EÖTVÖS LORÁND UNIVERSITY
FACULTY OF PEDAGOGY AND PSYCHOLOGY

Ádám Koncz

Effects of mindfulness-based interventions on self-regulation

Theses of Doctoral (PhD) dissertation

Doctoral School of Psychology
Head of the doctoral school: Prof. Dr. Róbert Urbán

Developmental and Clinical Child Psychology programme
Head of the doctoral programme: Prof. Dr. Judit Balázs

Topic supervisors: Dr. Zsófia K. Garai-Takács, Prof. Dr. Zsolt Demetrovics

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List of publications used in the dissertation [1]

Koncz, A., Demetrovics, Z., & Takacs, Z. K. (2021a). Meditation interventions efficiently reduce cortisol levels of at-risk samples: a meta-analysis. *Health Psychology Review,* 15(1) 56-84. https://doi.org/ 10.1080/17437199.2020.1760727

Koncz, A., Kassai, R., Demetrovics, Z., & Takacs, Z. K. (2021b). *Short mindfulness-based relaxation training has no effects on executive functions but may reduce baseline cortisol levels of boys in first-grade: A randomized controlled feasibility study*. [Manuscript submitted for publication]. Faculty of Education and Psychology, ELTE Eötvös Loránd University

Koncz, A., Demetrovics, Z., & Takacs, Z. K. (2021c). *Benefits of a mindfulness-based intervention upon school entry. A randomized controlled trial*. [Manuscript submitted for publication]. Faculty of Education and Psychology, ELTE Eötvös Loránd University

[1] The co-authors of the listed publications have contributed to the use of the publications in my dissertation.

1. Introduction

1.1 Self-regulatory skills

Self-regulatory skills are a set of cognitive components that are responsible for organizing and controlling our cognitive functions and behavior, to be able to achieve the set goal and if necessary, we flexibly change the plan to achieve this goal. Executive function skills are the cognitive aspects of self-regulation. These skills usually considered to consist of three distinct components: inhibition, working memory and cognitive flexibility (Diamond, 2013; Diamond & Lee, 2011; Miyake et al., 2000). Inhibitory control is the ability to suppress a response that is not appropriate in a situation (Miyake et al., 2000). Working memory is where information is being temporary stored, until it is processed or transferred to long-term memory (Baddeley & Hitch, 1974). At this point it is important to highlight that working memory is not to be confused with short-term memory. While the latter is just for holding information temporarily in mind, working memory is in addition, manipulates the information held in mind. Finally, Shifting or cognitive flexibility is the ability to flexibly change between different rules. The most important brain region of executive functions is the prefrontal cortex (PFC) (Stuss & Benson, 1986). This region develops most rapidly in pre-school age as do the executive function skills.

Diamond (2013) in a review summarizes that these skills are playing important role in several aspects of a person's life. First in case of some mental problems such as attention deficit hyperactivity disorder (ADHD) (Diamond, 2005), depression (Tavares et al., 2007) or conduct disorder (Fairchild et al., 2009) they work less well than in healthy individuals. An emerging number of studies show that self-regulatory skills and executive functions play an important role in school readiness and academic performance (Borella et al., 2010; Gathercole, et al., 2004), even more so than IQ (Blair & Razza, 2007). In fact, these skills are associated with mathematics and language skills. Later during adult life better productivity and greater chance of keeping a job is associated with better functioning executive function skills (Bailey, 2007). Beyond that, success in private life such as maintaining a well-functioning relationship (Eakin et al., 2004) and less likely to experience social problems such as emotional outbursts or crime are also related to better executive functions (Broidy et al., 2003; Denson et al., 2011).

Social factors such as being rejected by peers (Baumeister et al., 2005) or growing up as a child of divorced parents (Weaver & Schofield, 2015) are associated with lower self-regulatory capacity. Additionally, low socioeconomic status, is also a risk factor of impaired

self-regulation (Blair, 2010) and higher stress levels (Cohen et al., 2006). And these stressors also contribute to the disruption of these skills (Evans & Kim, 2012)

1.2 Stress and its relation to cognitive functions

Different methods are available to assess the stress experienced by school-age children; levels of stress can be determined by observing behavior based on the report of parents or teachers or even the child's own judgment, or the monitoring of certain physiological indicators (Romer, 1993). Among physiological indicators, salivary stress proteins are popular due to their non-invasive sampling methods (Obayashi, 2013). For example, cortisol is regarded as an objective stress biomarker and as self-reported assessment of stress is more prone to bias, while objective biomarkers such as cortisol levels might be more suitable for a firm test of the effects of an intervention (Matousek et al., 2010).

Protection from chronic stress in childhood is important because it can lead to abnormal brain development and decreased cognitive functioning (Noble et al, 2012). Stress can have a negative impact on children's executive functions as Wagner and colleagues (2016) found: there is an inverse relationship between salivary cortisol levels, and executive function performance. Starting elementary school requires adjustment to a new environment and novel requirements in addition to building new social relationships. In fact, Groeneveld and colleagues (2013) found higher hair cortisol levels after school entry in children. With all the negative effects of stress in mind, additional efforts to support children in adaptation in this stressful life situation may be beneficial.

1.3 Fostering executive function skills by mindfulness

For fostering children's executive functions several possibilities have been proposed such as computer programs, curricula, yoga, mindfulness meditation and sports (Diamond & Lee, 2011). In a meta-analysis Takacs and Kassai (2019) collected what kind of interventions are used to improve executive functions and tested their effectiveness. Based on the literature, interventions are classified into the following categories: computerized trainings, noncomputerized games, physical activity, art activities, complex full-time curricula, strategy teaching interventions, biofeedback-induced relaxation programs or mindfulness interventions. From the above-mentioned categories, mindfulness-based interventions have been found to be a really effective intervention for children in enhancing working memory and inhibition skills however, they highlight the number of studies was still quite limited.

The concept of mindfulness meditation is to be in the present moment without judgment (Kabat-Zinn & Hanh, 2009). This is often used in combination with other practices. For instance, Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT) combine mindfulness meditation practices with elements of cognitive behavioral therapy or some other psychoeducational elements (Fjorback et al., 2011). In the last 10 years, the number of studies that observed the effects of mindfulness programs developed for children still lags behind the number of studies with adults (Butterfield et al., 2020), and there is a literature gap in this case.

1.4 Effects of meditation on stress and anxiety

Goyal and colleagues (2014) found that mindfulness mediation has moderate beneficial effects on symptoms of anxiety and depression. In a meta-analysis MBSR compared to wait-list controls was found to be effective in reducing self-reported stress however, results are not conclusive whether these benefits remain more than 3 months later (Chiesa & Serretti, 2009). Sanada and colleagues (2016) conducted a meta-analysis of the available randomized controlled trials (RCTs) of mindfulness-based programs on salivary cortisol levels in non-clinical adult populations and revealed a significant, moderate-sized benefit. Pascoe and colleagues (2017) found similar results in case of blood samples and active control conditions. In the same vein, a meta-analysis by Kallapiran and colleagues (2015) found that mindfulness-based interventions reduce the symptoms of stress and anxiety in children and adolescents.

1.5 Effects of meditation on children’s behaviour

In line with the positive effects of mindfulness programs on children’s self-regulatory skills, such an intervention could also reduce children’s behaviour problems. For instance, if mindfulness practice improves executive functions, especially inhibitory control, it could potentially decrease children’s aggressive behaviours because lower inhibitory control is associated with higher aggression (O’Toole et al., 2017). In addition to the above, mindfulness practice can also improve children's prosocial skills. Cheang and colleagues (2019) reviewed the scientific literature and found that mindfulness-based interventions may have positive effects on children’s empathy and compassion. However, it should be noted that mindfulness programs developed for children often have content that directly targets prosocial skills such as kindness practice.

1.6 Theories on how mindfulness works

According to Creswell and Lindsay (2014) mindfulness has positive effects on health outcomes via improving stress management (mindfulness stress buffering hypothesis). The authors proposed that mindfulness affects both top-down and bottom-up stress processes in the brain including increased activation in regulatory areas like the prefrontal cortex and decreased stress reactivity in, for instance, the amygdala. Based on the stress buffering account, Creswell and Lindsay (2014) predicted that mindfulness-based interventions should have the largest effect for at-risk populations: highly stressed people or populations with diseases that are susceptible to stress such as mental disorders and somatic illnesses like inflammatory diseases or diabetes.

Zelazo and Lyons (2012) proposed that mindfulness programs contribute to the development of the executive function skills in two ways. First, mindfulness practice trains self-regulation by practicing monitoring and consciously driving one's attention to the object of the meditation (top-down processes). Secondly, such practice reduces stress, which in turn facilitates cognitive performance (bottom-up processes).

Based on these two theories mindfulness might affect on executive function skills through reducing stress and can be especially effective for those people who are in a stressful life situation.

2. Objectives

Based on the above, my aim in my doctoral work was to examine whether meditation really reduces stress and if so, which groups are most effective for. I would also like to test whether practicing meditation has an impact on the development of self-regulation through stress reduction because stress can be seen as a bottom-up process (Zelazo & Lyons, 2012). For this first we conducted a meta-analysis on the effects of meditative interventions on cortisol levels. After the meta-analysis two field experiments were conducted with pre schoolers and first graders around school entry.

3. Study 1:
Meditation interventions efficiently reduce cortisol levels of at-risk samples: A meta-analysis

3.1 Aim of the study

The main aim of the present study was to assess whether meditation is more effective in samples who are in most need of stress reduction: samples with elevated cortisol levels, that is, clinical samples and participants in stressful life situations as compared to healthy subjects

with supposedly lower cortisol levels. Secondly, we investigated whether benefits of meditation are sustained over time by focusing on the latest follow-up assessments.

3.2 Hypotheses

H1: In line with previous results, it was hypothesized that meditation interventions decrease cortisol levels because of their stress reducing effects.

H2: We expected a larger effect for samples that are at risk for elevated cortisol levels (based on the mindfulness stress buffering account of Creswell and Lindsay (2014).

H3: Regarding the long-term effects of these programs, we expected smaller effects with more and more time after the end of the intervention.

3.3 Methods

We conducted a systematic search in the databases of Web of Science (Core collection), EBSCO (PsychInfo, PsychArticles, MEDLINE) and PubMed for journal articles and in the ProQuest database for dissertations. All randomized controlled trials in which the main component of the intervention was meditation were included. We aimed to assess the effect specifically for subjects who are at a risk for elevated cortisol levels. In the primary studies the effect of meditation was assessed regarding a variety of at-risk samples.

3.4 Results

3.4.1 Effect of meditation on blood cortisol

We synthetized the results of 10 studies including data of 395 participants' using blood samples. Meditation interventions had a medium effect on the change in cortisol levels ($g = 0.62$). Within this group there was also a significant medium-sized effect for at-risk samples and a large but non-significant effect for no-risk samples. We investigated the efficacy of meditation interventions for different at-risk samples. Three studies included participants with a mental problem and showed no effects of the interventions. Five studies included participants with a somatic illness. In these studies the effect was large and significant. Intervention duration had a significant positive effect on the effect size suggesting that longer meditation interventions had larger effects. The other interesting finding is that these programs are more effective for men.

3.4.2 Effect of meditation on salivary cortisol

We synthetized the results of 21 trials including data of 1163 participants. Meditation had a small and marginally significant effect on change in cortisol levels in salivary samples (g = 0.18). Furthermore, we assessed the moderator of the samples' risk status. For both at-risk and no-risk samples the effect was small and not significant. We also investigated the efficacy of meditation interventions for different at-risk samples. On average, there was no significant effect of meditation either for the samples with a mental disorder or in the studies including participants with somatic issues. In the six studies that tested samples in stressful life situation a marginally significant, medium effect appeared. There were no effects of gender distribution, the age of the participants or the total time of the intervention. In case of the elapsed time after the intervention the effect was non-significant.

4. Study 2:

Short mindfulness-based intervention reduces baseline cortisol levels of boys in first-grade: A randomized controlled trial

4.1 Aim of the study

Based on the results mentioned in the introduction and in Study 1, mindfulness-based interventions seem to have positive effects on executive function skills (Takacs & Kassai, 2019) and stress (Koncz et al., 2021a; Pascoe et al., 2017; Sanada et al., 2016). Accordingly, the present study aimed to test whether a short mindfulness-based intervention right before school entry can improve executive functions kills and lower children's stress levels upon school entry.

4.2 Hypotheses

H4: A short mindfulness-based program enhances children's executive function skills, specifically such as working memory, inhibitory control and cognitive flexibility.

H5: The mindfulness program decreases children's morning cortisol levels compared to the control group.

H6: The mindfulness intervention might protect children from elevated cortisol levels upon school entry on follow-up assessment.

H7: The mindfulness group would show lower cortisol reactivity to an acute stress situation on post-test.

4.3 Methods

4.3.2 Participants

Preschoolers facing school entry were recruited. A total of 62 parents gave consent for their children to participate in the experiment, but the final sample consisted of 51 participants aged 71 to 94 months (M = 81.90, SD = 5.45) and 41% of the sample was male.

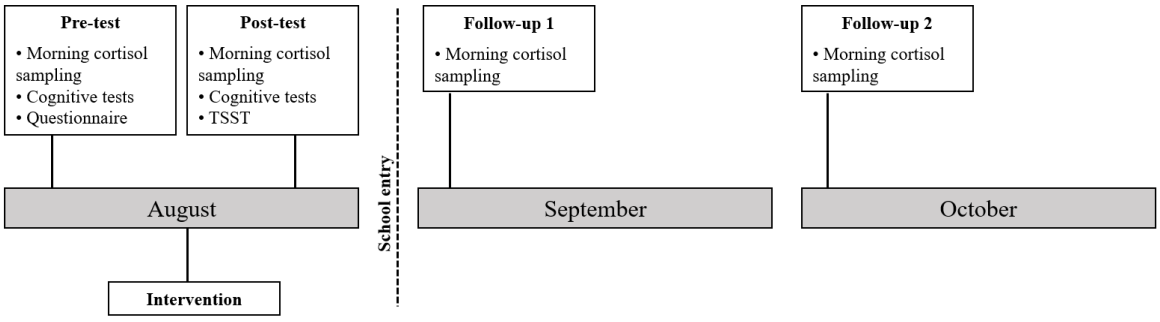
4.3.3 Design

A randomized controlled trial with a between-subject design was applied. Participants were matched based on age, gender and pre-test executive function performance and randomly assigned to the experimental or the passive control group.

4.3.4 Procedure

The experimental group were taken out of the classroom for five 30-minute sessions of mindfulness-based training, while the passive control group attended regular preschool activities. Measurements were implemented on four time points: on the week before (pre-test) and the week after (post-test) the intervention in August in the kindergarten, on the first week of school (first week of September (Follow-up 1)) and one month after school entry (on the first week of October (Follow-up 2)). There was cortisol sampling in the morning upon arrival to the preschool on all four measurement points and an individual session including executive function tests on pre- and post-test. Additionally, we applied the Trier Social Stress Test adapted for children (TSST-C) on post-test following the executive function tests (see Figure 1).

Figure 1.
Timeline of the experiment



4.3.5 Measurement instruments

Baseline cortisol levels and stress reactivity. Sample collection was implemented immediately after participants arrived to preschool or school in the morning. In order to measure cortisol reactivity, we also took saliva more samples before and after the TSST-C procedure.

Digit span forward and backward. For measuring short-term memory and working memory, digit span forward and backward tests were used, respectively (Wechsler, 2003).

Go/No-Go task. We used a modified version of the fish and shark Go/No-Go task (Wiebe et al., 2012) to measure inhibitory control. In this task the participant is asked to press a button for the go stimulus but not to press for the no-go stimulus.

Dimensional Change Card Sort (DCCS). The Dimensional Change Card Sort task (Zelazo, 2006) was used to measure cognitive flexibility.

4.4 Main results

4.4.1 Cognitive skills

We did not find any effect of the intervention on executive function skills and short-term memory.

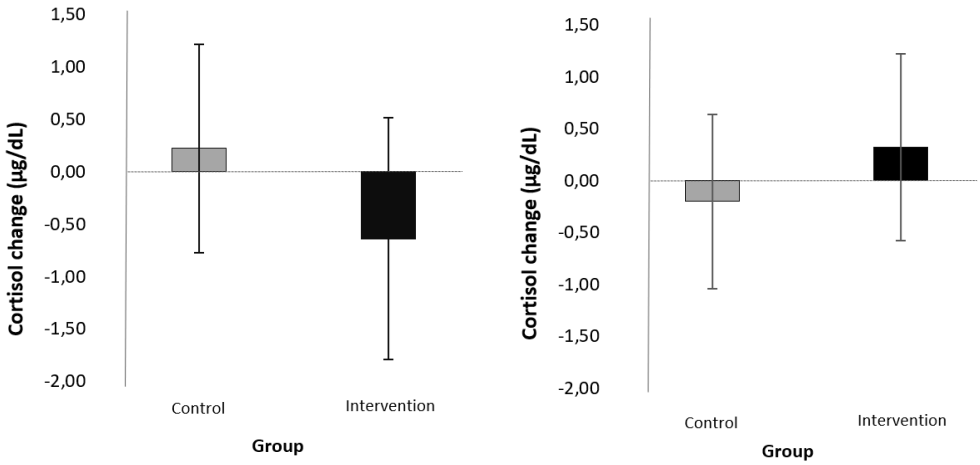
4.4.2 Morning cortisol levels

We found an effect associated with the intervention on the change scores from pre-test to September. We conducted a univariate ANCOVA with the standardised change scores in cortisol values from the pre-test in August to the first week of school in September as the dependent variable, condition and gender as fixed factors and the pre-test and follow-up sampling times as covariates. In this test we found a significant condition x gender interaction (F (1,35) = 5.43, p = .026, η^2 = .134, n = 41).

In order to investigate this interaction, we ran univariate ANCOVAs for boys and girls separately. For the boys the main effect of condition was found large, although it did not reach significance (F (1) = 2.62, p = .128, η^2 = .158, n = 18). More specifically, boys' cortisol levels decreased in the intervention (standardised change score: -0.64 (1.15)) and not in the control group (standardised change score: 0.22 (0.99)) while for girls the effect of the condition was small and not significant (F(1) = 0.29, p = .600, η^2 = .015, n = 23) (See figure 2.).

Figure 2.

Effects of the intervention (change scores and SD) on morning cortisol levels from pre-test to September in boys (left) and girls (right)



4.4.3 Cortisol reactivity

No intervention-related effects were found.

5. Study 3

Benefits of a mindfulness-based intervention upon school entry. A randomized controlled trial.

5.1 Aim of the study

In the present experiment we aimed to test the effects of a similar but slightly longer mindfulness-based program: we extended the intervention by one session to explain what stress is and why stress management is important to put the intervention in context. Additionally, in the present study we applied the intervention right upon school entry for maximal temporal contiguity.

5.2 Hypotheses

H8: A mindfulness program after school entry can reduce children's morning cortisol levels in this stressful life situation.

H9: Children's executive function skills, would be improved.

H10: There would be improvements in children's behaviour problems and prosocial behaviour as a result of the intervention.

5.3 Methods

5.3.1 Participants

First-graders were recruited and 63 parents agreed to participate with their children. The final sample consisted of 61 children (38 boys and 23 girls). The mean age of the participants was 84.95 months (*SD* = 5.21) ranging between 73 and 96 months.

5.3.2 Design

It was a randomised controlled trial with a between-subjects design. Participants were matched based on gender, age and pre-test executive function scores, and randomly assigned to either the experimental or passive control group. The pre-test was implemented on the week before (second week of September) and the post-test on the week after the intervention (third week of October), while a follow-up measurement of salivary cortisol levels was implemented one month after the post-test, that is, on the second week of November (see Figure 3).

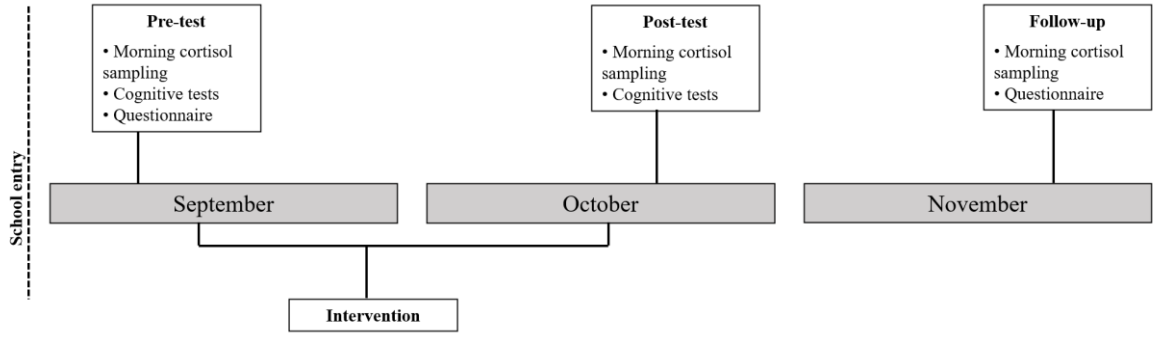
5.3.3 Procedure

Children were taken from the classroom to an empty room in the school for an individual testing session with executive function tests on the pre- and post-test. Morning cortisol samples were collected upon arrival to school on each measurement points (pre-test, post-test and follow-up). Cortisol sampling was timed to mid-week to avoid any differences due to the very first or very last day of the school week.

The mindfulness program for the experimental group started on the third week of September. The program consisted of six sessions of 45 minutes and was applied twice a week in groups of 6-9 children in their own classroom. In addition to the above, parents also completed the Strengths and Difficulties Questionnaire about their own child during the pre-test and follow-up period (for the timeline of the experiment see Figure 3).

Figure 3.

Timeline of the experiment



5 3.4 Measurement instruments

Baseline cortisol levels. As in Study 2 saliva samples were collected.

Corsi forward and backward. For measuring children's short-term and working memory capacity, a computerised version of the Corsi block tapping test was used (Corsi, 1972).

Go/No-Go task. The same Go/No-Go task was used as in study 2 to measure inhibitory control and sustained attention (Wiebe et al., 2012).

Hearts and Flowers task. The Hearts and Flowers task (Brocki & Tillman, 2014) was used to assess cognitive flexibility.

Strengths and Difficulties Questionnaire. The Hungarian parent version of the Strengths and Difficulties Questionnaire (Goodman, 1997) was sent to the parents of the participants before the intervention and on follow-up (one month after the post-test session). Five scales were computed: emotional problems, conduct problems, hyperactivity, peer problems and prosocial behaviour.

5.4 Main results

5.4.1 Cognitive skills

We did not find any effect of the intervention on short-term memory and sustained attention.

5.4.1.1 Corsi backward. Working memory.

Regarding the effects of the intervention there were significant time x condition ($F(1,52) = 4.28$, $p = .044$, $\eta^2 = .076$, $n = 56$) and time x condition x gender (F(1,52) = 7.63, 1,52 p = .008 $\eta^2 =$ 128, $n = 56$) interactions. To disentangle the time x condition x gender interaction effect, we ran ANOVAS separately for boys and girls. In case of the boys there was a significant main effect of time: scores increased from pre-test to post-test regardless of the condition, but there was no significant main effect of condition or a time x condition interaction. For girls there was no significant main effects of time or condition but there was a significant time x condition interaction ($F(1,19) = 9.22$, $p = .007$, $\eta^2 = .327$, $n = 21$). More specifically, the scores of the girls in the intervention condition increased significantly ($F(1,9) = 7.86$, $p = .021$, $\eta^2 = .467$, $n = 10$), from pre ($M = 2.90$, $SD = 1.60$) to post test ($M = 4.30$, $SD = 0.66$) while the scores of the girls in the control condition did not change significantly ($F(1,10) = 1.54$, $p = .242$, $\eta 2 = .134$, $n = 11$).

5.4.1.2 Go/No-Go task. Inhibitory control.

There was a significant time x condition interaction ($F(1,49) = 4.75$, $p = .034$, $\eta^2 = .088$, $n = 53$): errors in the intervention group did not change significantly from pre-test ($M = 6.41$, $SD = 4.31$) to post-test ($M = 6.26$, $SD = 3.88$), while the number of errors in the control decreased significantly ($F(1,24) = 9.05$, $p = .006$, $\eta^2 = .274$, $n = 26$) from pre-test ($M = 8.31$, $SD = 3.81$) to post-test ($M = 6.31$, $SD = 4.47$).

Also, there was a marginally significant time x condition x gender interaction ($F(1,49) = 3.77$, $p = .058$, $\eta^2 = .071$, $n = 53$). For boys there were no significant main effects of time or condition, and no time x condition interaction. For girls, however, while there were no significant main effects of time or condition again, there was a significant time x condition interaction ($F(1,15) = 10.13$, $p = .006$, $\eta^2 = .403$. $n = 17$). More specifically, the number of errors girls in the intervention condition made did not significantly change ($F(1,6) = 10.13$, $p = .122$, $\eta^2 = .351$ $n = 7$) from pre- ($M = 5.14$, $SD = 2.91$) to post-test ($M = 6.43$, $SD = 3.16$), however, the errors girls made in the control condition did decrease ($F(1,9) = 9.47$, $p = .013$, $\eta^2 = .513$, $n = 10$) from pre-($M = 9.00$, $SD = 4.80$) to post test ($M = 5.30$, $SD = 4.17$).

5.4.1.2 Hearts and Flowers task. Cognitive flexibility.

When testing the effect of intervention there was a marginally significant time x condition interaction ($F = 3.03$ (1,49), $p = .088$, $\eta^2 = .058$ $n = 53$). In order to disentangle this interaction, the effect of time was tested separately in the two conditions. Repeated measures ANOVAs with time as a within-subjects factor and gender as a between-subjects factor were run for the two groups. A significant effect of time was found in the intervention group ($F(1,28) = 8.23$, $p = .008$, $\eta^2 = .227$, n = 30) showing that the number of errors decreased from pre-test ($M = 11.55$, $SD = 6.83$) to post-test ($M = 7.83$, $SD = 6.55$). In contrast, the effect of time was not significant in the control group ($F(1,21) = 2.68$, $p = .117$, $\eta^2 = .113$, $n = 23$) (pre-test: $M = 8.22$, $SD = 7.08$, post-test: $M = 7.09$, $SD = 7.54$).

5.4.3 Morning cortisol levels.

No intervention-related effects were found from pre to post-test or follow-up measures.

5.4.4 Strengths and Difficulties Questionnaire.

No intervention-related effects were found in case conduct problems, hyperactivity or peer problems.

Emotional problems.

A marginally significant time x condition interaction was found ($F(1,39) = 3.35$, $p = .075$, $\eta^2 = .079$, $n = 43$). In order to unveil this, we used repeated measures ANOVAs separately for the two conditions, with time as a within-subjects factor and gender as a between-subjects factor. In the intervention group no effects of time or gender and no significant time x gender interaction were found. In the control group, there was no significant effect of gender or a time x gender interaction. There was a significant effect of time in the control group, however ($F(1,17) = 6.22$, $p = .023$, $\eta^2 = .268$, $n = 19$): emotional problems scores increased from pre-test ($M = 1.32$, $SD = 1.11$) to follow-up ($M = 1.89$, $SD = 1.41$) in the control group.

Prosocial behavior.

When testing the effect of the intervention no main effects of time, condition or gender. We did not find any interaction effects between condition x gender or time x condition x gender either. However, a marginally significant time x condition interaction was detectable ($F(1,42) = 3.68$, $p = .062$, $\eta^2 = .081$, $n = 46$). Regarding the time x condition interaction, further analyses showed that in the intervention group there was a marginally significant main effect of time ($F(1,22) = 3.56$, $p = .072$, $\eta^2 = .139$, $n = 24$) showing that children's prosocial behavior increased in the intervention group from pre-test ($M = 7.88$, $SD = 1.70$) to post-test ($M = 8.29$, $SD = 1.70$), while no such effect was found in the control group. There was no significant main effect of gender in the intervention group, however, there was a marginally significant time x gender interaction ($F(1,22) = 3.56$, $p = .072$, $\eta^2 = .139$, $n = 24$). No significant effect of time was found for the boys in the intervention group, but for the girls in the intervention group there was a significant increase in prosocial behavior ($F(1,8) = 8.16$, $p = .021$, $\eta^2 = .505$, $n = 9$) from pre-test ($M = 7.67$, $SD = 2.00$) to post-test ($M = 8.78$, $SD = 0.97$). In the control group no significant main effect of time or gender and no significant time x gender interaction were found.

6. Discussion and limitations

6.1 Discussion and limitations of Study 1:
Meditation interventions efficiently reduce cortisol levels of at-risk samples: A meta-analysis

6.1.1 Discussion of the results of the analyses

These analyses provide a synthesis of all available evidence regarding the efficacy of meditation interventions on the change in participants' cortisol levels in different sampling sources. Effects

were tested not only on the short-, but also on the long-term. Additionally, we assessed whether participants at a risk for elevated cortisol levels benefit more from these interventions as compared to no-risk samples. There was a significant, medium-sized effect of meditation interventions on changes in cortisol levels in blood samples (g = 0.62) that is in line in line with the result of Pascoe et al. (2017). additionally there was a significant, medium-sized benefit of meditation interventions for at-risk samples. More specifically, meditation interventions showed a large, significant effect on cortisol for samples with a somatic illness and no effect for samples with mental problems. Thus, partially in line with our expectations and the mindfulness stress buffering account of Creswell and Lindsay (2014) who predicted more benefits of mindfulness interventions for at-risk samples, but it should be noted that there were only two no-risk samples in the studies focusing on blood cortisol.

When assessing results on salivary cortisol, there was no main effect of meditation interventions or any effects for at-risk or no-risk samples either. However, there was a moderate-sized benefit of these programs for samples living in stressful life situations. A puzzling finding is that meditation interventions showed no effects, based on the available three studies on blood cortisol and three studies on salivary cortisol for participants with a diagnosis or symptoms of a mental disorder.

We intended to conduct meta-regression analyses to test the sustained effect of meditation interventions and we did not find any significant effect of the time between the end of the intervention and the sampling on the effect size on salivary cortisol.

An interesting finding of the present study was the significant effect of the length of the interventions on the effect size in case of blood samples suggesting that longer meditation programs were more effective in stress reduction. We found that meditation interventions might be more effective for men.

6.1.2 Limitations

There was a small number of randomized controlled trials of meditation interventions that provided information on changes in cortisol levels that we could include and they used different sample sources or sampling schedules (one or more sampling occasion per day, sampling on one or more consecutive days). Accordingly, statistical power was low for all subgroup analyses. Additionally, interventions in the primary studies were complex and not described in details making it difficult to determine what exactly happened during the sessions. At-risk

groups and the subgroups are highly heterogeneous groups. Finally, the measurement of cortisol also varied substantially in the primary studies (eg., one samples, daily mean etc).

6.2 Discussion and limitations of Study 2

Short mindfulness-based intervention reduces baseline cortisol levels of boys in first-grade: A randomized controlled trial

6.2.1 Discussion of the results of the analyses

In the present study the effects of a short mindfulness-based intervention were tested on pre-schoolers' short-term memory and executive function skills, morning cortisol levels and cortisol reactivity. We chose a stressful life event, school entry (Groeneveld et al., 2013) to investigate these questions, because it seems that mindfulness-based interventions are effective in stressful life situations as it had been shown in the meta-analysis (Study 1). Our results showed no effects of the mindfulness program on executive functions, the discrepancy in the findings in the present study and the previous literature might be due to relatively short intervention that we applied. However, we found a significant interaction between condition and gender on the change in cortisol levels from pre-test to the first follow-up taken right after started elementary school. That is, cortisol levels of boys in the mindfulness condition decreased, while that of in the control group did not, however this gender x condition effect faded for the second follow-up assessment. This might be explained by the finding that school entry is a stressful life event.

6.2.2 Limitations

The number of the participants was low in the present experiment so it may be worthwhile to repeat the experiment with a larger sample. Cortisol sampling could not be synchronized to waking time, and there was a significant difference between the school and preschool sampling times thus we could not test whether school entry elevated children's cortisol levels. Thirdly, the intervention used in the current study was a short, 5-session program while mindfulness programs are often longer, consisting of about 8 sessions.

6.3 Discussion and limitations of Study 3

Benefits of a mindfulness-based intervention upon school entry. A randomized controlled trial.

6.3.1 Discussion of the results of the analyses

In this study the effects of a six-session long mindfulness-based intervention was observed, compared to a passive control group, on first-graders' executive function skills, cortisol levels, behavior problems and prosocial behaviour. This is a slightly modified version of the previous study (please see Study 2) (Koncz et al., 2021b). First, working memory capacity significantly improved in the mindfulness condition when inspecting data of the girls in the sample. Second, a puzzling finding is children made more errors of inhibitory control after the intervention compared to controls. Third, the mindfulness group improved on cognitive flexibility. Surprisingly, boys in the control condition also did, while the girls did not. it seems that the mindfulness program made somewhat different gains for the executive function skills of boys and girls in the sample. We found no evidence in the present study that the mindfulness intervention reduced children's stress levels. This finding is in contrast to the results of the previous experiment (Study 2). Finally, we found positive effects of the intervention on children's emotional problems and prosocial skills. The mindfulness program seems to have had a protective effect because emotional problems increased over time only in the control and not in the intervention group in line with previous meta-analytical results of Maynard and colleagues' (2017). Additionally, somewhat in line with Cheang and colleagues' (2019) findings, the intervention improved prosocial behavior, but only for girls and not for boys.

6.3.2 Limitations

This study could be methodologically improved by synchronising the timing of all the cortisol sampling to waking, although these samplings were taken in a narrow time frame: between 7:30 to 8:00 a.m. . On the other hand, the intervention was somewhat shorter (6 sessions) than the most commonly used mindfulness programs (about 8 sessions). Additionally, this program included not just mindfulness, but psychoeducational content and yoga embedded in a narrative story.

7. Conclusion

In sum, practicing meditation seems to be effective in reducing cortisol levels in cases where there is a risk of having elevated cortisol. These techniques seem to be also effective for children in case of stressful life circumstances, thus this may be a promising intervention in stressful life situations such as school entry however there may be a gender difference, our results show it could be more effective for boys. In addition to stress reduction, mindfulness also has a role to play in the development of executive functions, but it is conceivable that there may be some gender effect here as well.

8. Main results of the doctoral work

- The stress-reducing effect of meditation-based interventions is greater in case if there is a chance of having elevated cortisol levels.
- The stress-reducing effects of meditation-based interventions have been demonstrated over the long term.
- A short intensive mindfulness intervention right before school entry seem to be protective for boys against elevating their cortisol levels.
- A three-week mindfulness intervention right after starting school improves cognitive flexibility and, in girls, working memory performance.
- A three-week mindfulness intervention right after starting school may be preventive against an increase in emotional symptoms and improve prosocial behavior in girls.
- It is possible that gender has a moderating effect of the effectiveness of mindfulness interventions for stress and executive functions

9. References

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