of false positives may have increased due to the multiple analyses, it is possible that some differences in benefits are seen only in the long term. However, given that this extraversion result was small in effect size and appeared only when contrasted with the active control group at the follow-up, not with the inactive control group, replication is necessary in future studies.

The finding that the greater benefits were observed among adolescents with low extraversion aligns partly with the idea that the effectiveness of psychological intervention techniques depends on how well they match individuals' natural strengths rather than solely targeting their deficits (Schueller, 2010, 2014). Individuals with low extraversion are often described as inward-looking and thought-oriented, with little need for external stimulation (e.g., the presence of many people; John et al., 2008; Thomas & Nelson, 2025; Watson et al., 2022). Mindfulness practices, such as observing and attending internal experiences, may resonate with their predisposition for introspection. Consequently, these adolescents may find the training easier to embrace, more engaging, and intrinsically rewarding, making them particularly receptive to learning new skills. As research indicates that low extraversion contributes to negative emotions and rumination (Anglim et al., 2020; Conway et al., 2000; Kotov et al., 2010), mindfulness training may target these experiences by building an ability to more objectively assess internal experiences (i.e., greater introspective accuracy) (Fox et al., 2012) and fostering skills such as non-reactivity, non-judgement, and acceptance of one's experiences (Bishop et al., 2004; Kabat-Zinn, 2003a). These skills can help to manage the negative thoughts and emotions that may contribute to depressive symptoms in the long run (Hölzel et al., 2011; van der Velden et al., 2015).

Although extraversion is positively associated with trait mindfulness, those exhibiting higher levels of sociability, activity, and a need for stimulation may find practices in slow-paced and repetitive situations challenging (Giluk, 2009). This could be especially the case after a guided, group-based program, when training is supposed to take place through solitary practices. Previous research on the FFM personality traits and mental health treatments suggests that higher extraversion predicts lower homework compliance (Bagby et al., 2016). However, we found in an additional analysis that extraversion was not associated with mindfulness home practice intensity at the follow-up ($p = 0.26$, Online Resource 3). It is also possible that other aspects of the MBI approach may have been more compatible with the preferences of individuals with lower extraversion. For instance, Tang and Braver (2020b) proposed that these individuals may respond better to structured and goal-oriented MBIs, whereas more extraverted individuals may benefit from approaches that emphasize interpersonal interactions (Wahbeh et al., 2014). In our study, the standardized and highly structured *.b* program may have been particularly well-suited for students with lower levels of extraversion, whereas other students might have benefited more if the practices had incorporated greater social interaction. Also, adolescents with higher extraversion typically exhibit greater positive emotionality and subjective well-being (e.g., Steinmayr et al., 2019), and habitually rely on coping strategies aimed at problem-solving or seeking social support (e.g., Kardum & Krapić, 2001); therefore, mindfulness exercises may be less relevant to their well-being.

Furthermore, our exploratory analysis found a nonsignificant result ($p = 0.07$) regarding agreeableness. At the follow-up, lower agreeableness was associated with better effectiveness in reducing depressive symptoms in the MBI group compared to the inactive control group. Given that this result was nonsignificant, small in effect size, and found only at T26, future research is needed to draw clear conclusions on the moderating effect of this trait. This is especially the case, since a previous study found that young people who were more agreeable derived greater benefits from this fact in terms of psychological well-being (Huppert & Johnson, 2010). However, the study in question was conducted on a small sample of adolescent boys without an active control group and random allocation (Huppert & Johnson, 2010). Our research was based on equal numbers of girls and boys and used the RCT design with active and inactive control groups. The literature suggests that agreeableness is positively associated with mindfulness skills (Giluk, 2009; Haliwa et al., 2021; Hanley, 2016). Perhaps, therefore, adolescents who are less warm and more critical may benefit more from mindfulness training by practicing an accepting attitude and the ability to let go of automatic negative thoughts and emotions (Carson & Langer, 2006; Frewen et al., 2008). In turn, this may act as a corrective measure for habitual criticism and further protect them against depressive symptoms (Schanche et al., 2021). However, due to their individual characteristics, these adolescents may also struggle to engage with intervention components that rely on the cultivation of an accepting attitude and fostering social connection, which may explain why our results were nonsignificant. Practicing new techniques for emotion regulation could be particularly important for this subgroup, which tends to experience greater levels of stress and negative emotions in daily life (Ebstrup et al., 2011; Kang et al., 2023; Kaplan et al., 2015). Like adolescents with lower levels of extraversion, those with lower levels of agreeableness may also have benefited from the highly structured MBI (Tang & Braver, 2020b). Moreover, research indicates that these adolescents benefit in terms of mental health and psychological well-being from various psychosocial interventions, including compassion interventions (Mongrain et al., 2018), positive psychology interventions (Barnes & Mongrain,

2020), and an intervention targeting psychosocial development in schools (Mertens et al., 2022). It may be that several psychosocial programs provide benefits to this adolescent subgroup.

Our study found that the effects of MBI on depressive symptoms did not differ by emotional stability, conscientiousness, or openness to experience, nor did its effects on resilience and socio-emotional functioning vary by any personality trait of the FFM. Similarly, Huppert and Johnson (2010) found no significant interactions between all five personality traits and the effects of an MBI on resilience in adolescents. They also did not find significant associations between openness to experience or conscientiousness and the effects of an MBI on psychological well-being. However, their study showed a significant interaction between emotional stability and the effects of mindfulness training on psychological well-being; adolescents with lower emotional stability gained the most benefits. Research on adults also indicates that individuals with lower emotional stability tend to obtain greater benefits from MBIs in terms of various well-being and mental health outcomes (de Vibe et al., 2015; Halland et al., 2015; Krick & Felfe, 2020; Nyklíček & Irrmischer, 2017). One possible explanation for these earlier findings on emotional stability is that mindfulness training is particularly beneficial for individuals with poorer baseline emotion regulation skills, and the development of suboptimal emotion regulation and self-awareness serves as a key factor behind these well-being benefits (Tang & Braver, 2020b). Yet, comparing evidence obtained from adults to our results is not straightforward. Adolescence represents a developmental stage with unique needs and rapid socio-emotional and neurobiological changes (Roeser & Pinela, 2014), including the process of developing emotion regulation skills and metacognitive capabilities, which may lead to different responses to MBIs from those of adults (Johnson et al., 2024). In particular, adolescents experience a normative decrease in emotion regulation (Cracco et al., 2017), and those with greater emotional instability have even more significant deficits. Based on the person-activity fit framework, these individuals may find mindfulness practices too frustrating or challenging, thus failing to achieve the substantial benefits found in adults. Although our results diverge from previous mindfulness research, general findings regarding emotional stability and its association with treatment outcomes have been inconsistent. Some studies have found that lower emotional stability predicts greater treatment outcomes, while others suggest the opposite or have reported no significant relationship (Bagby et al., 2016; Bucher et al., 2019). Similar variation has also been observed in the school context (Mertens et al., 2022; Sandberg et al., 2025). These mixed findings may be due to several factors, including methodological differences and variations in the content, length, and delivery of the interventions. Thus, it is important that researchers continue to examine associations between emotional stability and the effects of MBIs on mental health outcomes across different age groups and settings.

Overall, our nonsignificant findings for most traits and outcomes should be interpreted with caution due to some methodological and contextual issues. In particular, it is possible that a lack of motivation to practice mindfulness could have contributed to the null findings. Consistent with earlier studies on school-based MBIs (Tudor et al., 2022), only a small number of students reported an interest in practicing mindfulness at home during the follow-up. Universal school-based studies are also susceptible to floor or ceiling effects in outcome measurements, given that most participants are relatively healthy and cope adaptively with life's stresses. However, floor/ceiling effects may not fully explain our nonsignificant results, given that it has been previously demonstrated that the HLM baseline data on resilience levels, depressive symptoms, and socio-emotional difficulties had sufficient variability, was representative of Finnish adolescents, and aligned well with other national samples elsewhere (Lassander et al., 2023). Regarding other measurement issues, similar to Huppert and Johnson (2010), we used the short personality scale (TIPI). Yet, its relatively low reliability may have reduced our study's sensitivity to detect moderation effects. Furthermore, the inactive control group was more than three times smaller than the MBI and active control groups. This smaller sample size may have limited the ability to detect moderation effects due to insufficient power in comparisons involving the inactive control group. As such, our results were preliminary and should be replicated in further studies with large sample sizes and more comprehensive assessments of the FFM personality traits.

A further aim of our study was to examine gender differences in the role of personality traits as moderators of mindfulness training. There are currently no studies on this topic; so, our research was hypothesis-generating in nature. Previously, de Vibe et al. (2015) suggested that female students might be an important target group for MBIs based on their personality traits—higher neuroticism and conscientiousness compared to males; however, the study did not include gender-related analyses, as only 26 male university students participated. It has also been hypothesized that female students might benefit from MBIs in terms of mental health due to their high levels of self-criticism (Kang et al., 2018). Previous gender analyses conducted as part of the HLM project have shown that an MBI in schools reduces depressive symptoms mostly in girls (Volanen et al., 2020). Similar results favoring female students have been obtained in several other cases (de Vibe et al., 2013; Kang et al., 2018; Rojiani et al., 2017). Our study suggested that the influence of personality traits on the effectiveness of MBI on mental health was not related to gender. On the one hand, contextual and methodological factors described above may have

contributed to this null finding. On the other hand, other gender-related factors may also explain why females are more responsive to mindfulness training than males. For example, gender-related differences in the use of emotion regulation strategies may modify the effects of MBIs (Rojiani et al., 2017; Saarinen et al., 2022). Scholars have also preliminarily proposed that female adolescents may be more committed to MBIs and have more faith in their effectiveness (Bluth et al., 2017). In addition, gender may affect individual preferences for different mindfulness practices, which may impact how well people respond to MBIs (Tang & Braver, 2020a).

Limitations and Future Directions

Our study involved almost 3000 adolescents and used the cluster RCT method with active and inactive control groups; it also included a 26-week follow-up. Despite these strengths, some important limitations should be noted. The key shortcoming was the use of the TIPI, a brief inventory with only two items per dimension, to measure the FFM personality traits (Gosling et al., 2003). The TIPI was chosen for practical reasons and exploratory purposes, but it offered limited precision compared to more extensive tools. While the correlations of the TIPI with longer questionnaires, such as the NEO Personality Inventory-Revised (NEO-PI-R) (Costa & McCrae, 1992) and the Big Five Inventory (BFI) (John & Srivastava, 1999), are adequate (Gosling et al., 2003), its low reliability might have decreased our study's sensitivity to observe moderation. Also, the study relied only on self-report questionnaires for assessing personality traits and mental health outcomes. To complement the self-report data, future studies should also incorporate alternative measures, such as personality assessments rated by a close person (e.g., parent), as well as behavioral tasks or physiological assessments of mental health. Given that some aspects of mental health, such as resilience, may develop over longer periods of time (Fletcher & Sarkar, 2013; Leys et al., 2020), future research could benefit from extended follow-ups beyond 26 weeks. Moreover, the sample size of the inactive control group was more than three times smaller compared to the samples of MBI and active control groups. This smaller sample size may have limited the ability to detect moderation effects due to insufficient power in comparisons involving the inactive control group. In addition, the risk of false positives may have increased because five possible moderators were tested against each outcome and no multiple testing adjustments were made due to the nature of the study. As such, our results were preliminary and should be replicated in further studies.

To verify the initial findings, we encourage scientists to continue investigating the role of personality traits as MBI moderators in adolescence. Further large-scale studies with RCT design are needed to examine the generalizability of these findings across diverse populations and settings. In particular, as our study was conducted on Finnish students aged 12–15 years with mostly mild baseline depressive symptoms and socio-emotional challenges (Lassander et al., 2023), the results are not directly generalized to populations with more severe baseline symptomology or different age groups. Moreover, given the small socio-economic differences in Finland by global standards, our relatively homogeneous sample restricts the applicability of the findings to contexts with greater socio-economic diversity. Future studies could benefit from targeting populations across various age groups and/or with greater initial distress (for example, due to socio-economic disadvantages). Longitudinal studies with extended follow-ups could provide valuable insight into how the relationship between personality traits of the FFM and benefits of mindfulness training evolves over time. Beyond the traits, future studies could also test other individual characteristics as moderators, such as self-compassion, mindfulness, and coping strategies, as well as examine gender differences in these moderators, to determine for whom MBIs are most useful and to explore the mechanisms at play behind MBI responses.

From a practical perspective, our preliminary findings suggested that school-based MBIs, when used as a brief universal intervention, may be effective in reducing depressive symptoms among adolescents with lower levels of extraversion. However, this result was isolated and featured a small effect size, warranting cautious interpretation and replication prior to any practical application. If replicated in future studies, a possible strategy for enhancing the effectiveness of MBIs could be to target the training specifically towards these students. For example, school psychologists could assess students' levels of extraversion using brief personality measures and offer structured MBIs, such as the *.b* program, in individual or small-group sessions. School psychologists could also emphasize the importance of regular practice at home (Volanen et al., 2020, 2025), assuming that this might be easier for this subgroup. On the other hand, it is important to consider adapting the universal programs to ensure their effectiveness for all students. Programs that emphasize peer interaction and guided practices led by adults, rather than relying heavily on home-based practices (Strohmaier & Bailey, 2023), may be more engaging and beneficial for students with higher extraversion. Moreover, since mindfulness training in slow-paced and repetitive situations may be challenging for these adolescents (Giluk, 2009), combining mindfulness and physical activity interventions, such as yoga practices, could potentially provide broader benefits (Huang et al., 2024). Finally, co-designing MBIs with adolescents and teachers in the schools could help to ensure successful implementation, so that individual characteristics of participants are also taken into account (Johnson et al., 2024).

By focusing on adolescents and employing a cluster RCT design, this study contributed to the limited research on FFM personality traits as moderators of MBI effectiveness. While the findings were largely nonsignificant across personality traits and mental health outcomes, we found slight, tentative indications that extraversion and possibly agreeableness may shape adolescents' responsiveness to MBIs. These findings must be interpreted with caution, underscoring the necessity of replication. Future large-scale studies using an RCT design and more comprehensive measures of personality traits, such as the NEO-PI-3 (Costa et al., 2008), are warranted to confirm these results and explore the underlying mechanisms by which personality traits might influence adolescents' responses to MBIs.

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

Declarations

Ethics approval The study plan of the HLM project was approved by the Ethical Review Board of the University of Helsinki in January 2014. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

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

Conflict of Interest The authors declare no competing interests.

Use of Artificial Intelligence Statement AI was used for editing the manuscript to improve the English language.

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