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HEALTHY LEARNING MIND – EFFECTIVENESS OF A SCHOOL-BASED MINDFULNESS PROGRAM

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DOCTORAL DISSERTATION

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ABSTRACT

Mindfulness is a capacity to focus on present-moment awareness that can be enhanced and learned. This awareness entails directing attention and accepting the experience as it presents itself, non-judgmentally, with curiosity and openness. The present series of 4 studies explores the outcomes of a school-based mindfulness intervention on 12–15-year-old children and adolescents.

Studies I and II examined the outcomes of mindfulness intervention on resilience, depressive symptoms, socioemotional functioning (primary outcomes) and health-related quality of life (secondary outcome). Finnish school children and adolescents (N=3519) aged 12–15 years (6th to 8th graders), from 56 schools, were cluster-randomised into a 9-week mindfulness intervention group or control groups with a relaxation program or teaching as usual. In Studies III and IV, a subset of students (N=131) completed a cognitive test-package to measure executive functioning, and a majority of these students (N=110) also completed the psychophysiological test-package to measure stress reactivity. All measures were completed at baseline, at completion of the programs at 9 weeks, and at follow-up at 26 weeks.

In Study I, the mindfulness intervention did not show more beneficial effects on the primary outcomes compared to the controls, except for resilience for which a positive intervention effect was found at 9 weeks in the whole intervention group compared to the active control group. In addition, in gender- and grade-related analyses, the intervention reduced the prevalence of depressive symptoms in girls, and the effect was also significantly different compared to boys. The mindfulness intervention improved socioemotional functioning among 7th graders at 9 weeks and 26 weeks, compared to the active control group. There was no effect compared to the inactive control group, except for students who reported nearly daily independent practice and showed significant benefits in resilience and socioemotional functioning compared to both control groups.

In Study II, a significant intervention effect was found for health-related quality of life at 9 weeks and 26 weeks as compared to the active control group. Moderating effects were found for both gender and grade. Girls and 7^{th}–8^{th} grade students benefited most from the intervention in terms of health-related quality of life compared to the active control group. There was no effect compared to the inactive control group, except for students who reported nearly daily independent practice and showed significant benefits compared to both control groups.

In the subset of students in Study III, both the intervention group and active control group improved on a majority of executive functioning measures (response inhibition, cognitive processing and flexibility, verbal fluency) at

both 9 weeks and 26 weeks. There was no effect on working memory. The inactive control group was not included in Study III.

In Study IV, the number of electrodermal responses indicative of stress stayed at the same level in the intervention group, but increased in the active control group, during a task of social stress at both the 9 week and 26 week follow-ups, suggesting that mindfulness may have a stress buffering effect in the intervention group. There was no significant effect on heart rate, heart rate variability or continuous level of electrodermal skin conductance. The inactive control group was not included in Study IV.

Altogether, the present results indicate that school-based mindfulness intervention may have benefits on mental health and wellbeing over a relaxation program and teaching as usual among 12–15-year-old students, measured by resilience, depressive symptoms, socioemotional functioning and health-related quality of life outcomes. The benefits are moderated by grade/age, gender and independent practice. There was no noticeable difference between intervention and active control groups in terms of executive functioning (working memory, response inhibition, cognitive processing and flexibility, verbal fluency), although both groups improved for all cognitive outcomes, except for working memory. In examining psychophysiological reactivity, in a highly stressful social situation, mindfulness might have a small effect in lowering sympathetically driven electrodermal stress reactivity, which tells us how the student experiences stress.

In sum, this thesis contributes to the field of mindfulness and socioemotional learning by showing the potential benefits of short-term mindfulness intervention for wellbeing outcomes in adolescents. The results of this thesis can be applied in adapting and targeting mindfulness interventions in schools to achieve optimal benefits. Despite the limited evidence, our results are promising and encourage teaching mindfulness in the school context.

TIIVISTELMÄ

Tietoisuustaidot viittaavat yksilön kykyyn suunnata huomio nykyhetkeen, ja tätä kykyä voidaan vahvistaa ja oppia. Tietoisuus nykyhetkestä pitää sisällään huomion ohjaamisen ja kokemuksen hyväksymisen sellaisenaan, tuomitsematta, uteliaasti ja avoimesti. Tämän väitöskirjatyön neljän osatutkimuksen tavoitteena on selvittää luokkaopetuksena tapahtuvan tietoisuustaito-intervention vaikutuksia 12–15 -vuotiailla lapsilla ja nuorilla.

Osatutkimukset I ja II selvittivät tietoisuustaito-intervention vaikutuksia resilienssiin, masennuksen oireisiin ja sosioemotionaaliseen toimintakykyyn (ensisijaiset vaikutukset) ja terveyteen liittyvään elämänlaatuun (toissijaiset vaikutukset). Kaikkiaan 3519 osallistujaa, 12–15 -vuotiasta (6–8 -luokkalaista) lasta ja nuorta 56 koulusta oli mukana tutkimuksessa. Osallistujat jaettiin satunnaisryväsotannalla koe- ja verrokkiryhmiin. Koeryhmä osallistui 9 viikon mittaiseen interventio-ohjelmaan ja aktiivinen verrokkiryhmä vastaavan pituiseen rentoutumisohjelmaan. Passiivisessa verrokkiryhmässä pysyttiin normaalissa opetussuunnitelmassa. Osatutkimuksissa III ja IV selvitettiin pienemmän osajoukon kognitiivisilla testeillä mitattua toiminnan ohjauksen kykyjä (N=131) sekä saman oppilasjoukon (N=110) psykofysiologisesti mitattua reaktiivisuutta stressivasteeseen. Kaikki mittaukset tehtiin tutkimuksen alussa, 9 viikon ja 26 viikon kohdalla.

Osatutkimuksessa I havaittiin, että tietoisuustaito-interventiolla oli myönteisiä vaikutuksia resilienssiin 9 viikon kohdalla, verrattuna aktiiviseen verrokkiryhmään. Muita vaikutuksia ei löydetty. Sukupuolen ja iän muokkaavaa vaikutusta analysoidessa havaittiin, että interventio vähensi merkitsevästi masennukseen liittyviä oireita tytöillä ja ero oli merkitsevä verrattuna poikiin. Interventio vahvisti myös sosioemotionaalista toimintakykyä 7-luokkalaisilla 9 ja 26 viikon kohdalla verrattuna aktiiviseen verrokkiryhmään. Suhteessa molempiin verrokkiryhmiin merkitsevä, myönteinen vaikutus havaittiin lähes päivittäin itsenäisesti harjoittavilla oppilailla resilienssin ja sosioemotionaalisen toimintakyvyn osalta.

Osatutkimuksessa II havaittiin, että tietoisuustaitointerventiolla oli tilastollisesti merkitsevä myönteinen vaikutus terveyteen liittyvään elämänlaatuun verrattuna aktiiviseen verrokkiryhmään molemmissa jälkimittauksissa. Sukupuolella, iällä ja itsenäisen harjoittamisen määrällä oli muokkaava vaikutus. Tytöt, 7-luokkalaiset ja intensiivisesti harjoittavat oppilaat hyötyivät eniten interventiosta aktiiviseen verrokkiryhmään verrattuna. Suhteessa molempiin verrokkiryhmiin merkitsevä, myönteinen vaikutus havaittiin lähes päivittäin itsenäisesti harjoittavilla oppilailla.

Osatutkimuksessa III sekä koe- että verrokkiryhmä osoittivat parannusta toiminnanohjauksen osatekijöissä (reaktion estäminen, kognitiivinen prosessointi ja joustavuus, sanallinen sujuvuus) 9 viikon ja 26 viikon kohdalla.

Työmuistiin ei löydetty merkittävää vaikutusta. Osatutkimuksessa III ei ollut passiivista verrokkiryhmää.

Osatutkimuksessa IV stressi-reaktiivisuutta indikoiva ihon sähkönjohtavuus pysyi samana koeryhmässä sosiaalisen stressin tehtävässä ja nousi aktiivisessa verrokkiryhmässä molemmissa jälkimittauksissa. Tämä tulos viittaa mahdolliseen tietoisuustaito-intervention stressiä ehkäisevään vaikutukseen. Muissa muuttujissa, joita olivat sydämen lyöntitiheys, sydämen lyöntitiheyden vaihtelu ja ihon sähkönjohtavuuden perustaso, ei ollut merkitsevää vaikutusta. Osatutkimuksessa IV ei ollut passiivista verrokkiryhmää.

Osatutkimusten perusteella näyttää siltä, että koulussa tapahtuvalla tietoisuustaito-interventiolla saattaa olla myönteisiä vaikutuksia 12–15-vuotiaiden peruskoulun oppilaiden mielenterveyteen ja hyvinvointiin mitattuna resilienssin, masennuksen oireiden, sosioemotionaalisen toimintakyvyn ja terveyteen liittyvän elämänlaadun mittareilla, verrattuna vastaavaan rentoutumisohjelmaan ja normaaliin opetukseen. Oppilaan ikä, sukupuoli ja harjoituksen määrä toimivat välittävinä tekijöinä. Kognitiivisen toiminnanohjauksen osatekijöiden (reaktion estäminen, kognitiivinen prosessointi ja joustavuus, sanallinen sujuvuus) osalta vaikuttaa siltä, ettei koeryhmän ja aktiivisen verrokkiryhmän välillä ole eroja, vaikkakin molemmissa ryhmissä todettiin merkitsevää muutosta työmuistia lukuun ottamatta kaikkien muuttujien kohdalla. Psykofysiologisten mittausten sosiaalisen (korkean) stressin tehtävässä havaittiin, että tietoisuustaito-interventiolla saattaa olla myönteinen (madaltava) vaikutus oppilaan psykofysiologiseen ihon sähkönjohtavuuteen, joka kertoo siitä, miten oppilas kokee stressiä.

Tämä väitöskirja asemoituu tietoisuustaitojen ja sosioemotionaalisen oppimisen tutkimusperinteeseen ja tarjoaa uutta tietoa siitä, miten lyhyt tietoisuustaitojen interventio voi edistää lasten ja nuorten hyvinvointia. Saatuja tuloksia voidaan hyödyntää tietoisuustaito-ohjelmien soveltamisessa ja kohdentamisessa, jotta niiden vaikuttavuus olisi paras mahdollinen. Vaikka näyttöä on vielä rajallisesti, tulokset ovat lupaavia ja viittaavat siihen, että tietoisuustaitojen opettamisesta koulussa voi olla hyötyä.

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Maarit Lassander

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Volanen, S-M., Lassander, M., Hankonen, N., Santalahti, P., Hintsanen, M., Simonsen, N., Raevuori, A., Vahlberg, T., But, A. & Suominen, S. (2020). Healthy learning mind – effectiveness of a mindfulness program on mental health compared to a relaxation program and teaching as usual in schools: A cluster-randomised controlled trial. Journal of Affective Disorders 260, 660-229.

II Lassander, M., Hintsanen, M., Suominen, S., Mullola, S., Vahlberg T., Volanen, S-M. (2021). Effects of school-based mindfulness intervention on Health-Related Quality of Life: Moderating effect of gender, age and practice intensity. Quality of Life Research

III. Lassander, M., Hintsanen, M., Suominen, S., Mullola, S., Fagerlund, Å., Vahlberg T., Volanen, S-M. (2020). The Effects of School-based Mindfulness Intervention on Executive Functioning in a Cluster Randomized Controlled Trial, Developmental Neuropsychology, 45:7-8, 469-484.

IV Lassander, M., Hintsanen, M., Ravaja, N., Määttänen, I., Suominen, S., Mullola, S., Makkonen, T., Vahlberg, T., Volanen, S-M. (2021). Students' stress reactivity after mindfulness intervention compared to relaxation control group. International Journal of Stress management *(under final review).*

The publications are referred to in the text by their roman numerals.

The articles are re-printed according to the guidelines of the copyright holders. The original published versions can be found in the respective journals.

ABBREVIATIONS

SEL, socioemotional learning
EFs, executive functions
HRQoL, health related quality of life
MBSR, Mindfulness-based stress reduction
MBCT, Mindfulness-based cognitive therapy
CBT, cognitive behavioral therapy
HR, heart rate
HF-HRV, high-frequency heart rate variability
SCL, skin conductance level
SCR, skin conductance responses

1 INTRODUCTION

The estimates for lifetime prevalence of mental health disorders indicate that half of lifetime cases start before age of 14 and three fourths before the age of 24 (Kessler et al., 2005). Preventing these problems has been shown to be more effective than intervening when problems have developed further (Farrell & Barrett, 2007). Many governments and agencies globally are concerned of the burden of health spending on both physical and psychological health (OECD Health at glance, 2018). Healthy Learning Mind -study was born from our interest to examine the potential of mindfulness intervention among children and adolescents during their early teenage-years. The benefits of mindfulness interventions have been established during the past decades, and they offer a cost-effective way to strengthen socio-emotional skills among youth.

Mindfulness programs are often located as a subset of social and emotional learning (SEL) programs (Meiklejohn et al., 2012). These programs are created to develop students' social and emotional skills, attitudes and capacities, creativity, and collective well-being. Global social, ecological and economic issues affect all our lives and set certain expectations to educational systems. Education can help to develop skills such as empathy, compassion, responsibility of our common resources and altruism (Jagers, Rivas-Drake, & Williams, 2019). Mindfulness may have the potential to address these needs (Weare, 2013) and has the added benefit of strengthening the wellbeing in children and youth rather than trying to resolve specific problems (Mendelson & Greenberg, 2010).

Interest in applications of mindfulness has during the past decade spread from adult studies to mindfulness-based approaches with children and adolescents (Burke, 2010; Felver, Celis-de Hoyos, Tezanos, & Singh, 2016; Greenberg & Harris, 2012; Zoogman, Goldberg, Hoyt, & Miller, 2015). Promising but preliminary data among both non-clinical (school settings) (Felver et al., 2016; Zenner, Herrnleben-Kurz, & Walach, 2014) and clinical samples (Hofmann et al., 2010) have suggested that mindfulness interventions are acceptable and feasible for children and adolescents. These interventions are often found also beneficial among youth (Burke, 2010) and seem to have a positive effect on attention, focus, emotional reactivity, social skills, academic performance, self-esteem, self-reflection and –regulation, sleep quality, behavioral regulation, global executive control, subjective happiness (Biegel, Brown, Shapiro, & Schubert, 2009; Huppert & Johnson, 2010a; Napoli, Krech, & Holley, 2005). School-based mindfulness interventions are also found to decrease their measures of perceived stress, anxiety, test anxiety, ADHD-behaviors, depression, and several psychopathological symptoms (Biegel et al., 2009; Britton et al., 2014; Cunha & Paiva, 2012; Kuyken et al., 2013). Previous studies have shown that those with lower pre-intervention self-regulation were observed to experience greatest improvements in behavioral regulation, meta-cognition, and executive function (Flook et al., 2010). Mindfulness seems to have an effect on working memory capacity (Jha, Stanley, Kiyonaga, & Gelfand, 2010), self-control (Caldwell & Baime, 2012) and attentional control (Napoli et al., 2005) suggesting the involvement of executive processes.

There are still many open questions that need to be addressed. Accumulating evidence indicates that the effect of school-based mindfulness interventions is consistent but small (Dunning et al., 2019). Some researchers have questioned whether we have the right recipe yet (Johnson, Burke, Brinkman, & Wade, 2017). Should we teach mindfulness as a universal curriculum or is there a greater need for adaptation? Is there an optimal age or key stage, where mindfulness may have the optimal effect on students? Does intensive practice lead to significantly better outcomes? These questions remain largely unanswered due to lack of larger, randomized, and controlled trials to determine the moderating effects of various background factors.

The present thesis addresses the outcomes of resilience, depressive symptoms, socioemotional functioning, health-related quality of life (studies I and II), executive functions and psychophysiological stress reactivity (studies III and IV) (Keng et al., 2011; McRae, Ochsner, & Gross, 2011; Vago & Silbersweig, 2012) of a school-based mindfulness intervention. We will also examine whether the intervention effects are universal for all 12–15-year-old students or moderated by specific background factors like gender and age. This will offer us insight for future research but also suggest how the intervention could be better adapted and targeted to achieve optimal results.

2 REVIEW OF THE LITERATURE

2.1 DEFINITION OF MINDFULNESS

Mindfulness refers to a non-condemning state of awareness and readiness to pay attention to the stream of experiences in the present moment (Bishop, Lau, & Shapiro, 2004; Kabat-Zinn, 1982; Kabat-Zinn, 2003). Mindfulness as a trait (tendency to be mindful any given moment) has been reported to positively correlate with many psychological health indicators (Brown, K. & Ryan, 2003)). State mindfulness (mindfulness practice) is suggested to strengthen trait mindfulness over time through intentional practice, consequently improving psychological health (Kiken, Garland, Bluth, Palsson, & Gaylord, 2015). State mindfulness among adults has been found to have a positive influence on learning, attention, and creativity, well-being (self-awareness, self-esteem, satisfaction with life, and compassion) (Keng, Moria, Smoski, & Robins, 2011) and on reduction of stress, anxiety, and depression (Greeson, 2009; Grossman, Niemann, & Schmidt, 2004; Hofmann, Sawyer, & Witt, 2010).

There are currently two dominant approaches to defining mindfulness. The approach taken by Ellen Langer's research group (Alexander, Langer, Newman, & Chandler, 1989) is based on social psychology research emerging in 1970's and is often referred as Western mindfulness. The other research tradition was based on clinical research in 1970´s and -80´s, by Jon Kabat-Zinn, Herbert Benson and Richard Davidson (Benson, 1975; Kabat-Zinn, 1982) and is more connected to Eastern meditative practices. Both research traditions agree that the definition of mindfulness should focus on present moment awareness. This capacity of awareness can be enhanced and learned. They also share the understanding of mind and body as a single system, where all change will have both psychological and physiological outcomes, defining the concept as awareness, directing attention, and accepting the experience as it presents itself, non-judgmentally, with curiosity and openness (Bishop, Lau, & Shapiro, 2004; Kabat - Zinn, 1994; Lutz, Slagter, Dunne, & Davidson, 2008; Shapiro, Carlson, Astin, & Freedman, 2006). The main difference between these two approaches is the role of practice, i.e., state mindfulness, which is emphasized in the Eastern tradition (e.g., Kabat - Zinn, 1994) and deemed unnecessary by the Western approach (Langer & Moldoveanu, 2000).

2.2 THEORETICAL BACKGROUND OF MINDFULNESS

Although the practice of mindfulness is associated with many positive psychological and physiological outcomes in different age-groups (Dunning et al., 2019; Galante, Friedrich, Dawson, Modrego-Alarcón, & Gebbing, 2021), we only have a limited knowledge of mechanisms behind mindfulness process, how and why these

positive changes come about (Chiesa, Anselmi, & Serretti, 2014; Lindsay & Creswell, 2017; Shapiro, Carlson, Astin, & Freedman, 2006). Researchers have proposed a number of theoretical models including a set of skills, attitudes or mechanisms that have been suggested to contribute to mindfulness. Most often are mentioned self-regulation (Baer, 2003b; Shapiro et al., 2006; Vago & Silbersweig, 2012), attention regulation (Holzel et al., 2011; Lindsay & Creswell, 2017), cognitive and emotional regulation (Holzel et al., 2011; Shapiro et al., 2006), exposure (Baer, 2003a; Brown, Kirk Warren, Ryan, & Creswell, 2007; Shapiro et al., 2006), acceptance (Baer, 2003; Lindsay & Creswell, 2017) and self-compassion (Neff, 2003). A systematic review examining the potential mechanisms of mindfulness identified moderate and consistent evidence for mindfulness, rumination, and worry, and preliminary but insufficient evidence for cognitive and emotional reactivity, self-compassion and psychological flexibility as mechanisms underlying mindfulness interventions. The results also suggested that mindfulness, rumination and worry significantly mediated the effects of mindfulness-based interventions on mental health outcomes (Gu, Strauss, Bond, & Cavanagh, 2015).

Evidence for rumination and worry as mechanisms is in line with the underlying theory of Mindfulness-based cognitive therapy (MBCT) (Segal, Williams, & Teasdale, 2002; Teasdale, Moore, Hayhurst, Pope, & Williams, 2002), i.e., increasing disengagement from maladaptive thinking and decreasing depressive symptoms (Segal et al., 2002). Another prominent approach in mindfulness practice is the Mindfulness-based stress reduction (MBSR). MBSR derived programs have their emphasis in healing, as they were originally developed for clinical populations suffering from chronic pain (Ludwig & Kabat-Zinn, 2008). These therapeutical approaches belong to the third wave of cognitive behavioral theory (CBT), together with Dialectical behavior therapy (Linehan, 1993) and Acceptance and Commitment Therapy (Hayes, S., Strosahl, & Wilson, 1999), where the same elements of openness and acceptance towards experience are introduced.

2.3 MINDFUL PROCESSES

The theoretical definition of mindfulness includes monitoring one's experience (attention and awareness) and accepting the experience in a non-judgmental manner (Baer, 2003; Lindsay & Creswell, 2017) and these mechanisms appear to be central in the mindfulness process. In Figure 1 I have presented the theoretical framework of mindfulness and the hypothetical path from practice to enhanced skills and eventually to study I-IV outcomes. Understanding the role of these processes in mindfulness interventions facilitates the analysis of intervention outcomes. Awareness/attention and acceptance have been found to develop concurrently but in somewhat different pace, attention seems to improve from the start, whereas acceptance takes longer to develop (Desbordes et al., 2012). These skills have also internal dynamic, acceptance may facilitate better executive control in situations where emotions are present by

allowing noticing (Teper, Segal, & Inzlicht, 2013) and letting go of affective stimuli (Vago & Nakamura, 2011).

Mindful awareness anchors us to the present moment, as opposed to being on an autopilot mode, for example, thinking about the past or future without being conscious of our focus. This temporal shift of becoming aware enables metacognitive insight (Sanger, 2016; Teasdale et al., 2002), i.e., taking a perspective, where mental events are regarded as passing constructs of the mind and less as facts or accurate presentations of reality. Being aware of our thoughts and emotions counteracts cognitive suppression, where painful cognitive experiences are avoided. Cognitive suppression has been found to mediate the effect of mindfulness intervention on anxiety and rumination, whereas cognitive fusion (being entangled with thoughts or emotions and not able to see them as such) may mediate the effect of mindfulness on depression (Nitzan-Assayag, Aderka, & Bernstein, 2015). The process of cognitive defusion allows us to recognize familiar thought processes (rumination, self-critique, self-labelling, catastrophizing) and not to be controlled by these waves of thought patterns (Segal et al., 2002; Teasdale et al., 2002). Researchers (Langer & Moldoveanu, 2000) have argued that mindful awareness can enhance taking new perspectives, being sensitive to context and understanding behaviors in multiple ways. Relational frame theory (Hayes, S., Barnes-Holmes, & Roche, 2002) has approached this from the perspective of human language, revealing how rigidity/automacity of frames can lead to adverse psychological effects.

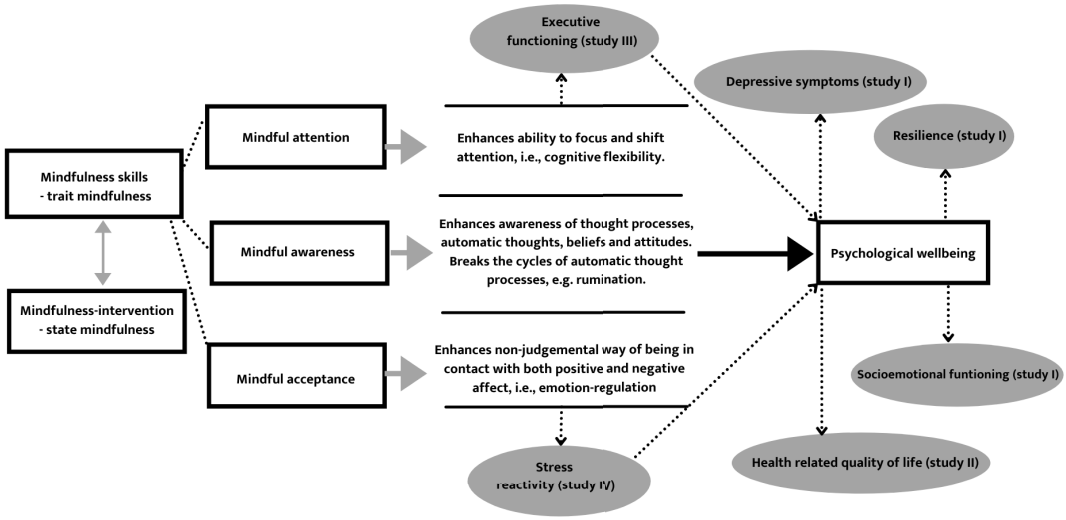

Figure 1. Theoretical framework and outcomes of studies I-IV

Mindful attention is one of key skills in mindfulness practice. Mindfulness meditators have been found to perform better in attentional tasks than non-meditators (Moore & Malinowski, 2009). Sustaining attention and having the executive control over attention seems to be essential for mindfulness to take place when examined with neuroimaging studies (Lutz, Slagter, Dunne, & Davidson, 2008). According to some research, mindfulness may improve attention regulation when measured with tests of performance (Galla, Hale, & Shrestha, 2012). The essence of mindfulness practice is to be aware of the way our attention moves, and how we can ourselves shift and control the attentional focus. Sustaining attention focus for longer periods of time can be enhanced through regular mindfulness practice (Chambers & Lo, 2008). Sustaining and shifting attention has been also defined as cognitive flexibility, referring to ability to respond to the demands of task in a relevant and flexible manner, allocating attentional resources by conscious choice (Moore & Malinowski, 2009).

Mindful acceptance refers to our capability to notice this tendency to judge and by noticing, question the judgement itself (Kabat - Zinn, 1994). Engaging in the practice of mindfulness, cultivating acceptance, is not to calm or suppress any existing emotion but to make it possible to stay with experiences, without trying to change, control or avoid them (Kaplan, Bergman, & Christopher, 2017). When evaluating the different facets of mindfulness, researchers have found support to this operationalization of acceptance, i.e., nonreactivity as prominent mechanism of change (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Kaplan et al., 2017). This process bears a close similarity to exposure (one of the core processes in cognitive behavioral therapy), where the reactivity is reduced, and maladaptive coping mechanisms rendered unnecessary (Baer, 2003). For example, often observed response to stress (fight-or-flight) may be triggered even when there is no imminent threat and it may cause a variety of maladaptive responses that are not useful in terms of coping (Creswell, D., Way, Eisenberger, & Lieberman, 2007). Preliminary research evidence suggests that acceptance is the key to lowering stress reactivity in mindfulness-based interventions (Lindsay, Young, Smyth, Brown, & Creswell, 2018) and it may also promote executive control (Teper et al., 2013).

3 PREVIOUS RESEARCH

3.1 MINDFULNESS AMONG ADULTS

The outcomes of mindfulness interventions of varying length have been studied among adults from 1970's and there are a number of reviews summarizing the psychological and physiological outcomes so far (de Vibe, Bjørndal, Fattah, Dyrdal, & Halland, 2017; Galante et al., 2021; Keng et al., 2011). I will present the state of the evidence, as there are many commonalities and supporting findings with the research among children and adolescents, but also differences that need more investigation.

3.1.1 MINDFULNESS INTERVENTIONS AMONG HEALTHY ADULTS

The most recent, comprehensive meta-analysis included 136 RCTs on mindfulness training for mental health promotion in community settings (Galante et al., 2021). Researchers found that mindfulness-based programs compared with active control conditions had a significant and positive effect on depression, but no statistically significant evidence for improving anxiety or distress. Compared with specific active control conditions (e.g., physical exercise) mindfulness programs performed equally well in comparison with the control program. Mindfulness programs targeting higher–risk populations had larger effects than universal mindfulness interventions. Another review (Keng et al., 2011) examining the effects of mindfulness on psychological health found positive psychological effects, including increased subjective wellbeing, reduced symptoms of depression/anxiety and improved behavior regulation.

A review on 101 RCTs (de Vibe et al., 2017) focusing on the manualised 8-week MBSR-program has found a small but significant effect on improving mental health at post-intervention compared to other active treatments, on anxiety, depression, stress/distress, and other measures of mental health. MBSR may not differ from other active interventions on somatic health and quality of life.

Mindfulness has been examined in working-age adults and older adults. A brief version of MBSR developed for workplace-settings has been equally effective as standard 8-week versions, suggesting medium-to-large mean effect sizes in lowering depressive symptoms in comparison with an inactive control (Virgili, 2015). A review of 24 workplace studies found strongest outcomes were reduced levels of emotional exhaustion, stress, psychological distress, depression, anxiety, and occupational stress. Improvements were found in terms of mindfulness, personal accomplishment, self-compassion, quality of sleep, and relaxation (Janssen, Heerkens, Kuijer, van der Heijden, & Engels, 2018). Among older adults, a systematic review found that MBSR seems more effective than inactive control group to reduce depression immediately following the intervention (Li & Bressington, 2019).

Mindfulness seems to improve cognitive skills in adults, that is sustained attention, visual-spatial memory, working memory and concentration (Chambers & Lo, 2008; Jha, Krombinger, & Baime, 2007; Zeidan et al., 2010). The outcomes of mindfulness in the domain of executive functioning are relatively specific, suggesting improvement in response inhibition, but more variable advantages to the cognitive flexibility (Gallant, 2016). A recent review found a small-to-medium effect of mindfulness meditation training in enhancing executive control, including working memory, inhibitory control, and cognitive flexibility (Cásedas, Pirruccio, & Vadillo, 2020).

3.1.2 MINDFULNESS INTERVENTIONS IN CLINICAL SETTING

Existing reviews of mindfulness-based interventions in clinical adult subpopulations include also non-randomised trials. Mindfulness interventions appear to have psychological benefits reducing ADHD-symptoms (Cairncross & Miller, 2020; Poissant, Mendrek, Talbot, Khoury, & Nolan, 2019) and aggressive behavior (Gillions, Cheang, & Duarte, 2019). Mindfulness seems to have a positive effect on psychological and physiological outcomes among adults with diabetes (Noordali, Cumming, & Thompson, 2017), cardiovascular-disease (Scott-Sheldon et al., 2020), eating disorders (Ruffault et al., 2017), sleep disorders (Winbush, Gross, & Kreitzer, 2007) and chronic pain (Reiner, MSc, & Lipsitz, 2013). Tentative findings of positive mindfulness meditation effects have been found on specific markers of inflammation, cell-mediated immunity, and biological aging (Black & Slavich, 2016).

The most recent review of psychiatric disorders (Goldberg et al., 2018) examined 142 RCT's and found most consistent evidence for mindfulness improving depression, chronic pain, smoking and addictive disorders. Mindfulness-based interventions were superior to no treatment, minimal treatment, non-specific active controls, and specific active controls. Mindfulness-based treatment did not differ from evidence-based treatments. At follow-up, mindfulness-based interventions were superior to no treatment, non-specific active controls, and specific active controls.

It is also important to note that mindfulness is not a universally effective, quick method to reduce symptoms for all, as a recent meta-analysis points out that 8% of adults may experience discomfort or worsening of symptoms (e.g., anxiety, stress, cognitive anomalies) (Farias, Maraldi, & Wallenkampf, 2020). These adverse experiences can be further specified as program-related (e.g., lack of appropriate structure), participant related (e.g., ignoring participant vulnerabilities), and clinician/teacher related, (e.g., lack of sufficient guidance) (Baer, Crane, Miller, & Kuyken, 2019). It is also well-known, that psychological change in itself can create discomfort, without causing harm (Bennett-Levy et al., 2004).

3.2 MINDFULNESS AMONG YOUTH

The mindfulness research among children and adolescents has been ongoing for two decades. Starting from smaller pilot studies and at-risk youth populations

research efforts have been growing towards larger RCT's and school-based, healthy population studies (Black, 2015).

3.2.1 MINDFULNESS INTERVENTIONS AMONG HEALTHY CHILDREN

There have been a number of reviews during the past decade, attempting to establish the effects of mindfulness interventions among healthy children and adolescents and assessing state of the evidence so far (Burke, 2010; Dunning et al., 2019; Felver et al., 2016). Despite the increasing number of studies in recent years, there have been a lack of sufficient samples, robust RCTs with both active/inactive control groups and studies with adequate follow-up periods (Tan, 2016). Current research base provides support for the feasibility and acceptance of mindfulness-based interventions with children and adolescents (Burke, 2010), but only recently have large-scale RCT's, such as Healthy Learning Mind-study, began to provide more nuanced and specific evidence of potential benefits (Volanen et al., 2016). The effect sizes in meta-analysis so far have included both rigorous RCTs and less robust research designs (e.g., non-randomized), which may have overestimated the effects of mindfulness interventions as moderate (Dunning et al., 2019). The general findings have been a small but consistent effect of improvement among healthy students, in terms of depressive symptoms, anxiety, stress, resilience, attention and mindfulness (Zenner et al., 2014; Zoogman et al., 2015). There has been no consistent evidence on the effect of behavioral outcomes and academic outcomes (Maynard, Solis, Miller, & Brendel, 2017).

A recent meta-analysis (Dunning et al., 2019) including 33 RCTs found significant positive effects of mindfulness interventions, relative to controls, for mindfulness, executive functioning, attention, depression, anxiety/stress, and negative behaviours, with small effect sizes (Cohen's *d*), ranging from .16 to .30. Of these RCTs 17 had active control groups, showing significant benefits on mindfulness (d = .42), depression (d = .47) and anxiety/stress (d = .18). These results have been partly replicated in a meta-analysis focusing on anxiety outcomes (both school-based and clinical studies), finding post-treatment effects were significant for mindfulness interventions conducted with children and for mindfulness interventions compared to inactive controls, but non-significant for adolescents when mindfulness interventions were compared to active controls (Odgers, Dargue, & Creswell, 2020).

3.2.2 MINDFULNESS INTERVENTIONS IN CLINICAL SETTING AMONG CHILDREN

Several clinical studies to guide both preventive measures for at risk groups and treatment for existing symptoms/diagnoses have been conducted in the past twenty years. Research shows promising results of mindfulness intervention for ADHD, depression, and anxiety (Hofmann et al., 2010; Mak, Whittingham, Cunnington, & Boyd, 2017). A review identifying at risk groups and subpopulations (i.e., participants were included based on specific psychiatric condition) found small to moderate effect,

indicating the superiority of mindfulness interventions compared to active control conditions. A significantly larger effect size was found on depressive symptoms and anxiety compared to other dependent variable types, i.e., social skills, quality of life, mindfulness, and attention (g = 0.37 vs. 0.21), and for studies drawn from clinical samples compared to non-clinical sample (0.50 vs. 0.20) (Zoogman et al., 2015). Two review articles examining the effect of mindfulness intervention on anxiety disorder among children and adolescents between ages of 5 and 18 suggest that mindfulness-based therapy is moderately effective for improving anxiety (g = 0.62–0.63) and mood symptoms (g = 0.59) from pre- to posttreatment in the overall sample (Borquist-Conlon, Maynard, Brendel, & Farina, 2019; Hofmann et al., 2010).

According to research on attention and executive functioning, mindfulness-based interventions are a promising approach for children and adolescence at risk of learning difficulties. A review summarizing 13 studies found in five of them a statistically significant intervention effect for at least one outcome measure of attention or executive function with medium to large effect sizes (g = 0.3–32.03) (Mak et al., 2017).

3.3 MINDFULNESS IN SCHOOLS

3.3.1 MINDFULNESS IN THE CONTEXT OF SOCIOEMOTIONAL LEARNING

Mindfulness interventions have often been introduced to schools as a part of the socioemotional learning framework (Meiklejohn et al., 2012) and as a response to acute need for mental health promotion in school contexts (Mendelson & Greenberg, 2010). Stress, anxiety and worry of own mental health have increased (Finnish School Health Survey, 2019), especially among girls and 14 and 15-year-olds. The experience of stress is likely to negatively influence well-being, general functioning, and factors specific to learning such as executive functioning and working memory (Meiklejohn et al., 2012). Growing challenges require new approaches; therefore, it has been proposed that schools should invest more in social and psychological learning environments to foster resilience against stress and to promote well-being of students (Mendelson & Greenberg, 2010; Weare, 2013).

Social and emotional learning (SEL) programs are created to develop students' social and emotional skills, attitudes and capacities, creativity, and collective well-being, as well as to benefit and support the teachers. More recently the aims of equity have been addressed as opportunities to mitigate the educational, social, and economic inequities (Jagers, Rivas-Drake, & Williams, 2019). Mindfulness (MF) programs are a subset of SEL programs sharing the same goals and to some extent same techniques (Meiklejohn et al., 2012). The Collaborative for Academic, Social, and Emotional Learning describes SEL in terms of five groups of interrelated core social and emotional competencies: self-awareness (accurately assessing one's feelings), self-management (regulating one's emotions to handle stress, controlling impulses, and persevering in addressing challenges), social awareness (being able to take the perspective of and empathize with others), relationship skills, and responsible decision-making (Devaney, Utne O'Brien, & Tavegia, 2005). The evidence suggests

that mindfulness interventions target and promote many of these same competencies, including self-regulation (Jha et al., 2007), self-awareness (Lutz, Slagter, Dunne, & Davidson, 2008) and emotion regulation (Arch & Craske, 2010; Chambers & Lo, 2008). Incorporating mindfulness into SEL programs could enhance the effectiveness of interventions in promoting social and emotional competencies (Meiklejohn et al., 2012).

3.3.2 SCHOOL-BASED MINDFULNESS

Schools as a setting for evaluating mindfulness interventions have several advantages. Interventions are inexpensive to implement, they seem feasible, acceptable and their preventive/promotive focus may reduce the overall health costs (Weare, 2013).

Mindfulness is particularly well suited for universal prevention programs and the framework of socioemotional learning, because it focuses on strengthening the wellbeing in children and youth rather than on specific problems (Mendelson & Greenberg, 2010) and has potential to involve the whole school (individuals, groups, teachers, and other personnel) (Meiklejohn et al., 2012). This results in less stigmatization and labelling when students are not targeted for intervention. Universal programs are a cost-effective method to deliver prevention focused school-based programs (Farrell & Barrett, 2007) and mindfulness training can be integrated into other subjects (e.g., physical or health education) to teach students from early on to manage stress and focus attention (Napoli et al., 2005).

So far there have been three systematic reviews on school-based mindfulness interventions (Carsley, Khoury, & Heath, 2018; Felver et al., 2016; Zenner et al., 2014). In the review conducted by Zenner et al. (2014) researchers found overall (effect sizes between groups $g = 0.40$) and significant improvement in the intervention group for cognitive performance, stress, and resilience. Researchers also reported that while interventions seem promising, the diversity of studies, underpowered research design and general challenges of the school setting make it difficult to draw firm conclusions. Felver et al. (2016) gathered evidence of decrease in behavioural problems, anxiety, depression, affective disturbances and increase in executive functioning, but also commented on the challenges of varying research designs and formulated recommendations to address gaps in research. Their conclusions were that although mindfulness intervention are feasible and acceptable, there are many remaining questions on their impact on student population. Average study has 100 participants, and many studies are diverse in terms of population studies. Many studies use MBSR-based intervention, as the evidence-base on MBSR is perhaps most developed. The recommendation for further research designs were to 1) use RCTs were possible; 2) use active control programs with both didactic and experiential components and 3) account statistically for students being nested in classrooms and schools.

Carsley et al. (2017) review focused on specific moderators contributing to mindfulness intervention outcomes. They reported small to moderate significant effects from mindfulness interventions compared to control groups on a variety of mental health wellbeing outcomes. Intervention delivered in later adolescence (15-18

years compared to younger participants) and interventions with combinations of various mindfulness activities had the largest effects, as well as interventions delivered by mindfulness trained classroom teacher (compared to facilitators coming from outside the school). These results highlight the role of moderators to intervention receptivity and the success of mindfulness training.

3.3.3 SUMMARY AND PRACTICAL IMPLICATIONS

Based on the previous research mindfulness-based interventions among adults have small to moderate effects on specific outcomes, mainly depression, anxiety, stress, and executive functioning, in comparison to active control programs (Galante et al., 2021). There are several potential benefits for psychological wellbeing outcomes awaiting accumulating, rigorous RCTs to replicate the findings (Janssen et al., 2018; Keng et al., 2011). The effects are larger when study participants are of at risk/clinical populations or have a somatic illness (Goldberg et al., 2018).

The research among children and adolescents is limited compared to adult studies, but the findings are highly concurrent. Mindfulness-based interventions seem to have small to moderate effects on specific outcomes, mainly depression, anxiety, and stress. These effects are observed even when compared with active control conditions, indicating that mindfulness-based interventions may be superior to other approaches for these outcomes (Dunning et al., 2019). Also, the effects are larger when interventions are targeted to high-risk/clinical populations (Zoogman et al., 2015). Previous studies suggest that mindfulness interventions may have general effects and specific effects, that can be only determined when the research design includes sufficiently similar and active control groups (Dunning et al., 2019). School-based mindfulness interventions have been found feasible, acceptable and offer a suitable option for enhancing socioemotional learning (Meiklejohn et al., 2012).

3.4 MENTAL HEALTH OUTCOMES IN PRESENT THESIS AND THEIR MODERATORS

3.4.1 RESILIENCE

Psychological resilience refers to the phenomenon that many people face the challenges of life with ability to adapt and maintain mental health despite exposure to adversity (Rutten et al., 2013; Wagnild & Young, 1993). In the present thesis resilience has been conceptualized and measured with a scale (RS14) that has two factor-components, personal competence and acceptance of self and life (Wagnild & Young, 1993). Lower resilience correlates with decreased mental health and higher resilience with positive mental health indicators. Correlations are stronger for adults compared to children and after experienced adversity (Hu, Zhang, & Wang, 2015). A study comparing the moderating effect of gender on resilience found no gender difference when there was no exposure to trauma. Female adolescents were more likely to use

social support and emotion-based coping methods (Stratta, Capanna, & Patriarca, 2013). Emerging research among adults shows that mindfulness and resilience are positively related (Pidgeon & Keye, 2014). Researchers have proposed that mindfulness increases resilience by decreasing rumination and maladaptive coping in difficult situations (Bajaj & Pande, 2016). Resilience may mediate the outcomes of mindfulness and it may also have common denominators, namely acceptance (Galla et al., 2012). A study among university students found that mindfulness mediated by self-esteem increased resilience (Bajaj & Pande, 2016). Another study among first responders (firefighters and police officers) found that increased mindfulness predicted increased resilience, which in turn decreased burn-out, lending support to psychological resilience as a mechanism of change in mindfulness intervention (Kaplan et al., 2017).

There is limited evidence of the effect of mindfulness on resilience among adolescents in school context, findings have been not significant (Huppert & Johnson, 2010b) or partly significant with older students (Hennelly, 2011). Studies among adolescents at risk have found that mindfulness influences resilience partly by self-compassion and emotional regulation (Sünbül & Güneri, 2019). A recent study found an increase in resilience after an intensive mindfulness and life skills training among adolescents with emotional and behavioral problems (Huang, Chen, Greene, & Cheung, 2019). In the present thesis, we hypothesize that mindfulness intervention will have an effect on resilience, based on the previous research and tentatively promising findings (Dunning et al., 2019).

3.4.2 DEPRESSIVE SYMPTOMS

Symptoms of depression become more prevalent in teenage years (Mojtabai, Olfson and Han, 2016). A recent review found that MBSR-programs were moderately effective in reducing depressive symptoms for adolescents and young adults at the end of the intervention, although follow-up effectiveness could not be determined due to lack of statistical power (Chi, X., Bo, Liu, & Zhang, 2018).

In the present thesis we hypothesize that considering the evidence base for mindfulness interventions improving depressive symptoms among both adults (moderate effect) (Galante et al., 2021; Virgili, 2015) and among children and adolescents (small effect) (Dunning et al., 2019), this study would also show improvement for all participants, and potentially greater benefits for girls (Kang & Gruber, 2014; Kuyken et al., 2013). We aim also to explore the effect at 26 weeks follow-up. Sufficiently long follow-ups have been often lacking in previous research (Felver et al., 2016).

3.4.3 SOCIOEMOTIONAL FUNCTIONING

Socioemotional functioning focuses on certain behaviors central to socioemotional wellbeing, and often highly noticeable in interaction with others (e.g., emotional problems, conduct problems, hyperactivity, peer problems). Thus, they present a

conceptually different outcome from resilience and depressive symptoms, that are more often described as inner resources or internal distress. The research on mindfulness and socioemotional functioning is still very limited, and there is no consistent evidence of behavioral outcomes in relation to mindfulness interventions (Dunning et al., 2019; Maynard et al., 2017). A recent study found that a mindfulness and life skills program had a significant effect on socioemotional functioning among adolescents with emotional and behavioral problems (Huang et al., 2019). There are some findings among adults in terms of aggressive behavior (Gillions et al., 2019) and among children adolescents in terms of attention and behavior difficulties (Franco et al., 2016; Weijer-Bergsma, Langenberg, Brandsma, Oort, & Bögels, 2014) that suggest a potential effect. Research has also indicated that low (trait) mindfulness is associated with both internalising and externalising symptoms (Pepping, Duvenage, Cronin, & Lyons, 2016). A systematic review (Maynard et al., 2017) found small but consistently significant effect of mindfulness interventions on internalizing behaviors (e.g., anxiety, stress) but no significant effect on externalizing behaviors (e.g., aggression, compliance).

3.4.4 HEALTH-RELATED QUALITY OF LIFE

Health-Related Quality of Life (HRQoL) is a subjective, multidimensional concept that measures satisfaction or happiness in various life domains (Varni, Limbers, & Burwinkle, 2006; Wallander & Koot, 2016) and is often utilized as a general outcome measure for evaluating intervention outcomes. HRQoL is particularly well-rounded measure for children and adolescents, as it takes into account the spheres of individual experience, family and school environment (Otto et al., 2020; Wallander, Schmitt, & Koot, 2001; Zullig, Matthews, Gilman, Valois, & Huebner, 2010). These dimensions affect or are affected by health and contiribute to the understanding of subjective health and well-being (Erhart, Ellert, Kurth, & Ravens-Sieberer, 2009). Previous research has found that girls have lower HRQoL in general compared to boys (Meade & Dowswell, 2016) and HRQoL decreases with age in adolescence (Michel et al., 2009).

There is also a definitive lack of studies among youth that would examine the impact of mindfulness-based intervention on HRQoL, or indeed examining how to generally improve quality of life without linking it to functional impairment or illness following medical or psychosocial interventions (Zullig et al., 2010). However, several studies among adults have examined the effects of mindfulness intervention on specific patient groups and found that mindfulness may reduce perceived stress and improve health-related quality of life (e.g., Zhang, Zhao & Zheng, 2019; deVibe, 2017). In the present thesis we hypothesize that mindfulness may increase health-related quality of life based on the evidence from adult studies. The benefits for girls and older adolescents may be greater, due to potentially lower baseline levels.

3.4.5 EXECUTIVE FUNCTIONING

Considering the potential of mindfulness practice to strengthen the ability to direct and sustain attention and allow flexibility in our cognitive processes (see Fig. 1) (Heeren, Van Broeck, & Philippot, 2009; Sedlmeier et al., 2012; Slagter et al., 2007), our interest is directed to examining the effect of mindfulness on higher cognitive functions that allow us to act on purpose. They allow us to make goal-oriented choices, especially in situations where a new, complex task is given, including problem solving, planning, impulse control, flexible thinking and generally directing attention towards the task at hand (Pennington & Ozonoff, 1996; Strauss, Sherman, & Spreen, 2006).

The existing studies on adults show mixed results. Some have found positive effects of mindfulness-based interventions on working memory (Jha, Stanley, Kiyonaga, & Gelfand, 2010; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013) and improvements in cognitive flexibility (Heeren et al., 2009; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). A recent review found small-to-medium effect ($g = 0.34$) of mindfulness meditation training in enhancing executive control (Cásedas & Pirruccio, 2020), whereas a review on neuropsychological outcomes found no overall support for attention or executive function improvements (Lao & Kissane, 2016). Another review (Dunning et al., 2019) found small effect sizes (Cohen's $d = .16$ -.30) for attention and executive functioning, but the effect was not found in RCTs with active control group.

3.4.6 STRESS REACTIVITY

One of the suggested mechanisms of mindfulness is our reactivity to thoughts, emotions and events (see Fig 1). Stress buffering hypothesis of mindfulness suggests that mindfulness mitigates stress appraisals and reduces stress reactivity responses, thus strengthening health and wellbeing (Creswell, J., 2014; Ludwig & Kabat-Zinn, 2008). The autonomic nervous system regulates the peripheral physical response to stress and is divided to sympathetic and parasympathetic nervous system. Sympathetic nervous system and in particular the sympathetic-adrenal-medullary pathway activates the body in face of threat and regulates short term stress responses (i.e., fight-or-flight stress response), whereas parasympathetic nervous system has generally opposing effects (Godoy, Rossignoli, Delfino-Pereira, Garcia-Cairasco, & de Lima Umeoka, 2018).

Several studies have shown that mindfulness interventions affect autonomic nervous system functioning. There is some evidence suggesting that mindfulness might alter the sympathetic-adrenal-medullary activation by reducing sympathetic response and its principal neurotransmitters (Creswell, 2014; Lush et al., 2009), or by increasing activity in the parasympathetic nervous system via the vagal nerve (Thayer & Lane, 2000). Recent systematic reviews among adults have reported either no significant effects due to lack of sufficiently large and rigorously conducted RCTs (Rådmark, Sidorchuk, & Osika, 2019) and increase in heart rate variability activity in available RCTs (Christodoulou, Salami, & Black, 2020). It is also worth noting that, in general, the effects of mindfulness interventions seem to be more prominent in high stress populations and high stress conditions (Arch & Craske, 2010; Brown, Weinstein,

& Creswell, 2012). Based on self-reports by children, adolescents and their parents, mindfulness may reduce perceived stress and stress related symptoms in elementary school children (Biegel, Brown, Shapiro, & Schubert, 2009; Flook et al., 2010; Schonert-Reichl et al., 2015; Weijer-Bergsma, Langenberg, Brandsma, Oort, & Bögels, 2014). Nevertheless, there is very little evidence available on psychophysiological stress reactivity after mindfulness intervention among children and adolescents (Schonert-Reichl et al., 2015). Based on the lack of definite findings, we aim to explore if mindfulness intervention would have a small effect on physiological stress reactivity, compared with the active control group.

3.5 FACTORS MODERATING THE EFFECTS ON OUTCOMES

The effects of mindfulness can be moderated by different factors supported by emerging research on their significance. Many studies have not been large enough to analyse the moderating factors (Felver et al., 2016; Tan, 2016), but unless we are aware of them, there is a possibility that significant results are not found. This could also explain some of the conflicting outcomes reported in the mindfulness-based intervention studies (Kang et al., 2018). In the Healthy Learning Mind-study our aim is to address this gap in the previous research by sufficiently large sample.

3.5.1 GENDER

Research to date suggests that males and females gain different benefits from mindfulness practices (de Vibe, Solhaug, & Tyssen, 2015; Desbordes et al., 2012; Katz & Toner, 2013; Volanen et al., 2020). It is well-known that adolescent girls have more depressive symptoms and achieve lower wellbeing compared to boys (Kang et al., 2018). Thus, it has been suggested that they may also benefit more from mindfulness interventions (Biegel et al., 2009; Kang et al., 2018; Kuyken et al., 2013) that ameliorate the symptoms. For example, from pre- and early adolescence depression and its symptoms are twice as prevalent in adolescent girls and adult women (Gater, Tansella, Korten, Tiemens, & Mavreas, 1998). The gender difference appears by age 12 and peaks around age 13-15 (Hyde & Mezulis, 2020).

Using the ABC (affective, biological, cognitive) model (Hyde, Mezulis, & Abramson, 2008) the potential explanations can be grouped together with negative life events and sociocultural influences (Hyde & Mezulis, 2020) as follows:

(1) There are affect related risk factors that seem to be gender biased, i.e., females may be more prone to affective processing of negative emotions (Mendrek, Potvin, & Lungu, 2015).

(2) Biological explanations have been associated with hormonal changes (Rojiani, Santoyo, Rahrig, Harold, & Britton, 2017) and other biological factors, such

as genetic vulnerability and pubertal timing (Altemus & Sarvaiya, 2014).

(3) Women tend to engage in maladaptive coping strategies, e.g., rumination and self-critique (Allgood-Merten, Lewinsohn, & Hops, 1990; Butler & Nolen-Hoeksema, 1994).

(4) Cultural factors include gender expectations (body surveillance, body shame), girls consume more digital/social media and are also more affected by the negative consequences (Altemus & Sarvaiya, 2014; Twenge & Martin, 2020). Girls experience higher incidence of reported negative life events compared to boys e.g., sexual abuse, harassment and victimization as well (Petersen, Sarigiani, & Kennedy, 1991) as the more subtle but pervasive influences of structural gender inequality (Hyde & Mezulis, 2020).

Adult females tend to have internalized distress response (e.g., rumination, self-critique) compared to more externalised responses among males (Hyde, 2020). Thus, it has been suggested that they may benefit from training the mindfulness attitudes towards cognitive and emotional processes (Kang, 2018). In a recent meta-analysis on moderating effects on mindfulness, gender differences were tentative but could not be confirmed (Carsley et al., 2018) due to lack of sufficiently large RCTs. In present thesis we have aimed to address this gap in the literature.

3.5.2 AGE

The developmental stage may influence the way mindfulness is guided but also how it is received. Differences in the development of self-concept and neurocognitive maturity may influence the effects of mindfulness-based interventions (Johnson et al., 2017). There is still limited evidence on the moderating effect of age on the effects of mindfulness practice. We know from previous research that wellbeing in general tends to decrease in mid-adolescence for both genders (González-Carrasco, Casas, Malo, Viñas, & Dinisman, 2017; Mak et al., 2017; Michel, Bisegger, Fuhr, & Abel, 2009; Moksnes & Espnes, 2013). A recent meta-analysis suggests that interventions delivered during late adolescence (among 15 to 18-years-olds) had the largest effects (g = 0.28) in comparison with ages 6 to 14 (g=0.20) on mental health and well-being outcomes (Carsley et al., 2018). Age seems to also moderate the effects of mindfulness significantly on executive functioning, with greater benefits for older adolescents (Dunning et al., 2019). Somewhat contrary findings have been observed in terms of anxiety, indicating more benefits for younger children (Odgers, 2020).

3.5.3 MINDFULNESS PRACTICE

The amount of practice may be one of the moderating factors in mindfulness intervention studies. In order to gain benefits from mindfulness interventions it seems

that sustained and regular practice is required. Among adults a meta-analysis (Parsons, Crane, Parsons, Fjorback, & Kuyken, 2017) found a small but consistent association between more frequent formal practice and positive intervention outcomes, presenting a wide range of psychological measures. What comes to independent mindfulness practice, we know less about its significance for wellbeing among youth than among adults. It has turned out to be difficult to motivate individuals to practice the necessary amount in order to enhance wellbeing and therefore, to measure the practice intensity (Chi, Xi, Bo, Liu, Zhang, & Chi, 2018). Two RCTs have so far explored a more intensive, MBRS-modelled program for adolescents (90-100 minutes long weekly lessons) (Johnson & Wade, 2019; Raes, Griffith, & Van der Gucht, 2014) with promising results, suggesting that also the intervention dose may be an important factor in adolescent mindfulness-training. Treatment duration may also moderate the outcomes (Chi et al., 2018). A recent article utilizing the same dataset as presented here discovered that the intensity of practice was related to social cognitions and outcome expectations whereas baseline mental health variables (depressive symptoms, internalization or externalization of difficulties or resilience) did not affect the amount of practice (Beattie, Konttinen, Volanen, Knittle, & Hankonen, 2020).

In the present thesis the role of independent practice outside intervention lessons (duration 1-15 minutes) was investigated in studies I, II and III. Previous studies on Stop and Breathe-program have found varying rates of continuous (once a week or more) practice, from 20% (Kuyken et al., 2013) to 12% (Johnson, Burke, Brinkman, & Wade, 2016) at the end of the intervention. There has been no evidence of practice levels after 6 months in previous literature. According to our findings 4% of students, who reported their level of mindfulness practice, were practicing once a week or more at 26 weeks.

4 OBJECTIVES AND OUTCOMES OF PRESENT THESIS

The present thesis is a part of the Healthy Learning Mind (HLM) study (Volanen et al. 2016). HLM is, to our knowledge, the first RCT to evaluate the specific effects of a mindfulness-based program in school-setting with a comparison program of equal dose and comparable activity, with the follow-up period of 26 weeks. Four separate sub-studies (studies I-IV) are conducted. Their outcomes and potential moderators are presented in Table 1.

4.1 STUDY I OBJECTIVES

The study I reports the effects of mindfulness intervention on the primary outcomes of resilience, depressive symptoms, and socioemotional functioning. These outcome measures were chosen to build on previous research of mindfulness-based interventions among youth. The accumulating evidence for positive effects of mindfulness-based interventions is consistent for depressive symptoms (Dunning et al., 2019), preliminary for resilience (Kaplan et al., 2017; Sünbül & Güneri, 2019) and partly conflicting for socioemotional functioning (Franco, Amutio, López-González, Oriol, & Martínez-Taboada, 2016; Maynard et al., 2017).

4.2 STUDY II OBJECTIVES

In the study II, we investigate the impact mindfulness intervention on children's health-related quality of life (HRQoL), chosen to provide a well-rounded measure for everyday functioning. Among adults, MBSR has been found equally effective as other active interventions on quality of life (de Vibe, Solhaug, & Tyssen, 2015). Previous research has found consistent gender differences suggesting that adolescent girls have lower HRQoL compared to boys. There is also an established, cross-cultural effect of HRQoL decreasing with age (Michel et al., 2009; Ravens-Sieberer et al., 2007).

4.3 STUDY III OBJECTIVES

In study III we chose to measure executive functions (EFs) (i.e., working memory, response inhibition, cognitive processing, cognitive flexibility, and verbal fluency) as they are essential for students' learning and classroom functioning. A growing number of educational interventions also aim to help students improve their EFs, including

mindfulness training, (Burke, 2010; Felver, Celis-de Hoyos, Tezanos, & Singh, 2016; Flook et al., 2010; Tan, 2016) while there is still limited evidence of specific neurocognitive outcomes of mindfulness-based intervention compared with a similar control intervention (Quach, Jastrowski Mano, & Alexander, 2016). Based on recent meta-analyses (Cásedas & Pirruccio, 2020; Dunning et al., 2019), we hypothesize that mindfulness intervention would have a small effect on executive functioning, compared with the active control group, but the effect might vary by specific executive function.

4.4 STUDY IV OBJECTIVES

In study IV we wanted to address the potential of mindfulness intervention to alleviate stress, as chronic stress is particularly disruptive for adolescent development and may have persisting consequences in adulthood, increasing the likelihood of anxiety, depression (Eiland & Romeo, 2013; Kovalenko et al., 2014) and behavioral problems (Ortiz & Raine, 2004). Also, there is very little research done with objective, psychophysiological measures (Schonert-Reichl et al., 2015). Due to lack of research among children and adolescent our study is exploratory by nature. The effects of mindfulness intervention vs. relaxation-based active control on psychophysiological reactivity are examined with cardiovascular and electrodermal measures.

5 METHODS

In this chapter I will present the participants, intervention and active relaxation control programs, measures, procedures, and data-analysis for the studies I-IV.

5.1 PARTICIPANTS

5.1.1 STUDY I AND II PARTICIPANTS

In studies I and II the sample size was estimated to detect the mean difference of 0.2 standard deviation units (effect size = 0.2) on main outcomes between intervention and the control groups with 80 % power and the two-tailed 5 % level of significance. The clustering of outcomes within schools was taken into account, assuming an intra-cluster (intra-school) correlation coefficient of 0.03 and assumed that on average 60 children in each school will complete the study. The required sample size was estimated to be 1090 children per group, and allowing for about 10 % dropout rate, the study required 1200 children per group and total of 2400 children to be recruited. Using the same assumptions to detect the mean difference of 0.3 standard deviation units (effect size of 0.3) between intervention and inactive control group, the required sample size was estimated to be 486 children per group, and allowing for about 10 % drop-out rate, the study required 540 children in the inactive control group.

Individuals from from 247 schools in 14 cities/municipalities in Southern Finland were invited to participate. Among contacted schools 56 (24%) chose to participate. Participants were sixth, seventh, and eighth graders (age 12–15) in Finnish comprehensive school, 50% girls and 50% boys. In study I out of 3519 students participating in the study 2996 students provided at least one measurement of resilience, depressive symptoms or socioemotional functioning at baseline, at 9 weeks or at 26 weeks follow-ups, 1334 in intervention, 1291 in active control and 371 in inactive control group. In study II out of 3519 students participating in the study 2754 students provided at least one measurement of quality of life at baseline, at 9 weeks or at 26 weeks follow-ups, 1220 in intervention, 1181 in active control and 353 in inactive control group. Demographic characteristics (Table 2) show that the parental background in this sample was mostly employed and had achieved higher education. The majority was Finnish speaking, the second largest language group was Swedish speaking, 14-15% (more than in Finnish population in general, 6%). The percentage of other languages was high, as there were two English speaking schools among participants.

5.1.2 STUDY III AND IV PARTICIPANTS

Study participants were 6th graders (median age 12) and 8th graders (median age 15) from schools in two cities: Helsinki, in Southern Finland and Turku in Western Finland. In studies III and IV there were two comprehensive schools with 67 students on 8th grade from Helsinki and two comprehensive schools with 64 students on 6th grade from Turku, one intervention school and one control school from both cities. In study III there were in total 131 participants. In the intervention group were 62 participants, 56.5% were girls and 47.5% boys, in the control group were 69 participants, 44.9% were girls and 55.1% boys. In study IV there were in total 110 participants. In the intervention group were 53 participants, 54% were girls and 46% boys, in the control group were 57 participants, 42% were girls and 58% boys. Study design omitted inactive control group, due to challenges in recruiting for intensive testing procedure.

5.2 ”SKILLS FOR WELLBEING” -PROGRAM AND FACILITATORS

In the beginning of the study period, both intervention and active control group participants were given a letter that introduced them to the “Skills for wellbeing” -program, that would be running in their classroom for the following 9 weeks. The intervention and active control program were timed to cover beginning of the term (autumn/spring 2014-2015) and not to coincide with exam period at the end of the term. The participants were blinded as to whether they were selected to the intervention group or to the active control program. The intervention and the active relaxation control groups were each taught by different facilitator. Mindfulness invention facilitators were Stop & Breathe teacher (mindfulnessinschools.org) trained. Facilitators were not school staff, but they were classroom teachers by profession or otherwise experienced in working with groups of adolescents. Facilitators were given training and their teaching (delivery of manualized material) was assessed before the study started. Facilitators were given a random lesson to teach, teaching was recorded on video and evaluated by the team to satisfy the requirements of consistency.

Inactive control group received teaching as usual, but they were given the opportunity to receive the intervention program after the study had been concluded.

5.2.1 INTERVENTION

School-based mindfulness-program (Stop & Breathe) is designed to teens aged 11-18 years by experienced classroom teachers and mindfulness practitioners together with experienced researchers (Huppert & Johnson, 2010). The program itself is in based on adult MBSR/MBCT-programs and incorporates mindfulness practices with cognitive behavior therapy (CBT), essentially to increase psychological flexibility to

deal with stress and everyday hassles. The program is standardised, highly recognized, and the preliminary research is promising (Kuyken et al., 2013). The pilot intervention-control study in two schools in Espoo (N=46) was conducted in autumn 2012 by Maarit Lassander and Sari Markkanen, confirming the suitability of course material for Finnish educational system. A questionnaire package was used to measure the outcomes. A qualitative assessment and the preliminary quantitative calculations showed promising effects on students' self-reported executive functions and wellbeing (report unpublished).

Stop & Breathe-program was taught in this study in its original 9-week format, including introductory lesson about the definition and potential benefits of mindfulness, seven topic centered lessons and one lesson to summarise the learning. Each lesson has an experiential part of practice (3-15 minutes) and the psychoeducative part of introducing topic, integrating topic to everyday life, encouraging discussion and guidance for home practice (Huppert & Johnson, 2010). Home practices that were followed-up at 9 weeks and at 26 weeks are listed in Table 1. In the following paragraphs I will take a closer look to core mindfulness skills (mindful awareness, attention, and acceptance) and how they are enhanced by the intervention program.

Mindful awareness (lesson 4 and 5). Students are guided to savor experiences and to notice bodily ques of pleasant and unpleasant emotions. Together with mindful movement, this topic emphasizes the mind-body connections (Huppert & Johnson, 2010). There is very little research evidence of mindful movement and its benefits in the context of mindfulness interventions. There are many similarities with yoga practice, which according to research in adult populations leads to better regulation of the sympathetic nervous system and hypothalamic-pituitary-adrenal system, as well as a decrease in depressive and anxious symptoms (Pascoe, 2015).

Mindful attention (lesson 1 and 6). Students are guided to train their attention to be more aware of surroundings, rather than being caught up on thought processes of past (what *has* happened) or future (what *might* happen). Being attentive to thought processes enables students to notice, how they identify themselves with their thoughts. This topic is intended to encourage to break this identification, to step back and observe the thought and feelings that are present in mind connections (Huppert & Johnson, 2010).

Mindful acceptance and adaptive emotion regulation *(lesson 2,3 and 7).* Anchoring practices are aimed to provide tools for calm, that enable sitting down to observe the experience. Students are guided to recognize the universal, human tendency to worry and the escalation of worry into rumination. Students are also given psychoeducation on stress response and guided to deal with acute emotions (Huppert & Johnson, 2010). Dealing with worry and stress is also indicative for low depressive symptoms and better psychological functioning (Papageorgiou, 2001).

Graphic 1 Intensity of practice questionnaire items

Did you do any home exercises during the programme, and how often.
Tick the box that fits best (alternatives 'many times a day', 'daily or almost daily', 3-5 days a week', 'a few times during the whole program', 'not once').

Questions 1-11 are for the intervention group, questions 12-14 for the active control group.

1	Counting breaths in one minute
2	FOFBOC (seated body-scan)
3	Breathing 7-11
4	BEDITATION (body-scan)
5	Mindful breathing (paying attention to sensations of breath)
6	Mindful eating
7	.b (pausing and breathing)
8	Walking mindfully
9	Watching thoughts pass by as if they were traffic
10	Seeing thoughts as clouds passing through the mind
11	Feeling my feet on the floor (when I feel stressed or anxious)
12	Breathing relaxation (e.g., the Balloon -exercise)
13	Relaxation through imagery (e.g., the Beach -exercise)
14	Movement relaxation (e.g., the Move in the wind -exercise)

5.2.2 ACTIVE CONTROL PROGRAM

Active control program, "Relax" is aimed to offer a similar dose of training towards skills of wellbeing. Relax is based on Chilla, a relaxation program developed by Folkhälsan Förbundet that has been taught in primary schools and received positive feedback from teachers. To match the activities to intervention program, each lesson has an experiential part (3-15 minutes) of varied relaxation practices, including traditional muscle relaxation, movement relaxation and visualization. The psychoeducative part of each lesson includes introducing topic, integrating topic to everyday life, encouraging discussion and guidance for home practice. The topics are focused on student health: stress, nutrition, sleep, friends, relaxation, and mental health. These topics were introduced as a part of health education, focusing on basic level knowledge, behavior activation (useful tips, for example, how to sleep better, or how to reduce stress) and discussions to encourage peer support. Topics do not focus on the workings of the mind or any mind and body education. Thus, the content of these lessons is not essentially different from schoolwork as usual, apart from the relaxation practices with visual imagery (e.g., moving like a tree in the wind), also used

in many schools nowadays. However, they offer a pause in schoolwork, a quiet space and less demanding lesson structure. Participation was encouraged but not enforced.

5.3 MEASURES

5.3.1 QUESTIONNAIRES

Questionnaires and other tests were completed as a part of the RCT in 2014-15. Questionnaires were filled in at baseline, 9 weeks and 26 weeks during the normal school hours (Volanen et al., 2016). Questionnaires included baseline demographic data: grade, gender and experienced socioeconomic status (SES). Students' experienced SES was considered in the main analyses as a potential confounder. The association between SES and psychological wellbeing childhood is well-known (Hackman, Farah, & Meaney, 2010; Sarsour, Sheridan, Jutte, & Nuru-Jeter, 2011) but confounded by many factors (Cooper, 2013). In this study, SES was measured as own experience of family financial wellbeing, which is known to have a considerable impact on wellbeing in general (Bruggen, Hogreve, Holmlund, & Kabadayi, 2017). Research also indicates that 11-15 old children and adolescents are able to report material conditions in their family (Currie, Elton, & Todd, 1997).

Question "what do you think about the financial situation in your family" was measured by 4 response categories: 46.6% were in the income group 1 (does very well financially), 35.9% in group 2 (does moderately well), 14.6% in the group 3 (does not very well) and 2.9% in group 4 (does not at all well financially). There were no significant differences at baseline between the intervention and active control group on experienced SES. On school district level the schools were matched for equal socio-economic catchment areas as a part of the randomization protocol.

The amount of intervention specific independent practice was self-reported at follow-up questionnaires. The respondents were divided into four groups: high frequency practice (nearly every day, n=46), moderate frequency practice (once a week, n=55), low frequency practice (once or twice a month n=104) and infrequent practice (only few times, n=733).

5.3.2 STUDY I MEASURES

The Resilience scale (RS14) was employed to measure resilience (Wagnild & Young, 1993). RS14 consists of 14 self-report-items. A higher score for RS14 indicates more resilience. Baseline Cronbach's alpha coefficient of RS14 was 0.87. Resilience has been defined as a protective personality factor associated with stress resistance and adaptation in adverse situations (Rutten et al., 2013). Resilience Scale is a widely used resilience research instrument due to its good psychometric properties (Wagnild, G. & Collins, 2009), also as translated in Finnish (CA 0.90-.87) (Losoi et al., 2013). The Resilience Core characteristics, meaning, perseverance, equanimity, self-reliance, and

existential aloneness are represented in the RS14. Resilience Scale is recommended to use with adolescent population (Ahern, Kiehl, Lou Sole, & Byers, 2006) and it has been applied beginning from 6th grade level (12-13 years) and demonstrating good reliability (CA 0.91) for racial/ethnic, age, geographic, and gender groupings in adolescence (Pritzker & Minter, 2014). Scoring high in RS14 indicates high resilience, but normative data for adolescent population are not available. Maximum score in the test is 98 and the total resilience score is reported.

The Revised Beck Depression Inventory (RBDI) (Beck, 1961; Raitasalo, 2007) was used to measure level of depressive symptoms. Raitasalo's modification of the short form of the Beck Depression Inventory is well established in screening adolescent samples in Finland (Kaltiala-Heino, Rimpelä, & Rantanen, 1999). The scoring is not to be used as diagnostic but it can reveal symptoms of depression and the need for consultation and care. RBDI consists of statements in 12 question categories, (excluding suicidal ideation), with 4 response options. Lower score for RBDI indicates less depression symptoms. RBDI has demonstrated adequate psychometric properties among youth (CA 0.83, 0.87) (Raitasalo, 2007). Baseline Cronbach's alpha coefficient of RBDI was 0.86. Total score of RBDI is reported.

The Strengths and difficulties questionnaire (SDQ) (Goodman, Ford, Simmons, & Gatward, 2000) was used to measure socioemotional functioning. SDQ includes 25 items forming five subscales: emotional problems, conduct problems, hyperactivity, peer problems and prosocial behaviour. Lower score for SDQ indicates better socioemotional functioning (Goodman et al., 2000). SDQ has been recommended as a broad measure for mental health and wellbeing outcomes among children and adolescents, capable of detecting change over time (Deighton et al., 2014). We report the total difficulties score of the test that excludes the prosocial dimension. The score range in the test is 0 - 40, classified as 0 - 15 normal, 16 - 19 borderline, and 20 - 40 abnormal. Scores exceeding 90th percentile (18 points or under in our data) of the SDQ total have been strongly associated with help-seeking variables and problematic behavior according to parents (Koskelainen, Sourander, & Kaljonen, 2000). Baseline Cronbach's alpha coefficient of SDQ was 0.79.

5.3.3 STUDY II MEASURES

To measure Health Related Quality of Life we chose KINDL-R, a generic instrument for assessing HRQoL in children and adolescents aged 3 to 17 (Ravens-Sieberer & Bullinger, 1998). The questionnaire has been developed based on interviews with children and adolescents to reflect their own priorities. KINDL-R consists of 5 domains (physical and psychological well-being, self-esteem, family, friends, and school), each indicated with 5 self-report-items assessed on a 5-point likert scale from 1 (strongly disagree) to 5 (strongly agree; transformed score range 0–100) and giving the time frame of past week. Higher scores indicate better HRQoL. Higher scores indicate better HRQoL. In the current study baseline Cronbach's alpha coefficient of KINDL-R was 0.89.

5.3.4 STUDY III MEASURES

Working memory capacity, ability to hold and manipulate new information in the short-term memory, was assessed by Working Memory Index (WMI) backward digit span subtest from the WISC-IV Wechsler Intelligence Scale for Children (Wechsler, 1991). The test also included a rote memory measurement, forward digit span subtest. Higher score reflects better performance in given time.

Response inhibition, ability to inhibit and switch response types, was measured with a test from the NEPSY-II (Developmental Neuropsychological Assessment). NEPSY-II is a series of standardized neuropsychological tests, used to assess neuropsychological development in children (Korkmann, Kirk, & Kemp, 2007). As this is a timed task, lower score reflects better performance.

Cognitive flexibility and processing were assessed with Trail Making test from D-KEFS (Delis-Kaplan Executive Function System), a set of neuropsychological tests used to measure a variety of verbal and non-verbal EFs (Delis, Kaplan, & Kramer, 2001). The Trail Making test is a visual-motor sequencing task and consists of five conditions. As these are timed tasks, lower score reflects better performance.

Verbal fluency, meaning letter, category and category switching fluency was also tested with a D-KEFS subtest (Delis et al., 2001). Higher score reflects better performance in given time.

5.3.5 STUDY IV MEASURES

The effects of mindfulness intervention vs. relaxation-based active control on psychophysiological reactivity measured by heart rate (HR), high-frequency heart rate variability (HF-HRV), skin conductance level (SCL) and number of skin conductance responses (SCR) in adolescents. Both HR and HF-HRV were measured by electrocardiography. The electrocardiograms were conducted with three mobile devices (two NeXus-10 MKI and one NeXus-10 MKII, Mind Media, The Netherlands) and with BioTrace+ software. Electrodermal activity was measured by the electrical conductance of the skin, which varies due to the moisture level of the skin (Stern, Stern, Ray, & Quigley, 2001) . Electrocardiography (ECG) was recorded with pre-gelled bipolar electrodes (Ambu BlueSensor M) at right and left side of the chest, while using a separate ground electrode beneath the left rib cage.

5.4 PROCEDURES

The ethical review board of the University of Helsinki (approval 1/2014) reviewed the study plan. A consent to participate was requested from all headteachers for randomization, intervention, and data collection. A written informed consent was requested from all students and their parents for data collections and the study was conducted according to the Helsinki Declaration. Participants could withdraw their participation at any point without giving any reason. Data handling and analyses were

performed according to the EU General Data Protection Regulation, and personal identification of the participants was removed from all data (Volanen et al., 2016).

5.4.1 STUDY I AND II PROCEDURE

The participating schools were first recruited among all elementary schools in 14 cities/municipalities in the Metropolitan area and in South-Western Finland (247 schools contacted, 56 schools agreed to participate) and then randomized before the baseline data collection. The schools were randomly assigned to intervention schools (N = 25 schools with 94 classes), active control schools (N = 24 schools with 85 classes), and inactive control schools (N = 7 schools with 31 classes). Inactive control group was included in study design to ensure comparability with other mindfulness intervention studies, which usually only include an inactive control group. The main comparison was done with the active control group, ensuring that we can measure non-specific changes due to being part of an intervention. The whole class participated in the designated intervention/control.

5.4.2 STUDY III AND IV PROCEDURE

The schools were randomly assigned to mindfulness intervention schools and active control schools from the pool of all participating schools (56). First, the schools were matched into three groups based on school location and the average apartment price per square meter, to account for socioeconomic differences, then the random allocation sequence was implemented (Volanen et al., 2016). All students from the selected grades were asked to participate, both the student and their parent received a letter explaining the study, its procedure and aim. All students who returned the consent form signed by student and parent, were able to participate in the intensive research protocol of neuropsychological and psychophysiological testing. Of the 194 invited students, an informed consent form was obtained from 131 (68%) students and their parents. A few students were not able to participate (n= 13) or changed their minds (n= 8) regarding the psychophysiological tests when the research period started. Finally, 131 students (from 6th and 8th grades) were able to participate in the intervention/active relaxation control sessions and neuropsychological testing and a majority of them (n=110) also participated in psychophysiological testing. Tests were conducted by trained psychology students.

The study III began with baseline measurements, participants were individually tested with selected neurocognitive measures (working memory, response inhibition, cognitive processing, cognitive flexibility, and verbal fluency), which took 1 - 1.5 hours in total. These measures were repeated at 9 weeks and 26 weeks. Three students were tested at the same time, in the same space but on separate working stations, they were able to hear murmur but not to discern words from other working stations.

The study IV was initiated with a baseline phase when participants were tested using psychophysiological measures (HR, HF-HRV, SCL and SCR). In the follow-up

phase at 9 weeks and at 6 months, participants were again tested using psychophysiological measures.

In the baseline phase and follow-up phases (9 weeks, 26 weeks), test session in the school premises lasted about 30 minutes and consisted of three different tasks 1) cognitive stress inducing task; 2) minimal stress inducing task and 3) social stress inducing task, intermediated with relaxation phases. Each individual session began with a different task, sequence of tasks running in the same order.

5.5 DATA-ANALYSIS

In Table 2 are presented the study I-IV variables and the main statistical methods we have utilised to analyse the data.

Table 2. Research design study variables and main statistical methods used in studies I-IV

	Independent variables	**Dependent variables**	**Moderating variables**	**Control variables**	**Main statistical methods**
Study I	Treatment (3 manipulations)	Resilience	age	SES	multilevel models for intra-class correlation
	mindfulness intervention	Depressive symptoms	gender		multilevel linear models
	active control program	Socioemotional functioning	independent practice		analysis for effect sizes*
	inactive control				
Study II	Treatment (3 manipulations)	Health-related quality of life	age	SES	multilevel models for intra-class correlation
	mindfulness intervention		gender		multilevel linear models
	active control program		independent practice		analysis for effect sizes*
	inactive control				
Study III	Treatment (2 manipulations)	Rote memory	motivation	SES	t-test (baseline differences)

	mindfulness intervention	Working memory	independent practice		repeated measures analysis of variance
	active control program	Response inhibition			Pearson correlation coefficients
		Cognitive Processing			
		Cognitive Flexibiility			
		Verbal Fluency			
Study IV	Treatment (2 manipulations)	Heart rate		SES	t-test (baseline differences)
	mindfulness intervention	Heart rate variability			repeated measures analysis of variance
					analysis for effect sizes*
	active control program	Skin conductance level			
		Skin conductance responses			

*Effect sizes were calculated for the difference in 9 weeks and 26 weeks changes between intervention and control groups.

5.5.1 STUDY I AND II DATA-ANALYSIS

In study I and II the effect of intervention on main outcomes was analysed with multilevel models to account for the clustered nature of the data. Four-level models with time at level 1, student at level 2, students in a particular classroom at level 3, and school at level 4 were fitted. Intra-class correlation (ICC), which is the proportion of the total variance explained by each level, were calculated for student (ICC=0.634), classroom (ICC=0.030) and school level (ICC=0.008). Thus, school-level variance was excluded from the final multilevel models and a three-level model with time at level 1, student at level 2, and classroom at level 3 were used. Maximum likelihood estimation was used to obtain unbiased and efficient parameter estimates for data with missing values in the follow-up measurements. Multilevel linear models included the main effects of group, time, gender, and grade (=age).

To analyse the modifying effect of gender and grade, i.e., whether the intervention effect (intervention vs. active control and intervention vs. inactive control) was different depending on gender or grade, the second-order interaction term group × grade × time or group × gender × time was entered to the model. To examine the effect of continuing independent practice intensity after the intervention compared to the active control and inactive control groups on health-related quality of

life the interaction term practice intensity group × time was entered to the model. Analyses were performed for all students and separately for boys and girls. Multilevel linear modelling was done with MLwiN Version 2.35 (Centre for multilevel modelling, University of Bristol) and other analysis with the SAS System for Windows 9.4 (SAS Institute Inc., Cary, NC). Two-sided statistical tests with a 5% significance level were used, and no adjustments were made for multiplicity.

5.5.2 STUDY III AND IV DATA-ANALYSIS

In study III two-sample t-test was used to test the baseline differences in EFs between intervention and active control groups. Raw scores were used for all test measures to be able to accurately measure change and as we did not compare to standardized population norms. The intervention effects on the working memory, response inhibition cognitive processing and flexibility and verbal fluency were analyzed with repeated measures analysis of variance. The unstructured covariance structure was used to account for the correlation between repeated measurements. The repeated measures model included the main effects of group (intervention vs. control), gender (girls vs. boys), grade (grade 6 vs. 8) and time (9 weeks vs. baseline, 26 weeks vs. baseline) and the interaction effect between group and time (group × time effect). The follow-up measurements were compared to the baseline with Dunnett's adjustment in pairwise comparisons. To examine the modifying effect of gender and grade on the intervention effectiveness, the intervention effect gender/grade × group × time was included in the model. The level of practice and the difference in the change in EFs by level of practice was analyzed with two-way analysis of variance. Correlations between EFs were calculated using Pearson correlation coefficients.

In study IV a two-sample t-test was used to test the baseline differences in psychophysiological measurements between intervention and the active relaxation control groups. All data recorded for each test session was analyzed for HR, HF-HRV (0.15 – 0.4 Hz), SCL and SCR. These variables were subsequently divided by the individual baseline measurement, i.e., first relaxation phase of each test session to calculate the task-related reactivity. The intervention effects were analyzed with repeated measures analysis of variance. Restricted maximum likelihood estimation method was used to obtain unbiased estimates for longitudinal data with missing values. The unstructured covariance structure was used to account for the correlation between repeated measurements. The repeated measures model included the main effects of group (intervention vs. control), gender (girls vs. boys), grade (grade 6 vs. 8) and time (9 weeks vs. baseline, 26 weeks vs. baseline) and the interaction effect between group and time (group × time effect). HF-HRV, SCL and SCR variables were log-transformed for statistical analyses due to positively skewed distributions. The follow-up measurements were compared to the baseline with Dunnett's adjustment in pairwise comparisons. In both studies statistical analysis was performed with SAS for Windows (version 9.4, SAS Institute Inc., Cary, NC). Two-sided statistical tests with 0.05 level of significance were used.

6 RESULTS

The comprehensive aim of the studies I-IV was to find out the potential of mindfulness-based intervention to enhance psychological wellbeing compared to active relaxation control program and inactive control. In the Healthy Learning Mind-study there were 3519 participants in total, 1646 students in the intervention group, 1488 students in the active relaxation control group and 385 students in the inactive control group. In Table 3 are presented the demographic characteristics of these groups.

Table 3. Demographic characteristics by treatment groups at baseline in studies I-II

Demographic characteristics	**Intervention**	**Control**	**Inactive control**	**Total**
	n (%)	*n* (%)	*n* (%)	*N*
N	1646 (46.8)	1488 (42.3)	385 (10.9)	3519
Gender				
Boys	835 (51.0)	727 (49.1)	190 (49.7)	1752
Girls	804 (49.0)	754 (50.9)	192 (50.3)	1750
No information	7	7	3	17
School grade				
6th grade	620 (37.7)	546 (36.7)	116 (30.1)	1282
7th grade	294 (17.9)	230 (15.4)	163 (42.3)	687
8th grade	732 (44.4)	712 (47.9)	106 (27.6)	1550
Mother tongue				
Finnish	966 (78.7)	938 (78.6)	329 (92.9)	2233
Swedish	160 (13.1)	119 (10.0)	1 (0.3)	280
Other	101 (8.2)	136 (11.4)	24 (6.8)	261
No information	419	295	31	745
Child living with [a]				
Both parents	662 (69.2)	560 (70.2)	205 (70.5)	1427
Other [b]	295 (30.8)	238 (29.8)	86 (29.5)	619
No information	689	690	94	1473
Highest education of the parents[a]				
Basic education	15 (1.5)	15 (1.8)	5 (1.7)	35
Secondary education	297 (30.2)	238 (28.9)	93 (31.4)	628
Higher education	660 (67.0)	561 (68.1)	194 (65.5)	1415
Other	13 (1.3)	10 (1.2)	4 (1.4)	27
No information	661	664	89	1414
Work situation of the parents[a]				
Employed [c]	945 (95.6)	775 (94.2)	281 (94.6)	2001
Unemployed [d]	9 (0.9)	9 (1.1)	5 (1.7)	23
Other [e]	35 (3.5)	39 (4.7)	11 (3.7)	85
No information	657	665	88	1410

[a]) reported by the parent

[b]) child living with: the mother, the father, the mother and her new spouse, the father and his new spouse or another adult

[c]) at least the other parent working

[d]) both parents unemployed or other parent unemployed and data missing from the other

[e]) studying, at home with a child, job alternation leave/vacation or something else

In studies I-IV multiple outcomes were studied. In study I three primary outcomes of the HLM-study were analysed, resilience, depressive symptoms, and socioemotional functioning. In study II the focus was on health-related quality of life. In study III the core executive functions were rote memory, working memory, response inhibition, cognitive processing, cognitive flexibility, and verbal fluency. In study IV heart rate, heart rate variability, skin conductance level and skin conductance responses were explored. In Table 4 we have reported the means and standard deviations for these variables. In the following subchapters results of the studies I-IV outcomes are reported.

Table 4. Descriptive statistics for all study variables and all students in studies I-IV

		Intervention group		**Relaxation control group**		**Inactive control group**
Baseline	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
RS14 (resilience scale)	1228	77.093 (11.347)	1196	76.992 (11.153)	356	76.814 (10.825)
RBDI (depressive symptoms)	1162	2.174 (4.024)	1141	2.097 (3.747)	339	2.174 (4.138)
SDQ (socioemotional functioning)	1219	10.403 (5.442)	1168	10.199 (5.446)	350	10.323 (5.536)
HRQoL: Physical wellbeing	1203	69.56 (21.95)	1170	70.41 (21.53)	N	Mean (SD)
HRQoL: Emotional wellbeing	1220	75.85 (15.74)	1181	76.42 (15.31)	353	60.93 (22.39)
HRQoL: Self-esteem	1216	62.84 (20.04)	1179	62.14 (19.92)	352	75.37 (15.62)
HRQoL: Family	1216	78.60 (16.46)	1177	79.30 (16.35)	353	63.17 (20.35)
HRQoL: Friends	1210	70.60 (15.90)	1168	71.10 (16.24)	351	81.02 (14.79)
HRQoL: School	1209	64.11 (18.08)	1169	63.96 (18.43)	348	70.04 (16.54
Rote memory	62	7.79 (1.85)	68	7.59 (1.58)	349	64.76 (15.98)
Working memory	62	6.68 (1.70)	68	6.93 (1.65)		
Response inhibition	58	80.78 (20.86)	66	79.12 (18.64)		
Cognitive Processing	62	77.79 (31.62)	68	71.85 (23.81)		
Cognitive Flexibiility	61	94.00 (36.84)	69	88.30 (30.48)		
Verbal Fluency	61	65.72 (18.85)	69	68.22 (15.23)		
Heart rate*	47	83.90 (10.14)	48	88.90 (11.50)		
Heart rate variability*	50	955.59 (518.98)	50	839.04 (476.20)		
Skin conductance level*	47	5.57 (2.86)	48	6.27 (3.13)		
Skin conductance responses*	48	20.95 (17.55)	44	24.16 (18.29)		
9 weeks	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
RS14 (resilience scale)	1175	76.864 (12.150)	1114	75.512 (12.624)	323	77.349 (13.094)

RBDI (depressive symptoms)	1120	1.934 (3.910)	1054	1.971 (3.597)	318	1.944 (4.110)
SDQ (socioemotional functioning)	1157	10.099 (5.850)	1101	10.398 (6.078)	318	10.035 (5.963)
HRQoL: Physical wellbeing	1156	70.91 (20.86)	1095	70.53 (20.37)	319	73.01 (20.10)
HRQoL: Emotional wellbeing	1152	75.88 (15.66)	1104	74.20 (16.29)	320	76.11 (16.41)
HRQoL: Self-esteem	1155	65.03 (20.16)	1102	63.84 (19.97)	320	64.84 (20.28)
HRQoL: Family	1150	79.28 (16.90)	1101	77.51 (17.65)	321	80.98 (16.13)
HRQoL: Friends	1156	70.95 (16.66)	1088	70.12 (16.40)	319	71.10 (16.22)
HRQoL: School	1158	63.11 (17.87)	1100	60.43 (18.01)	320	65.10 (17.51)
Working memory	58	7.02 (1.50)	59	6.83 (1.66)		
Response inhibition	54	74.46 (20.26)	59	67.83 (12.92)		
Cognitive Processing	55	66.64 (22.15)	58	59.55 (15.45)		
Cognitive Flexibiility	55	75.29 (33.57)	59	69.97 (19.89)		
Verbal Fluency	58	69.78 (19.31)	55	71.98 (16.01)		
Heart rate*	28	83.97 (7.62)	35	85.27 (10.85)		
Heart rate variability*	29	887.68 (558.86)	34	937..09 (500.17)		
Skin conductance level*	19	6.04 (3.25)	24	5.14 (2.64)		
Skin conductance responses*	20	27.35 (15.78)	21	21.52 (16.15)		

26 weeks	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
RS14 (resilience scale)	966	77.218 (13.168)	1030	76.913 (13.597)	307	76.907 (11.832)
RBDI (depressive symptoms)	934	1.805 (3.651)	966	1.966 (4.232)	304	2.007 (4.232)
SDQ (socioemotional functioning)	947	9.812 (5.867)	1014	9.743 (6.112)	302	9.752 (5.916)
HRQoL: Physical wellbeing	949	71.88 (20.26)	994	71.88 (20.91)	305	71.83 (20.75)
HRQoL: Emotional wellbeing	957	75.95 (15.85)	1012	75.53 (16.54)	306	75.63 (15.60)
HRQoL: Self-esteem	953	65.57 (19.31)	1012	64.81 (20.65)	305	65.53 (20.66)
HRQoL: Family	951	78.81 (18.85)	1008	79.27 (16.70)	306	80.57 (16.69)
HRQoL: Friends	948	71.62 (17.04)	1010	71.76 (17.63)	304	72.13 (16.57)
HRQoL: School	955	63.08 (18.55)	1010	62.03 (18.98)	304	63.29 (17.55)
Working memory	59	6.95 (1.50)	56	7.21 (1.91)		
Response inhibition	58	72.29 (18.54)	56	64.09 (16.48)		
Cognitive Processing	58	58.60 (18.04)	56	55.91 (18.80)		
Cognitive Flexibiility	58	71.76 (27.29)	56	68.07 (21.01)		
Verbal Fluency	52	70.29 (16.52)	54	74.46 (14.80)		
Heart rate*	30	83.45 (10.03)	42	85.91 (9.41)		
Heart rate variability*	32	958.38 (575.32)	42	1047.51 (528.50)		
Skin conductance level*	30	4.78 (2.97)	40	3.59 (1.89)		
Skin conductance responses*	29	11.78 (13.75)	34	14.33 (13.31)		

* descriptives for general task

6.1 STUDY I AND II: INTERVENTION OUTCOMES

In studies I and II, our aim was to investigate does mindfulness intervention promote mental health, and wellbeing at school and in general in 12 to 15-year-old adolescents – and further, is the effect universal or moderated by gender or age.

6.1.1 BASELINE DIFFERENCES IN OUTCOMES

Tables 5 and 6 below demonstrate the baseline, pre-intervention differences by gender and grade in studies I-II outcomes (Lassander, Saarinen, Simonsen, Suominen, & Volanen, 2021). There is a significant difference by gender for depressive symptoms and health related quality of life, girls have more depressive symptoms and lower health-related quality of life. There is also a significant difference by grade for socioemotional functioning, depressive symptoms and health-related quality of life, for all these outcomes older students have lower wellbeing or more behavioral problems.

Table 5. Baseline descriptive statistics by gender in studies I-II

Variable	*n*	Mean (SD)		
	Female / Male	**Female**	**Male**	***p***
Socioemotional functioning (SDQ)	1398 / 1339	10.39 (5.3)	10.21 (5.61)	0.387
Depressive symptoms (RBDI)	1383 / 1259	2.67 (4.33)	1.56 (3.32)	<0.001
Resilience (RS14)	1415 / 1365	76.9 (11.43)	77.13 (10.95)	0.580
Health-related quality of life (KINDL-R)	1411 / 1336	69.39 (13.03)	71.57 (12.53)	<0.001

Table 6. Baseline descriptive statistics, grades 6th to 8th in studies I-II

Variable	*n*	Mean (SD)			
	6th / 7th / 8th	**6th**	**7th**	**8th**	***p***
Socioemotional functioning (SDQ)	1009 / 500 / 1228	9.75 (5.3)	10.17 (5.53)	10.82 (5.5)	<0.001
Depressive symptoms (RBDI)	969 / 475 / 1198	1.80 (3.82)	2.08 (3.87)	2.44 (4)	<0.001
Resilience (RS14)	1036 / 502 / 1242	77.32 (10.47)	77.18 (12.15)	76.69 (11.37)	0.373
Health-related quality of life (KINDL-R)	1018 / 496 / 1233	72.54 (12.70)	70.57 (12.93)	68.68 (12.65)	<0.001

Significant pairwise differences between grades, the number of symbols refer to level of significance (*p<0.05, **p<0.01 and ***p<0.001): for SDQ 6 vs. 8***; for RBDI 6 vs. 8***; for KINDL-R 6 vs. 7*, 6 vs. 8***, 7 vs. 8*

6.1.2 MINDFULNESS-INTERVENTION EFFECTS ON RESILIENCE, DEPRESSION, AND SOCIOEMOTIONAL FUNCTIONING

In study I, the mindfulness intervention did not show more beneficial effects on the primary outcomes compared to both control groups, except for resilience, for which a positive intervention effect was found at 9 weeks in whole intervention group (group x 9 weeks, $\beta = 1.183$, $p = 0.038$) as compared to the relaxation control group (Table 6). In addition, in gender and grade related analyses, mindfulness-based intervention increased resilience (group x 9 weeks, $\beta = 1.30$, $p = 0.03$) at 9 weeks and the effect was significantly different comparing girls and boys at both follow-ups (at 9 weeks $\beta = 2.92$, $p = 0.03$, at 26 weeks $\beta = -0.30$, $p = 0.03$), indicating that girls benefited more from the intervention. Intervention also lowered depressive symptoms in girls at 26 weeks (group x 26 weeks, $\beta = -0.49$, SE = 0.21, $p = 0.02$). Intervention improved socio-emotional functioning at 9 weeks ($\beta = -1.37$, SE = 0.69, $p = 0.049$) and at 26 weeks ($\beta = -1.71$, SE = 0.73, $p = 0.02$) among 7th graders as compared to active relaxation control group. Intervention effect was marginally different between 6th and 7th graders (socioemotional functioning and resilience), indicating more benefits for 7th graders, and significantly different between 6th and 8th graders (socioemotional functioning), indicating more benefits for 8th graders. Effect sizes were under 0.20 (Cohen's d) except for small effect on socioemotional functioning among 7th graders, comparing intervention with the active control group (at 9 weeks and 26 weeks) and inactive control group at 26 weeks (d = 0.22-0.31).

Table 7. Results of multilevel models: Intervention effects on resilience (RS14), depression (RBDI) and socioemotional functioning (SDQ) in study I

	RS14 Model 1 β (*SE*)	**RBDI** Model 1 β (*SE*)	**SDQ** Model 1 β (*SE*)
Baseline			
Intercept	**77.407 (0.566)**	**2.395 (0.170)**	**9.752 (0.276)**
Grade 7 vs. 6	0.478 (0.721)	0.189 (0.218)	0.136 (0.374)
Grade 8 vs. 6	-0.936 (0.551)	**0.525 (0.166)**	**1.134 (0.287)**
Boys vs. girls	0.034 (0.381)	**-1.019 (0.129)**	0.258 (0.187)
Group (Int vs. 0)	0.624 (0.898)	0.011 (0.268)	-0.107 (0.425)
Group (Int vs. Cont)	0.267 (0.602)	0.078 (0.178)	0.064 (0.282)
Change by 9 weeks			
T9	-0.415 (0.399)	**-0.217 (0.094)**	-0.117 (0.161)
Group (Int vs. 0) × T9	-1.135 (0.837)	-0.006 (0.198)	0.066 (0.341)
Group (Int vs. Cont) × T9	**1.183 (0.570)**	-0.140 (0.135)	-0.419 (0.231)
Change by 26 weeks			
T26	-0.190 (0.398)	**-0.286 (0.137)**	-0.341 (0.197)
Group (Int vs. 0) × T26	-0.441 (0.813)	-0.231 (0.274)	0.181 (0.395)
Group (Int vs. Cont) × T26	0.132 (0.558)	-0.286 (0.193)	-0.178 (0.276)
Variance components			
Student level			
Intercept	**80.211 (2.851)**	**9.625 (0.324)**	**20.579 (0.679)**
T9	**18.076 (3.636)**	0.000* (0.000*)	**2.556 (0.703)**
T26	**42.229 (4.161)**	**2.580 (0.344)**	**4.714 (0.746)**
Classroom level			
Intercept	**6.117 (1.516)**	**0.294 (0.114)**	**1.243 (0.334)**

		0.000*	**0.595**
T9	**4.854 (1.347)**	(0.000*)	**(0.220)**
			1.050
T26	1.936 (1.249)	**0.393 (0.128)**	**(0.303)**

Note. Statistically significant (p<0.05) estimates from Wald tests are bolded.

Note. Estimates (β) are standardised.

*Due to convergence problems, the variance was fixed to zero.

Int = Intervention group (n=1334)

Cont = Active relaxation control group (n=1291)

0 = Inactive control group (n=371)

6.1.3 MINDFULNESS-INTERVENTION EFFECTS ON HEALTH-RELATED QUALITY OF LIFE

In study II we investigated the impact of mindfulness intervention on children's self-reported Health Related Quality of Life (HRQoL). Results show a positive intervention effect between mindfulness intervention and the active relaxation control group at 9 weeks (group x 9 weeks, $\beta = 1.587$, $p < 0.001$) due to slight increase in HRQoL scores in the intervention group and decrease in the active relaxation control group (Table 8a and 8b). A positive intervention effect between the intervention and the active relaxation control group was also found at 26 weeks (group x 26 weeks, $\beta = 0.987$, $p = 0.038$) due to increased HRQoL scores in the intervention group. Moderating effects were found for both gender and grade. Girls, 7th and 8th grade students and students with regular independent mindfulness practice benefited most from the intervention compared to the active control group. Effect sizes were under 0.20 (Cohen's d) except for small effect on socioemotional functioning among 7th graders, comparing intervention with the active control group at 9 weeks and 26 weeks (d = 0.20-0.28).

Table 8a. Results of Multilevel models: Intervention effect of KINDL-R total (all and by gender) in study I

	All			**Boys**		**Girls**	
	β	95% CI	*p*	β	95% CI	β	95% CI
Change 9 weeks							
Group (Int vs. 0) × T9	-0.958	(-2.303; 0.387)	0.163	-0.597	(-2.708; 1.514)	-1.348	(-3.008; 0.312)
Group (Int vs. Cont) × T9	**1.587**	**(0.672; 2.502)**	**<0.001**	**2.156****	**(0.719; 3.593)**	**1.159***	**(0.032; 2.286)**
Change 26 weeks							
Group (Int vs. 0) × T26	-0.159	(-1.841; 1.523)	0.853	-0.982	(-3.604; 1.640)	0.52	(-1.434; 2.474)

Group (Int vs. Cont) × T26	0.953	(-0.221; 2.127)	0.112	-0.143	(-1.987; 1.701)	**2.028****	**(0.685; 3.371)**

Note. Statistically significant (p<0.05) estimates from Wald tests are bolded. Statistical significance of estimates: *p < 0.05; **p < 0.01; ***p < 0.001.

Note. Estimates (β) are standardised.

CI = confidence interval

Int = Intervention group

Cont = Active relaxation control group

0 = Inactive control group

Table 8b. Results of Multilevel models: Intervention effect of KINDL-R total (by grade) in study II

	Grade 6		**Grade 7**		**Grade 8**	
	β	95% CI	β	95% CI	β	95% CI
Change by 9 weeks						
Group (Int vs. 0) × T9	-1.561	(-3.962; 0.841)	0.332	(-1.990; 2.945)	0.128	(-2.185; 2.552)
Group (Int vs. Cont) × T9	0.4	(-0.875; 2.026)	**3.589****	**(1.187; 5.991)**	**1.902****	**(0.637; 3.168)**
Change by 26 weeks						
Group (Int vs. 0) × T26	0.41	(-1.042; 4.123)	0.597	(-1.878; 3.595)	0.439	(-1.712; 2.975)
Group (Int vs. Cont) × T26	-0.233	(-1.767; 1.300)	0.453	(-0.096; 5.162)	**1.780****	**(0.466; 3.093)**

Note. Statistically significant (p<0.05) estimates from Wald tests are bolded. Statistical significance of estimates: *p < 0.05; **p < 0.01; ***p < 0.001.

Note. Estimates (β) are standardised.

CI = confidence interval

Int = Intervention group

Cont = Active relaxation control group

0 = Inactive control group

6.2 STUDIES III AND IV OUTCOMES

In study III and IV, our aim was to detect any changes in executive functioning or on psychophysiological stress response due to mindfulness intervention.

6.2.1 MINDFULNESS-INTERVENTION EFFECTS ON EXECUTIVE FUNCTIONING

A total of 131 students completed a cognitive test-package. There was no significant difference between the mindfulness intervention group and the active control program in executive functions. The analyses indicated a similar significant improvement in response inhibition, cognitive processing, cognitive flexibility and verbal fluency in both intervention and active control groups at 9 weeks and at 6 months compared to baseline (p-values < .002 for all associations) (Table 9). The corresponding changes in rote memory (p = .913) and working memory (p = .302) were not observed. Gender or grade did not modify the effects of the intervention on EFs, i.e., no significant gender/grade × group × time interactions were detected. There was a significant effect of group for response inhibition (p = 0.043) and of grade for verbal fluency (p < .0001). The results were compared with the standardized age-appropriate norms and mean changes in participant scores were above the expected compared to the age norms.

Table 9. Results of repeated measures ANOVA: Intervention effects on Executive functions in study III

Executive functions		β	*SE*	*p*
Rote memory	Group, Intervention vs. active relaxation	.364	.243	.137
	Gender, girls vs. boys	-.334	.242	.170
	Grade, 6 vs. 8	-.427	.240	.078
	Time			.913
	9 weeks vs. baseline	-.058	.149	.892
	26 weeks vs. baseline	-.011	.155	.997
	Time x Group			.595
	9 weeks vs. baseline	.296	.298	.323
	26 weeks vs. baseline	.103	.311	.740
Working memory	Intervention vs. active relaxation	-.133	.248	.594
	Gender, girls vs. boys	.151	.247	.542
	Grade, 6 vs. 8	-.149	.246	.546
	Time			.302
	9 weeks vs. baseline	.112	.137	.627
	26 weeks vs. baseline	.238	.153	.212
	Time x Intervention			.393
	9 weeks vs. baseline	.351	.274	.204
	26 weeks vs. baseline	.065	.306	.831

Response inhibition	Intervention vs. active relaxation	5,395	2.637	.043
	Gender, girls vs. boys	-2.811	2.611	.284
	Grade, 6 vs. 8	.778	2.595	.764
	Time			<.0001
	9 weeks vs. baseline	-8.395	1,719	<.0001
	26 weeks vs. baseline	-11.649	1,777	<.0001
	Time x Intervention			.254
	9 weeks vs. baseline	4.469	3,439	.196
	26 weeks vs. baseline	5.599	3,555	.118
Cognitive processing	Intervention vs. active relaxation	5.501	3.391	.107
	Gender, girls vs. boys	-2.425	3.038	.426
	Grade, 6 vs. 8	2.185	3.022	.471
	Time			<.0001
	9 weeks vs. baseline	-11.555	1.907	<.0001
	26 weeks vs. baseline	-18.172	1.983	<.0001
	Time x Intervention			.278
	9 weeks vs. baseline	2.270	3.814	.553
	26 weeks vs. baseline	-2.804	3.967	.481
Cognitive flexibility	Intervention vs. active relaxation	5.408	3.901	.172
	Gender, girls vs. boys	-4.432	3.812	.247
	Grade, 6 vs. 8	3.965	3.792	.298
	Time			<.0001
	9 weeks vs. baseline	-17.795	3.128	<.0001
	26 weeks vs. baseline	-21.046	2.931	<.0001
	Time x Intervention			.919
	9 weeks vs. baseline	-.756	6.256	.904
	26 weeks vs. baseline	-2.266	5.864	.700
Verbal fluency	Intervention vs. active relaxation	-3.196	2.540	.211
	Gender, girls vs. boys	3.596	2.514	.155
	Grade, 6 vs. 8	-11.205	2.503	<.0001
	Time			<.0001
	9 weeks vs. baseline	3.718	1.077	.002
	26 weeks vs. baseline	5.169	1.131	<.0001
	Time x Intervention			.932
	9 weeks vs. baseline	.310	2.154	.886
	26 weeks vs. baseline	-.638	2.262	.778

6.2.2 MINDFULNESS-INTERVENTION EFFECTS ON STRESS REACTIVITY

In study IV a total of 110 students completed the test protocol for cognitive, minimal and social stress, while the indicators of psychophysiological reactivity were examined with cardiovascular and electrodermal measures. The effect of mindfulness-based intervention vs. active control group was significant for the second speech task (oppose) measured by skin conductance responses (SCR) (β = 0.928, 95% CI 0.116 – 1.739, p = 0.023). Number of skin conductance responses to a task of social stress increased in the active control group during both the 9 week and the 6 months follow-ups but stayed at the same level in the intervention group (p = 0.460) (Tables 10a and 10b).

The effect of mindfulness-based intervention vs. active control group in heart rate (HR) during cognitive stress task was near statistical significance (p = 0.064). There was no change in reactivity for the intervention group (p = 0.729), whereas for the active control group HR reactivity seemed to increase nearly significantly from baseline to 26 weeks, although this did not reach statistical significance (β = 0.039, 95% CI -0.001 – 0.080, p = 0.057). Nearly significant effects were also found in skin conductance level (SCL) reactivity for speech tasks O (oppose; p = 0.061) and C (comment; p = 0.062). SCL for speech tasks O did not change in intervention group (p = 0.471), whereas the increase was nearly significant in active control group at 9-week follow-up (β = 0.304, 95% CI -0.032 – 0.640, p = 0.082). Reporting the near significant results gives some promise for further research considering that the effect sizes were moderate to large for HR, SCL and SCR in stress tasks. Heart rate variability (HRV) did not reach any significance and the effect sizes for HRV were weak in all tasks.

6.3 STUDIES I, II, III: THE MODERATING EFFECT OF MINDFULNESS PRACTICE

In studies I, II and III our aim was to the investigate the moderating effect of independent practice on wellbeing outcomes and executive functioning.

In study I the modifying effect of continuing practice after the intervention was examined by interaction term between independent practice group and time. The intervention was most effective in the high intensity practice group, that is students who had practiced mindfulness nearly every day (n = 43, 79% boys, 21% girls), compared to control groups. This highest intensity practice group had greater increase in resilience compared to all students within the active control group at post-intervention and at follow-up (at 9 weeks p = 0.06, at 26 weeks p = 0.03) and greater increase in resilience compared with the inactive control group at follow-up (at 26 weeks p = 0.07). Effect sizes were small to moderate (d = 0.29-0.35) comparing intervention to active control and weak to small (d = 0.07-0.30) comparing intervention to inactive control

group. There was more improvement in socioemotional functioning in the highest intensity practice group compared to all other students in the active control group at post-intervention (at 9 weeks p = 0.004) and more improvement compared with the inactive control group at post-intervention (at 9 weeks p = 0.03). Both effects waned at 26 weeks follow-up. Effect sizes were small to moderate (d = -0.41– (-0.24)) comparing intervention to active control and small (d = -0.33 – (-0.18)) comparing intervention to inactive control group.

In study II our results indicated that the dosage of independent practice in the intervention group was related to the changes in health-related quality of life. Students with highest intensity (nearly daily, n=43) mindfulness practice reported the most significant gains in HRQoL. Students with high frequency practice had positive intervention effects in HRQoL at 9 weeks (p = 0.01) and at 26 weeks (p = 0.002) compared with the active control group and at 26 weeks (p = 0.016) compared with the inactive control group. Effect sizes were close to moderate (d = 0.35-0.41) comparing intervention to active control and small (d = 0.16-0.33) comparing intervention to inactive control group.

In study III our results indicated that the amount of student's independent practice was not directly related to the changes in neurocognitive skills in terms of executive functions between baseline and follow-ups. However, the lack of associations may be explained by the low level of independent practice (39 participants practiced more than once or twice) and smaller sample answering questions about practice (n=83). In study IV independent practice was not included in the analysis.

6.4 RESULTS SUMMARY

In studies I-IV mindfulness-based intervention was effective in whole intervention group compared with active control program when we measured resilience (at 9 weeks) and health related quality of life (at 9 and 26 weeks). Strongest overall significant effect was found for HRQoL at 9 weeks. When the moderators of gender and age where examined, intervention was effective for girls in increasing resilience immediately after intervention and in lowering symptoms of depression at 26 weeks. There was no effect in executive functions and small effect in psychophysiological reactivity in response to social stress. Effect sizes were small to moderate in studies I-III and moderate to large in study IV. Among the students with highest intensity practice, the effects were also more pronounced, and intervention was effective compared to both active control and inactive control group. Older students benefited more of mindfulness intervention in terms of HRQoL and 7th graders in terms socioemotional functioning.

Table 10a. Results of repeated measures ANOVA: Age and gender intervention effects on electrocardiac measures (ECG) through tasks (values relative to individual baseline) in study IV

Psychophysiological measures		β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
Task		**Arithmetic**			**General**			**Speech A (argue)**			**Speech O (oppose)**			**Speech C (comment)**		
Heart rate (HR)	Group, Intervention vs. control	0.000	0.013	0.978	-0.006	0.016	0.718	0.011	0.206	0.595	0.028	0.017	0.096	0.013	0.019	0.505
	Time			0.420			0.367			0.277			0.261			-0.032
	9 weeks vs. baseline	-0.005	0.015	0.911	0.005	0.018	0.945	-0.017	0.020	0.615	-0.019	0.021	0.587	-0.029	0.019	0.242
	26 weeks vs. baseline	0.012	0.013	0.567	0.020	0.016	0.333	-0.032	0.020	0.209	-0.027	0.016	0.177	-0.014	0.019	0.704
	Time x Group			0.064			0.934			0.328			0.304			0.179
	9 weeks vs. baseline	-0.002	0.029	0.955	-0.000	0.036	0.993	-0.042	0.038	0.274	-0.065	0.042	0.127	-0.036	0.037	0.330
	26 weeks vs. baseline	-0.055	0.027	0.043	0.009	0.032	0.777	-0.054	0.040	0.181	-0.020	0.032	0.536	-0.071	0.038	0.069
High frequency heart rate variability (HF-HRV)*	Intervention vs. control	0.214	0.218	0.331	0.010	0.230	0.967	0.237	0.237	0.321	0.280	0.210	0.187	0.161	0.207	0.441
	Time			0.474			0.128			0.274			0.072			0.380
	9 weeks vs. baseline	0.015	0.244	0.997	-0.243	0.226	0.432	-0.432	0.270	0.197	-0.600	0.284	0.070	-0.079	0.224	0.905
	26 weeks vs. baseline	0.365	0.243	0.848	0.138	0.235	0.758	-0.129	0.793	0.795	0.018	0.244	0.996	0.185	0.221	0.594
	Time x Intervention			0.684			0.339			0.895			0.969			0.711
	9 weeks vs. baseline	0.091	0.048	0.851	-0.664	0.450	0.144	0.111	0.531	0.834	0.063	0.557	0.911	-0.036	0.441	0.936
	26 weeks vs. baseline	0.402	0.488	0.142	-0.516	0.469	0.275	-0.119	0.457	0.795	0.121	0.488	0.804	-0.306	0.442	0.491

Note. Estimates (β) are standardised

Table 10b. Results of repeated measures ANOVA: Age and gender adjusted intervention effects on electrodermal measures (EDA) through tasks (values relative to individual baseline) in study IV

Psychophysiological measures		β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
Task		**Arithmetic**			**General**			**Speech A (argue)**			**Speech O (oppose)**			**Speech C (comment)**		
Skin conductance level (SCL)	Intervention vs. control	0.039	0.083	0.641	0.091	0.081	0.262	-0.192	0.080	0.019	-0.179	0.081	0.031	0.128	0.085	0.134
	Time			0.474			0.885			0.336			0.647			0.792
	9 weeks vs. baseline	-0.128	0.125	0.504	-0.024	0.118	0.972	-0.203	0.138	0.258	0.090	0.116	0.673	-0.071	0.114	0.779
	26 weeks vs. baseline	0.023	0.091	0.956	-0.046	0.092	0.845	-0.062	0.090	0.730	-0.025	0.109	0.967	-0.036	0.088	0.899
	Time x Intervention			0.401			0.552			0.137			0.061			0.062
	9 weeks vs. baseline	-0.200	0.210	0.342	0.014	0.190	0.941	-0.411	0.226	0.074	-0.428	0.179	0.019	-0.397	0.194	0.046
	26 weeks vs. baseline	0.078	0.183	0.671	0.180	0.184	0.333	-0.293	0.182	0.111	-0.032	0.218	0.152	-0.313	0.176	0.081
Skin conductance responses (SCR)	Intervention vs. control	-0.242	0.213	0.263	0.155	0.215	0.475	-0.202	0.239	0.401	-0.209	0.246	0.398	0.139	0.268	0.607
	Time			0.061			0.579			0.201			0.636			0.124
	9 weeks vs. baseline	-0.235	0.315	0.683	0.355	0.338	0.484	0.544	0.354	0.238	-0.030	0.325	0.994	0.037	0.323	0.991
	26 weeks vs. baseline	0.376	0.218	0.162	0.122	0.296	0.889	0.387	0.304	0.366	0.2264	0.259	0.610	0.727	0.362	0.095
	Time x Intervention			0.710			0.789			0.995			0.023			0.239
	9 weeks vs. baseline	0.193	0.566	0.734	-0.017	0.618	0.978	-0.018	0.610	0.977	-0.124	0.584	0.833	0.403	0.555	0.471
	26 weeks vs. baseline	-0.207	0.440	0.641	-0.369	0.593	0.536	-0.062	0.608	0.919	-1.403	0.525	0.011	-0.838	0.732	0.258

Note. Log-transformed values were used in statistical analyses

Note. Estimates (β) are standardised

7 DISCUSSION

Our findings indicate that school-based mindfulness intervention may have benefits on mental health and wellbeing over an active relaxation control program, measured by resilience, depressive symptoms, socioemotional functioning, and health-related quality of life outcomes. The benefits of all these outcomes are moderated by grade/age and independent practice. The benefits of resilience, depressive symptoms and health-related quality of life outcomes are also moderated by gender. In terms of executive functioning there was no noticeable difference between intervention and active control group, although both groups improved for all cognitive outcomes, except for working memory. In a highly stressful social situation, mindfulness might also have a small effect lowering sympathetically driven electrodermal stress reactivity. To our knowledge, the HLM-study is also the first RCT among children and adolescents to evaluate the specific effects of a mindfulness program in school-setting with comparable active control program and with a relatively long follow-up period (26 weeks).

7.1 THEORETICAL IMPLICATIONS

Mindfulness-based interventions show small but consistent effects (de Vibe, Bjørndal, Fattah, Dyrdal, & Halland, 2017; Galante et al., 2021; Keng et al., 2011). Previous research among children and adolescents show that smaller effect sizes are expected when mindfulness-based interventions are compared with active control programs, training same targeted outcomes as the interventions themselves (Dunning et al., 2019). The benefits of mindfulness are based on underlying mechanisms that are hard to detect and partly common for socioemotional learning programs in general. Larger effects could be gained by focusing on optimal training for gender and age (Kang et al., 2018), exploring more intensive training programs (Johnson & Wade, 2019) and highlighting the role of continuous practice even from young age (Weare, 2013). In the following subchapters I will discuss the results for each outcome in studies I-IV.

7.1.1 MINDFULNESS MAY STRENGTHEN RESILIENCE FOR ALL

In study I, we found out that mindfulness has a significant effect on resilience among all students directly after the intervention (effect waned at 26 weeks) and the effect is slightly stronger for girls. As we have limited

evidence of the mindfulness-based intervention effects on resilience among children and adolescents, the results are promising but also highlight the need for further exploration. Most studies on adolescent resilience have focused on adolescents at-risk (Sünbül & Güneri, 2019). It has been suggested that childhood adversity alters the functioning of resilience factors and may help us understand why strengthening resilience may not have equal effect on all (Fritz et al., 2018). It seems likely that detecting change in resilience among universal student population where adverse events are perhaps less frequent, the results are prone to ceiling effects, resulting in non-significant findings (Hennelly, 2011; Huppert & Johnson, 2010). The evidence from both adolescent and adult studies also indicates that that resilience is more correlated with mental health after experienced adversity (Fritz et al., 2018; Hu et al., 2015).

Resilience and mindfulness are shown to be positively related (Pidgeon & Keye, 2014)and they are likely to have common denominators, that would directly benefit from training, for example, acceptance as a mindful attitude (Galla et al., 2012). We should also note that the possible mediating mechanisms in resilience are self-compassion and emotional regulation (Sünbül & Güneri, 2019), while compassion towards oneself and own experiences is also often emphasized quality of mindful awareness (Bluth & Blanton, 2014; Kabat-Zinn, 2003). These skills, or mindful attitudes, are especially important for resilience in adverse life situations, preventing maladaptive coping, i.e., internalizing and externalizing responses (Pepping et al., 2016). We also know that the effects of adolescent mindfulness interventions are generally more prominent when targeted to subgroups with specific emotional or behavioral problems (Zoogman et al., 2015).

For future research in the field, it would be important to find out more how resilience develops, what are the principal mediators and how the experience of adversity may influence the trajectory.

Persistent gender differences are common to many wellbeing outcomes (González-Carrasco et al., 2017; Lutz et al., 2008; Michel, Bisegger, & Fuhr, 2009), but in terms of resilience, there was no significant gender difference in pre-intervention levels. In general, it seems that resilience is more gender neutral than other wellbeing measures in our study. These results are in line with previous findings among adolescents, who have not experienced a particular trauma (Stratta et al., 2013) and gender differences may also emerge later in life (Hu, 2015), possibly through life adversity and experiences of coping. In future research it would be important to examine how adverse life experiences and traumas moderate the effects of mindfulness on resilience.

Considering that resilience did not show significant difference in 26-week follow-up, we suggest that the maintaining and strengthening of effect require regular practice. When compared with the group of high intensity (nearly daily) practice (N=43), resilience increased markedly and particularly boys (79% of high intensity practioners) seemed to benefit of regular practice. If

mindfulness and resilience have common denominators (acceptance, self-compassion) regular practice would be likely to enhance them simultaneously.

7.1.2 MINDFULNESS DECREASES DEPRESSIVE SYMPTOMS IN GIRLS

In study I, we found evidence that mindfulness intervention ameliorates depressive symptoms, in line with previous studies (Biegel et al., 2009; Kuyken et al., 2013) and only among girls. The effect was not significant directly after intervention but became apparent at 26 weeks. This is an interesting finding and has not been reported in previous research (Johnson et al., 2016; Kuyken et al., 2013), suggesting that longer follow-ups and active control groups may indeed be necessary to capture the potential delayed effects. These effects might also be linked to the development of mindfulness skills, considering the findings that awareness and acceptance develop at somewhat different pace, acceptance takes longer to develop (Desbordes et al., 2012). Mindful acceptance has been found to lower stress reactivity (Lindsay, Young, Smyth, Brown, & Creswell, 2018) and ACT (Acceptance and Commitment Therapy) is evidence-based treatment for mild depression (Hayes, L. & Bach, 2010).

There was significant difference in baseline levels of depressive symptoms between genders, often found from pre- and early adolescence on (Hosseinpoor et al., 2012). During adolescence, girls have higher self-consciousness that may lead to self-critique, negative affect, and lower self-compassion (Hyde et al., 2008). As mindfulness interventions address and improve positive affectivity, adaptive coping, and self-compassion, as well as decrease rumination in adults (Heeren et al., 2009; Jain et al., 2007) and adolescents (Mendelson & Greenberg, 2010), they may be by nature more targeted towards girls (Anderson, N. D., Lau, Segal, & Bishop, 2007; Shapiro et al., 2006), particularly the emphasise on cultivating self-compassion and acceptance (Kang et al., 2018). These findings are well-predicted by the theoretical model behind mindfulness-based cognitive therapy, which has been found to prevent repeating periods of chronic depression. The model postulates that mindfulness practice decreases depressive recurrence through reducing recurrent maladaptive thinking focused on depressive symptoms (Segal et al., 2002; Teasdale et al., 2002). There is also some preliminary evidence that mindfulness-based approaches perform equally well compared with gold standard treatments for internalizing difficulties among children (Wright, Roberts, & Proeve, 2019).

The gender difference at baseline also suggests the possibility of ceiling effects for boys, when measuring change. When measuring depression/depressive symptoms the instruments are predominantly clinical, designed to measure clinical change, which means that majority of responses will be under the clinical threshold and the sensitivity of the scale will be lower

than in the clinical population (Hayes, L. & Bach, 2010). Research has also shown that baseline differences in depression moderate the effects of mindfulness interventions (Chi et al., 2018). The change in depressive symptoms was not affected by practice, but we note that the sample of students practicing regularly was small and 79% of students practising nearly every day were boys. The larger percentage of boys among high-intensity practitioners may have prevented significant findings in depressive symptoms due to possible ceiling effect among boys. However, it should also be noted that mindfulness practice may increase psychological wellbeing not directly mediated by increased mindfulness (Kiken et al., 2015), suggesting that there may be varying ways to benefit from any particular intervention. Considering that the depressive symptoms had significantly decreased among girls at 26 weeks after mindfulness intervention and the effect was not due to increased practice, it seems likely that girls benefit from the intervention in multiple ways that enhance cognitive flexibility and emotion regulation in longer term.

7.1.3 MINDFULNESS MAY HELP TO COPE WITH DEVELOPMENTAL CHALLENGES

Third primary outcome in study I, socioemotional functioning, is also an outcome that has no significant gender difference at baseline. There was no significant intervention effect compared to active control group, except when we look at the 7th grade students. The majority of the wellbeing outcomes show a decreasing trend with age, highlighting the need for mental health promotion and prevention especially among older adolescents (González-Carrasco, Casas, Malo, Viñas, & Dinisman, 2017; Mak et al., 2017; Michel, Bisegger, Fuhr, & Abel, 2009; Moksnes & Espnes, 2013). Socioemotional functioning follows this trend, and it seems that that grade-related differences may be connected to transition from lower to upper school and not only to grade as such.

The beginning of upper elementary school brings on changes in physical environment, supporting adults, peers, and educational demands (Benner, 2011; West, Sweeting, & Young, 2010). Therefore, we may consider this period as a one of the key periods of change in adolescent life, when both maladaptive and adaptive coping mechanisms are utilized and tested. Mindfulness has been found to decrease internalizing and externalizing behaviors (Pepping et al., 2016) although there is stronger evidence of the effect on internalizing behaviors (Maynard et al., 2017). Mindfulness may decrease emotional and behavioral problems in students with these particular challenges (Huang et al., 2019) and thus, could be a tailored approach for this particular time of life.

It is interesting to note that psycho-educative but similarly wellbeing focused active control program did not achieve similar benefits. The lack of evidence of mindfulness influencing emotional and behavioral problems may

well be due to the fact that sufficiently large RCTs are often conducted in healthy school populations, where they fail to consider subgroups with these particular difficulties (Maynard et al., 2017; Zoogman et al., 2015).

7.1.4 MINDFULNESS ENHANCES HEALTH-RELATED QUALITY OF LIFE

Study II examined whether a mindfulness-based intervention program shows unique effect on children's self-reported health-related quality of life. We found that a mindfulness intervention vs. relaxation-based active control group has an immediate intervention effect on health-related quality of life (HRQoL) for whole intervention groups at 9 weeks and at 26-week follow-up and the frequency of independent practice was associated with higher HRQoL.

In terms of gender and grade effects, we found a significant improvement among girls and 7th- and 8th grade students at 9 weeks and at 26 weeks. These results align with existing evidence of more pronounced effects among women (de Vibe et al., 2015; Desbordes et al., 2012; Katz & Toner, 2013) and girls (Kang et al., 2018), as well the evidence from study I. Gender and grade differences at baseline also show that girls and older children have significantly lower health-related quality of life to begin with. Start of upper school at the age of 13 may be a particularly opportune time for mindfulness training to alleviate the age-related decline in HRQoL. Older adolescents have often received greater benefits from mindfulness intervention, compared with younger children (Carsley et al., 2018). It has been suggested that the age period of 15–18 years would be a particularly opportune time for mindfulness to be effective due to heightened brain plasticity (Anderson, V., Anderson, Northam, Jacobs, & Catroppa, 2001) and increases in self-reflection, social-perspective taking and interest in self and others (Blakemore & Mills, 2014).

7.1.5 MINDFULNESS PRACTICE SEEMS TO ENHANCE POSITIVE EFFECTS

In both studies I and II, findings demonstrated that the high intensity practice group received greater benefits in terms of resilience and health-related quality of life compared with students who practiced less often, active control group and inactive control group. Also, the effect increased in time, from immediate post-intervention assessment to 26 weeks assessment. However, we should note that the high intensity practice group was small (n=43) and more research is needed to confirm these findings.

Another study utilizing the same data as we have here (Beattie et al., 2020), has shown that high intensity practitioners were not significantly different from other participating students in terms of mental wellbeing at basline.

However, they had more social encouragement and acceptance to engage with mindfulness practice. These results highlight the possibilities to support the practice, as we recognize the appropriate motivational factors.

Another possibility to increase the dose of intervention, is to intensify the intervention itself. Two studies examining an intensive format mindfulness intervention (90-100-minute lessons and longer inquiry) have been favorably received by participants and demonstrated significant between-group differences in depression and anxiety. Promising effect sizes support further investigation in larger samples (Johnson & Wade, 2019; Raes et al., 2014). We might question, if the intensity of the intervention is the variable that adapts mindfulness programs from adult format to better fit children and adolescents. Research should also guide the adaptation process, considering the optimal developmental periods and brain development (Anderson et al., 2001; Roeser & Pinela, 2014).

7.1.6 IMPROVEMENT ON EXECUTIVE FUNCTIONS BY INTERVENTION AND CONTROL

Study III examined whether a mindfulness-based intervention program has a unique effect on core executive functions (working memory, response inhibition, cognitive processing and flexibility, verbal fluency) and the results indicate intervention and active control program do not differ in their impact on executive functions (EFs). We found that there were significant improvements in response inhibition, cognitive processing, cognitive flexibility and verbal fluency and results continued to improve at the 26-weeks follow up. The results were compared with the standardized age-appropriate norms and mean changes in participant scores were above the expected compared to the age norms, suggesting that the effect may not solely be due to learning or maturation.

It is possible that decreased stress due to self-motivated silent pauses (Lees, 2013) as well as positive social interaction and support could enhance cognitive performance (Beauchemin et al., 2008; Durlak, Weissbeg, Dymnicki, Taylor, & Schellinger, 2011). This would be also in congruence with recent research reviews, confirming the lack of significant intervention effects in similar, active control trials (Dunning et al., 2019; Lao & Kissane, 2016). However, considering the lack of inactive control group, we propose that further research is needed to analyse the effects and the effect sizes of similar programs for cognitive functioning. We suggest that socioemotional learning programs that incorporate the core elements of mindfulness and relaxation might be useful in enhancing executive functions, especially as these skills are fairly resistant to significant change. We would like to contribute to future research by emphasizing the importance of including an active control group, sufficiently similar to mindfulness intervention, to be able to discover if any mindfulness specific effects are to be found.

Accumulating research among adults have given indication that that mindfulness induction improves cognitive performance in tasks involving complex higher-order functions (Gill, Renault, Campbell, Rainville, & Khoury, 2020). This may be something that warrants future attention also among the adolescents.

7.1.7 MINDFULNESS MAY HELP COPING WITH SOCIAL STRESS

In study IV, we found a significant difference in the change of skin conductance responses (SCR) over time between mindfulness-based intervention group and relaxation-based active control group in the opponent speech task. The difference was due to increase of SCR in control group. The stress task may have elicited higher stress response in the control group, as they were not trained in mindfulness skills. Mindfulness skills may, for example, increase adaptive regulation of emotions, including coping with negative affect (Erisman & Roemer, 2010). Control participants may have also anticipated the experience of stress in post-intervention and follow-up measurements (pre-task anxiety) creating an increase in sympathetic activity and worry of own performance (Kadziolka, Di Pierdomenico, & Miller, 2016).

Our findings give support for mindfulness training having an effect on the sympathetic activity, in line with mindfulness stress buffering hypothesis (Creswell, 2014), congruent with previous notions that the stress buffering effects of mindfulness may be more consistently found in high stress conditions (e.g., social stress) (Kirschbaum et al., 2004; Brown et al., 2012). Due to the small sample and finding significant association only for one of our physiological measures in one task, these results should be considered tentative. However, marginally significant findings in terms of heart rate (HR) and skin conductance level (SCL) with strong effect sizes suggest that the effect may be consistently found in tasks of social stress. These results are in line with previous research, suggesting that even if mindfulness interventions seem to have a positive effect on self-reported stress, these effects are less clear for physiological measures. Variations in study methodology may influence stress reactivity outcomes; the type of mindfulness practice and the dosage of practice seem to be particularly influential, more research with larger samples would be warranted (Morton & Helminen, 2020). We propose that these mechanisms may even be common for stress reactivity and socioemotional functioning (study I), high stress reactivity may increase maladaptive coping and problematic behavior (Ortiz & Raine, 2004), thus increasing the need for mindfulness skills. It is also possible that these effects require either 1) induced high-intensity stress, or 2) challenging developmental/environmental changes, to enable detection by symptomatic measures; 3) longer intervention to enable the processes of mindful acceptance to take hold (Desbordes et al., 2012).

7.2 PRACTICAL IMPLICATIONS

School years are the optimal time for the development of socioemotional skills. Schools can also provide equal access to programs and educational initiatives that strengthen personal and interpersonal wellbeing and provide enriching the experiences. Mindfulness training as a strategy for socioemotional learning may be a cost-efficient, equity enhancing way to achieve this goal (Jagers et al., 2019; Meiklejohn et al., 2012) especially if we can boost the effects by adaptation and timing (Weare, 2013). Although research has consistently confirmed that children and adolescents benefit of mindfulness programs (Dunning et al., 2019; Zenner et al., 2014; Zoogman et al., 2015), they are still not established practice in schools in most countries (Weare, 2013).

The present thesis suggests that girls may particularly benefit from mindfulness practice by strengthening adaptive coping (vs. maladaptive, e.g., rumination). Considering the prevalence of female adolescent depression and anxiety, peaking around age 13-15 (Hyde & Mezulis, 2020), it seems that a structured mindfulness curriculum could have a positive impact, even when implemented as a brief intervention. If this approach could be more integrated in educational curriculum as a comprehensive way to tackle mental health challenges, these benefits could have long term significance for both genders.

We also found some preliminary evidence that more intensive practice can achieve better results in terms of wellbeing, in line with the previous research (Chi et al., 2018; Parsons et al., 2017). Considering that regular independent practice seems to benefit all, we should explore ways to promote opportunities for school-based practice and aim to follow up the effects beyond immediate assessments. In school context this could mean e.g., options to participate in more intensive practice groups.

We found, again confirming the previous findings (Carsley et al., 2018) that benefits of mindfulness interventions tend to be greater in later adolescence and after the period of transferring to secondary school. There might be an added benefit of offering mindfulness-based training in the beginning of the new school stage as a way ease adaptation to new environment and challenges, and to continue offering the booster sessions during the exam periods.

School-based mindfulness research has some unique characteristics, as the participants are not volunteering and may not have particular interest to participate, as in many clinic-based studies, even if they have filled in the study permission. Working with this population is demanding and requires structured programs, high quality teaching materials and clear aims. In some sense, working with children and youth poses challenges that are not found elsewhere. We might also question, if the turmoil of early adolescence, when significant biological, neurodevelopmental, social and psychological changes occur (11-14 years) (Patton et al., 2016) prevents majority of students of drawing optimal benefits from programs, that often have been designed for

adults and scaled down for young participants. Therefore, we are inclined to interpret our findings overall as encouraging, providing further impetus for strengthening evidence and engaging schools in piloting mindfulness training that is up to rigorous standards, motivating and tailored to this specific group.

We suggest that next steps will be to build on our evidence how and for whom mindfulness works. There is some evidence that individual trajectories influence how mindfulness practice strengthens tendency to be mindful and trait mindfulness is not always the mediating factor between mindfulness practice and improved psychological health (Kiken et al., 2015). This would mean implementing innovative research designs and engaging more schools to partner in these pilots.

7.3 RELIABILITY AND VALIDITY, METHODOLOGICAL STRENGTHS

7.3.1 BENEFITS OF SCHOOL SETTINGS

The Finnish school system offers several significant benefits for large-scale studies: almost all children are enrolled in public schools and regardless of socioeconomic background follow a national curriculum. Further, the students are assigned to the schools based on their living region and socioeconomic differences between catchment areas are generally small.

In studies III and IV, testing procedure was conducted in normal school environment (not laboratory conditions) and therefore more applicable to executive functioning and psychophysiological reactivity in educational settings. We had laboratory quality measurements brought to school, which allowed all students an equal opportunity to participate during the day and participation was not limited nor influenced by parental motivation to visit a clinic. As we had the unique opportunity to measure neurocognitive performance and record physiological reactivity in familiar environment, we gained information beyond laboratory conditions on stressful situations that children and adolescents may experience during their school day.

7.3.2 SUFFICIENT SAMPLE

Our study sample comprised a universal student population and was therefore applicable to general school context. The study sample in studies I and II was large compared to previous studies (see Dunning et al., 2019). The sample size was estimated to detect the mean difference of 0.2 standard deviation units (effect size = 0.2) on main outcomes between intervention and the control groups with 80 % power and the two-tailed 5 % level of

significance. In studies III and IV, the sample was also larger than in many similar studies in the field (see Cásedas & Pirruccio, 2020; Rådmark, Sidorchuk, & Osika, 2019).

7.3.3 INTERVENTION FIDELITY

Professional mindfulness facilitators implemented the intervention they were particularly trained for, and their performance was video-taped, discussed and validated before the intervention to guarantee the intervention fidelity. We chose to use evidence-based and manualized intervention (Stop & Breathe), easily replicable for other studies. Out of the 14 facilitators, all nine intervention group facilitators had attended an 8-week mindfulness-based stress reduction course and certified to deliver Stop & Breathe-program. All facilitators were provided with a self-monitoring sheet which are used for the self-assessment of their performance (e.g., intention, attitude, ability to be mindful and conduct the lesson with empathy and kindness) as well as to guarantee that the core elements of each lesson are delivered. Students, who were randomized to intervention group showed a high participation percentage: Out of nine mindfulness lessons, in all, 90% of students took part in 7–9 lessons, 5% took part in 6 lessons, and 5% took part in 1–5 lessons.

7.3.4 ACTIVE AND INACTIVE CONTROL GROUP

We had both an active relaxation-based and an inactive control group. Participants were blinded as to whether they were selected to the intervention or active control program.

Also, the program materials and slides did not specify which program was in question. However, they could of course draw conclusions themselves, whether they were introduced mindfulness or relaxation exercises.

7.3.5 ESTABLISHED OUTCOME MEASURES

We chose established and reliable measures (RS14, RBDI,SDQ, WISC-IV, NEPSY 2) that had been tested and validated with the population and in Finnish language (Losoi et al., 2013; Kaltiala-Heino et al., 1999; Koskelainen, et al., 2000; Ravens-Sieberer & Bullinger, 1998; Korkmann et al., 2007; Delis et al., 2001). Many of them had not been applied before to examine the effects of mindfulness intervention, which gave us the opportunity to offer new evidence to this field of research.

7.3.6 DATA-ANALYSIS FOR CLUSTER-RANDOMIZED CONTROLLED TRIAL

Analysis statistically accounted for classroom and school effect (Volanen et al., 2016). Randomization was conducted at school level, which reduces the risk of contamination between groups. Wide-ranging characteristics of students and school district were also included. There were no significant differences at baseline between the intervention and active control group on experienced socioeconomic status, thus it was not included in the main multivariable analysis.

7.3.7 FOLLOW-UP TO DETECT LONGER TERM EFFECTS

We conducted post-intervention follow-ups at 9 weeks and at 26 weeks. For studies I-II these were longer than usual follow-ups in previous research (e.g., Johnson et al., 2016; Kuyken et al., 2013), in studies III-IV, it was the first time to our knowledge that similar measures were followed up past the immediate post-intervention assessments.

7.4 LIMITATIONS OF THE PRESENT STUDY

There are some limitations that should be considered in interpreting the findings of this study. Studies I-IV were implemented following the protocol (Volanen et al. 2016) as closely as possible. However, separate analyses for the amount of independent practice were not included as pre-planned analyses in the protocol. Since there is a gap in research on this topic, and some contradicting results, we decided that it was appropriate to deviate from the protocol for this part. We also note that we did not control for trait mindfulness at baseline, but we controlled for baseline mindfulness and relaxation practice in the questionnaire package ("when you want to relax, how often do you do 1) relaxation or breathing exercise; 2) mindfulness exercise"). The participating schools had not received any previous mindfulness training.

The number of participants was reduced by dropout in studies I and II (attrition 5.9%, with no significant differences between intervention and control groups), which was expected considering drop-out rates in similar trials. Boys were more likely to drop out than girls (63.9% of dropouts) and students whose mother language was other than Finnish/Swedish (13.1 % of the participants were Swedish speaking) were also more likely to drop out (14.6% of drop-outs). Other differences were small and not significant. In studies III and IV, the intensive testing procedure had an impact on the number of participants and some of the participants dropped out due to this.

The sample size was estimated to detect the mean difference of 0.2 standard deviation units (effect size = 0.2) on primary outcomes between intervention and the control groups with 80 % power and the two-tailed 5 % level of significance. The inactive control group was smaller than the intervention and active control groups (n=353) and the active control group (n=1181) was slightly under the power calculations for primary outcomes (n=1200 in each group), which reduces statistical power and increases the probability of the type-II-errors.

In studies III and IV, we did not have an inactive control group, due to practical challenges of recruitment. In study III, we compared the outcomes of executive functions (working memory, response inhibition, cognitive processing, cognitive flexibility, and verbal fluency) with standardized norms for this age-group to find out if the overall improvement in scores were more likely to be due to program content or to non-specific effects. As the baseline level of neurocognitive functioning among participants was average or above and the standard deviation in all measures was low, the sample is representative of students with fairly good executive functioning and not directly transferable to clinical populations. Higher baseline levels of cognitive functioning may also result in ceiling effects and less evident benefits (Flook et al., 2010).

In interpreting the results of studies I-IV, we should note that the intervention period was relatively short (9 weeks). Thus, it may be difficult to find differences between mindfulness and relaxation training, which both share common elements of calming, breath-focused practices. Particularly in study III, examining EF, there was no difference between the intervention and active control groups and the non-specific effects were likely to impact the scores, including the maturation process and learning in general. Also, some non-specific effects of school-based interventions, for example interaction, interest, and attention, are valuable parts of the intervention itself that we should acknowledge when we study intervention mechanisms (Donovan, Kwekkeboom, Rosenzweig, & Ward, 2009).

A relatively small sample size reduced the power to find significant results in study IV, examining psychophysiological stress reactivity. Small samples have been observed as a common challenge in psychophysiological studies in general (in meta-analysis ranging from 7 to 118, see Pascoe et al., 2017) . Since our sample was small there is increased risk for type I error especially as we found differences in only one test condition. However, considering the additional borderline significant results we are inclined to interpret the results as promising, and encouraging further studies with larger samples.

In study IV, we should also note that the testing situation involved participant movement (writing, placing cards) where the body movements are not controlled. This may increase the signal-noise ratio of recording and diminish the measured effects. We still know little of HRV measurements and their reliability in short (under 24 hours) recordings (Shaffer & Ginsberg, 2017). Detection of SCRs was done automatically. Due to individual

differences in skin conductance signals the algorithm may give different results than detection based on manual inspection.

8 CONCLUSIONS AND FUTURE DIRECTIONS

The aim of the present series of studies was to find out if implementing a mindfulness-based intervention will have a significant impact on various wellbeing outcomes and their potential mechanisms. These studies have expanded the research in the field by following ways: 1) a mindfulness-based program was introduced to Finnish schools; 2) cluster-randomized controlled trial offered new insights into the usefulness of school-based mindfulness intervention in promoting wellbeing of adolescents; 3) focus was on the unsolved questions in mindfulness research, using systematic and sound designs to avoid methodological shortcomings; 4) the outcomes of the research results provided new tools for the schools to promote learning and wellbeing.

We were able to discover that compared to active control group mindfulness has a significant, albeit small and not universal, effect on all the selected outcomes, except for executive functioning. The effect is enhanced if we consider the moderating effect of gender, grade, and independent practice. The perceived stigma towards mental ill health and the shortage of mental-health professionals are known to make it difficult for many young people to receive the support they need. Interventions need to be designed to enhance equity (Patel, Flisher, Hetrick, & McGorry, 2007). It is therefore important that early intervention and prevention strategies are developed for this age group. The outcomes of resilience, depression, socioemotional functioning, and health-related quality of life are also among priorities in mental health promotion, socioemotional learning, and risk-prevention strategies among youth.

The Developmental Contemplative Science Framework (DCS) has specified core premises in which mindfulness operates and impacts response to training: 1) brain adapts in response to mindfulness experience, training, and education and physiological changes can result from neuroplasticity; 2) mindfulness activities will increase daily mindful moments and consequently influence cognitive and emotional processes; 3) adolescence is one of the opportune developmental periods when specific brain regions and networks are more likely to be modified, optimizing openness to training. Thus, different developmental periods will have different response and varying effectiveness to mindfulness interventions (Roeser & Pinela, 2014). These developmental periods interact with the environment and may demand varying resources and coping mechanisms (Maynard et al., 2017). It seems likely that mindfulness can strengthen adaptive coping in these circumstances.

The broad definition of mindfulness can contribute to a particular way of looking into our lives and the world, seeming particularly suitable to

integrated into school curriculums (Weare, 2013). Looking into the skills of mindful awareness, attention, and acceptance we can examine the benefits of mindfulness by no means restricted to only personal and cognitive effects. Many of the dimensions that we have investigated, are also interpersonal. Socioemotional functioning is behavior in interpersonal contexts, including peer problems and prosocial behaviour. Self-esteem, family relations, and wellbeing at school, all part of health-related quality of life, are interpersonal dimensions. Psychological well-being and resilience are impacted by personal and interpersonal resources. Researchers have proposed that mindfulness allows us to understand ourselves in order to understand others and to treat our fellow humans with openness and fairness (Langer, 2014; Siegel, 2014).

Despite the growing evidence, the previous studies conducted among youth are still few, and their methodological shortcomings have prevented generalizing of the efficacy of these interventions (Burke, 2010; Felver et al., 2016; Greenberg & Harris, 2012; Zoogman et al., 2015). When reviewing only the current RCTs on mindfulness interventions among youth, researchers have recommended scaled-up definitive trial designs including e.g., observed-rated (physiological measures), true active interventions that are aimed to enhancing wellbeing and reducing mental health problems and established mindfulness protocols (Dunning et al., 2019). Our study has been the first large-scale study designed to address these recommendations by robust methodology, including sufficient sample, established mindfulness program, both questionnaire-based and objective measures, sufficiently similar active control group and relatively long follow-up period. Based on our data and its analysis we have been able to examine the general and specific outcomes of mindfulness interventions, thereby gathering the evidence to design optimal interventions and to support student mental health and wellbeing in schools. In future it will be essential to continue building standardized formats for interventions, allowing replication and comparative studies, to develop firm evidence-based research allowing undisputable conclusions. Despite the limited evidence, our results are promising and encourage teaching mindfulness in the school context.

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APPENDIX OF PUBLICATIONS

I Volanen, S-M., Lassander, M., Hankonen, N., Santalahti, P., Hintsanen, M., Simonsen, N., Raevuori, A., Vahlberg, T., But, A. & Suominen, S. (2020). Healthy learning mind – effectiveness of a mindfulness program on mental health compared to a relaxation program and teaching as usual in schools: A cluster-randomised controlled trial. *Journal of Affective Disorders* 260, 660-229.

II Lassander, M., Hintsanen, M., Suominen, S., Mullola, S., Vahlberg T., Volanen, S-M. (2021). Effects of school-based mindfulness intervention on Health-Related Quality of Life: Moderating effect of gender, age and practice intensity. *Quality of Life Research*

III. Lassander, M., Hintsanen, M., Suominen, S., Mullola, S., Fagerlund, Å., Vahlberg T., Volanen, S-M. (2020). The Effects of School-based Mindfulness Intervention on Executive Functioning in a Cluster Randomized Controlled Trial, *Developmental Neuropsychology*, 45:7-8, 469-484.

IV Lassander, M., Hintsanen, M., Ravaja, N., Määttänen, I., Suominen, S., Mullola, S., Makkonen, T., Vahlberg, T., Volanen, S-M. (2021). Students' stress reactivity after mindfulness intervention compared to relaxation control group. *International Journal of Stress management (under final review).*