

# Impact of Natural Products and Mindfulness Practices on Serum Serotonin Levels, Clinical Symptoms, and Mindfulness in Adolescents with ADHD Symptoms

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## ABSTRACT

**Introduction:** Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental condition marked by impulsivity, hyperactivity, and impaired attention (inattention). Pharmacological treatments are often effective but have limitations, necessitating the exploration of alternative therapies. Interventions based on mindfulness (MBIs) have demonstrated effectiveness in alleviating symptoms of ADHD, but their effects on clinical symptoms, serotonin levels, and mindfulness in adolescents have not been thoroughly studied in Indonesia. This study aimed to evaluate the effectiveness of mindfulness-based interventions on the improvement of clinical symptoms, changes in serum serotonin levels, and mindfulness levels in adolescents with ADHD symptoms. **Methods:** A true-experimental design with a randomized controlled trial was employed. ADHD symptoms were screened using the Abbreviated Conners' Teacher Rating Scale (ACTRS) among adolescent students in grades 7 through 9 of junior high school (n = 1067). After meeting all inclusion and exclusion criteria, the study included 28 adolescents aged 12–16 years diagnosed with ADHD, divided into treatment (mindfulness) and control groups. Clinical symptoms were assessed using the SPPAHI questionnaire, mindfulness levels were measured with the CAMM scale, and serum serotonin levels were analyzed pre- and post-intervention. **Results:** The mindfulness group demonstrated notable reductions in clinical symptoms and mindfulness levels in comparison to the control group. There was no notable difference in serum serotonin levels between the two groups. **Conclusions:** MBIs effectively reduced ADHD symptoms and increased mindfulness levels in adolescents. No substantial changes were observed in serotonin levels, indicating that mindfulness impacts behavioral and cognitive aspects more than biochemical markers. These findings suggest that mindfulness may be a valuable complementary therapy for ADHD management in adolescents. **Keywords:** CAMM, mindfulness, serotonin serum, SPPAHI.

## INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a chronic and persistent neurodevelopmental disorder that is commonly found in both clinical practice and the community. This disorder is defined by the presence of three primary symptoms: impulsivity, hyperactivity, and impaired attention (inattention), which are more severe when compared to peers.<sup>1</sup> The global prevalence of ADHD ranges from 3–7% of the primary school population. The male ADHD population is greater than the female population, with a ratio ranging from four to one (Setiawati, 2020). According to the results of research by Thomas et al. (2015), ADHD is a prevalent neurodevelopmental condition, affecting roughly 7.2% of the global population.<sup>2</sup>

Children with ADHD, with predominant inattention, will show symptoms of an inability to focus attention, appearing as a dreamy child, passive, and finding it difficult to socialize with their peers. Meanwhile, children with ADHD, predominantly hyperactive/impulsive, will show symptoms of being naughty, nosy, defiant, and prone to conflict in school and family environments. Most cases of children with ADHD (50–60%) will present sequelae and difficulties in adulthood. They tend to have other psychiatric disorders in adulthood, such as alcohol dependence, antisocial

personality disorder, substance abuse, generalized anxiety disorder, and major depressive episodes.<sup>1</sup>

The etiology of ADHD in children is not known for certain. Several factors are thought to contribute to ADHD in children, including the interaction of genetic factors, brain damage, neurochemicals, psychosocial factors, and the presence of sugar and additives in food (Juniar et al., 2014). Research conducted by Setiawati in 2020 reported that the serotonin (5-HT) concentration in the blood of children with ADHD was found to be elevated relative to that of children without the condition. In contrast, research by Banerjee & Nandagopal (2015) reported that the concentration of 5-HT in the blood was lower among children with ADHD.<sup>3</sup>

The management of ADHD in children involves a multimodal approach, including a combination of pharmacological and non-pharmacological therapies. The best treatments for ADHD in children are psychoeducation, pharmacotherapy, and behavioral therapy,<sup>4</sup> contribute to the mitigation of ADHD symptoms, support better life adaptation, and promote an improved quality of life,<sup>5</sup> as well as improve executive and attentional functions.<sup>6</sup> Pharmacological treatments include stimulants such as amphetamine, methylphenidate, or dextroamphetamine, while non-stimulant drugs like antidepressants and alpha agonists may also be prescribed.

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However, pharmacotherapy for ADHD has been found to be ineffective in 20-35% of children, partly due to lack of medication compliance, side effects, or uncertainty about the long-term effects of medication. Non-pharmacological therapies include family and patient psychoeducation, cognitive behavioral training, and mindfulness-based behavioral interventions.

Mindfulness-based interventions can serve as an alternative therapy to increase self-control, eliminate or correct negative behaviors, and generate positive outcomes. Mindfulness training, which originates from the local wisdom of the Eastern world, encourages participants to cultivate awareness by focusing on the present moment without judgment. Mindfulness is suggested as a self-regulation method to strengthen attentional processes, including orientation, vigilance, and executive attention.<sup>7</sup> Numerous meta-analyses have explored mindfulness-based interventions for individuals with ADHD, revealing their effectiveness in alleviating primary symptoms like inattention and hyperactivity/impulsivity.<sup>8</sup> The effectiveness of mindfulness therapy for ADHD has not yet been studied in Indonesia, nor has this approach been explored within the country's ADHD child and adolescent population. Seeing the potential of mindfulness as a therapeutic modality for ADHD treatment has prompted researchers to explore this issue. This study aims to evaluate the effectiveness of mindfulness-based interventions on the improvement of clinical symptoms, changes in serum serotonin levels, and mindfulness levels in adolescents with ADHD symptoms.

## MATERIALS AND METHODS

This was a true-experimental study using a randomized controlled trial pre- and post-test design. The study was conducted on a research sample of SMPN 3 Krian students school of 2023/2024 between March 2023 and March 2024. ADHD symptoms were screened using the Abbreviated Conners' Teacher Rating Scale (ACTRS) among adolescent students in grades 7 through 9 of junior high school ( $n = 1067$ ). After meeting all inclusion and exclusion criteria, the study included 28 adolescents aged 12–16 years diagnosed with ADHD, who agreed to be involved in the study. They were separated into treatment (mindfulness) and control groups. Each subject drew a lottery number, resulting in odd-numbered individuals being allocated to the treatment group and even-numbered individuals to the control group. The parents of the prospective research subjects were given informed consent forms, which they completed and signed if they agreed to their child's participation in the study. Clinical symptoms were assessed using the SPPAHI questionnaire, mindfulness levels were measured with the CAMM scale, and serum serotonin levels were analyzed pre- and post-intervention using ELISA kit for human serum serotonin.

SPPAHI (Indonesia Hyperactive Child Behavior Assessment Scale) contains items related to behavioral problems in children and is filled out by doctors, teachers, and parents. This scale was developed in Indonesian by Dr. dr. Dwidjo Saputro, Sp.K.J., in 2004, and is adapted to the psychopathological conditions of ADHD children and parents' perceptions of ADHD symptoms in Indonesia. CAMM (Child Adolescent Mindfulness Measurement) is a standalone instrument used to measure mindfulness abilities in adolescents. CAMM has been validated and adapted for the Indonesian child and adolescent population (Saragih & Abidin, 2022).<sup>9</sup>

Data were collected and processed in the form of several distribution tables and were further presented as diagrams according to each distribution. To determine the difference in clinical symptoms and serum serotonin levels in adolescents with ADHD before and after mindfulness intervention, paired t-tests were used if the distribution was normal, or the Wilcoxon Signed Rank Test if the distribution was not normal. To compare clinical symptoms and serum serotonin levels

in adolescents with ADHD who received mindfulness interventions and those who did not, two independent samples t-tests were used if the distribution was normal, or the Mann-Whitney test if the distribution was not normal.

## RESULTS

### Data Characteristics of Research Subjects

According to Table 1, the mean age of the study subjects was  $14.86 \pm 1.027$  in the treatment group and  $14.64 \pm 0.745$  in the control group, with a p-value of 0.533, demonstrating that the age distribution was homogeneous among the study subjects. The statistical analysis demonstrated that the two groups did not differ significantly in terms of gender ( $p = 1.000$ ), further confirming the homogeneity of the data.

The p-value of 0.591 for parental education indicated an even distribution, with the majority of parents having completed secondary school as their highest level of education.

### Analysis of differences in clinical symptoms based on changes in SPPAHI scores in adolescents with ADHD before and after mindfulness therapy

The Shapiro-Wilk test results for SPPAHI difference data, as rated by parents, indicate that the scores for inattention, impulsive hyperactivity, oppositional attitude, social problems, and total SPPAHI were not normally distributed ( $p < 0.05$ ) in both the mindfulness and control groups. Therefore, the Wilcoxon test was used to analyze differences before and after treatment. Similarly, for teachers' reports, the Shapiro-Wilk test showed that inattention, oppositional attitude, social problems, and total SPPAHI scores were not normally distributed in the mindfulness group ( $p < 0.05$ ). Meanwhile, all variables showed a typical distribution pattern within the control group ( $p > 0.05$ ).

Table 3 presents that the Wilcoxon test results in the mindfulness group revealed substantial variations in inattention, impulsive hyperactivity, oppositional attitude, and total SPPAHI scores reported by parents before and after treatment ( $p < 0.05$ ). However, no substantial difference was observed in social problems ( $p > 0.05$ ). For teachers' reports, the Wilcoxon test also showed substantial variations in inattention, oppositional attitude, social problems, and total SPPAHI scores before and after treatment ( $p < 0.05$ ), with the independent samples t-test confirming substantial variations in impulsive hyperactivity ( $p < 0.05$ ).

The control group exhibited no noteworthy variations in inattention, impulsive hyperactivity, oppositional behavior, or social problems reported by parents before and after treatment ( $p > 0.05$ ), except for the total SPPAHI score, which showed a substantial variation ( $p < 0.05$ ).

For teachers' reports, the Wilcoxon test showed no substantial variations in inattention, impulsive hyperactivity, oppositional attitude, or social problems ( $p > 0.05$ ), although a noteworthy variation was found in the total SPPAHI score ( $p > 0.05$ ).

As presented in Table 5, the Mann-Whitney test results demonstrate substantial variations in the SPPAHI scores rated by parents for inattention, impulsive hyperactivity, oppositional attitude, and total SPPAHI scores between the mindfulness and control groups ( $p < 0.05$ ). No meaningful variations were observed in social problems between the two groups ( $p > 0.05$ ).

As presented in Table 5, the Mann-Whitney test results demonstrate substantial variations in the SPPAHI scores rated by teachers for inattention, impulsive hyperactivity, oppositional attitude, and total SPPAHI scores between the mindfulness and control groups ( $p < 0.05$ ). No meaningful variations were observed in social problems between the two groups ( $p > 0.05$ ).

**Table 1: Data characteristics of research subjects.**

	Group		Total	p-value
	Treatment	Control		
Student age	14.86 ± 1,027	14.64 ± 0.745		0.533
Student gender				
Male	12 (85.7%)	12 (85.7%)	24 (85.7%)	1,000
Female	2 (14.3%)	2 (14.3%)	4 (14.3%)	
Parental education				
Junior high school	2 (14.3%)	4 (28.6%)	6 (21.4%)	0.591
High school	10 (71.4%)	9 (64.3%)	19 (67.9%)	
D3 / D4 / S1	2 (14.3%)	1 (7.15)	3 (10.7%)	

**Table 2: Normal distribution test results for SPPAHI difference data.**

	Results of the normal distribution test for the SPPAHI difference data rated by parents		Results of the normal distribution test for the SPPAHI difference data rated by teachers	
	p-value		p-value	
	Mindfulness (n = 14)	Control (n = 14)	Mindfulness (n = 14)	Control (n = 14)
Inattention	0.024	< 0.001	0.005	0.645
Impulsive Hyperactivity	0.003	< 0.001	0.271	0.395
Oppositional Attitude	0.038	-	0.003	0.133
Social Problems	< 0.001	< 0.001	0.001	0.241
Total SPPAHI	0.001	< 0.001	0.006	0.259

**Table 3: Differences in SPPAHI before and after mindfulness group treatment.**

	N	Differences in SPPAHI scores rated by parents before and after treatment in the mindfulness group		Differences in SPPAHI scores rated by teachers before and after treatment in the mindfulness group		
		Median (min-max)	p-value	Mean ± Standard deviation Median (min-max)	p-value	
		Inattention	Pre	14	19 (4-36)	0.001*
	Post		14 (2-18)		15.5 (9-20)	
Impulsive Hyperactivity	Pre	14	5.5 (0-18)	0.025*	± 12.86 5.869	< 0.001*
	Post		4 (0-9)		± 6.93 2.947	
Challenging Attitude	Pre	14	1.5 (0-4)	0.047*	2 (1-5)	0.016*
	Post		1 (0-2)		1.5 (0-2)	
Social Problems	Pre	14	0 (0-2)	1.000	1 (0-3)	0.026*
	Post		0 (0-1)		0 (0-1)	
Total SPPAHI	Pre	14	26.5 (8-60)	0.001*	35.5 (26-77)	0.001*
	Post		19.5 (6-30)		23.5 (17-30)	

\*Significant

**Table 4: Differences in SPPAHI before and after control group treatment.**

	N	Differences in SPPAHI scores rated by parents before and after treatment in the control group		Differences in SPPAHI scores rated by teachers before and after treatment in the control group		
		Median (min-max)	p-value	Mean ± Standard deviation	p-value	
		Inattention	Pre	14	21 (2-35)	0.054
	Post		21.5 (2-34)		26.07 ± 11.276	
Impulsive Hyperactivity	Pre	14	8.5 (0-15)	0.180	12.21 ± 5.860	0.434
	Post		8.5 (0-15)		13.00 ± 6.102	
Challenging Attitude	Pre	14	2 (0-3)	1.000	2.50 ± 1.653	0.374
	Post		2 (0-3)		2.93 ± 1.542	
Social Problems	Pre	14	0 (0-1)	0.317	0.71 ± 0.825	0.671
	Post		0 (0-1)		0.86 ± 1.027	
Total SPPAHI	Pre	14	32.5 (2-48)	0.027*	43.86 ± 17.101	0.033*
	Post		33.5 (2-49)		42.86 ± 17.386	

\*Significant

### Analysis of serum serotonin differences in adolescents with ADHD before and after mindfulness therapy

Table 6 shows that the Shapiro-Wilk test results for serum serotonin levels were normally distributed ( $p > 0.05$ ) in both groups. Therefore, the paired t-test was used to analyze differences before and after treatment.

Based on Table 7, the paired t-test showed no substantial variations in serum serotonin levels before and after treatment in both the mindfulness and control groups ( $p > 0.05$ ).

According to the data in Table 8, the independent samples t-test showed that serum serotonin levels did not differ significantly between the mindfulness group and the control group ( $p > 0.05$ ).

### Analysis of differences in CAMM scores in adolescents with ADHD before and after mindfulness therapy

Table 9 shows that the Shapiro-Wilk test results indicate the CAMM scores in the mindfulness group were not normally distributed ( $p < 0.05$ ), whereas in the control group, they were normally distributed ( $p > 0.05$ ).

Table 10 shows that the Wilcoxon test results revealed substantial variations in CAMM scores before and after treatment in the mindfulness group ( $p < 0.05$ ), while the control group's paired t-test results indicated no substantial variations ( $p > 0.05$ ).

Table 11 shows the Mann-Whitney test results, indicating a substantial variation in CAMM scores between the mindfulness and control groups ( $p < 0.05$ ).

**Table 5: Differences in SPPAHI before and after treatment between the mindfulness and control groups.**

Difference	Group	N	Differences in the SPPAHI scores of the mindfulness and control groups rated by parents before and after treatment		Differences in the SPPAHI scores of the mindfulness and control groups rated by teachers before and after treatment	
			Median (min-max)	p-value	Median (min-max)	p-value
Inattention	Mindfulness	14	-4 (-19-(-1))	< 0.001*	-7 (-34-(-3))	0.001*
	Control	14	0 (-1-9)		-2.5 (-9-7)	
Hyperactivity Impulsivity	Mindfulness	14	-1 (-15-2)	0.007*	-5 (-14-(-1))	< 0.001*
	Control	14	0 (0-2)		1.5 (-8-6)	
Challenging Attitude	Mindfulness	14	0 (-3-1)	0.034*	-0.5 (-4-0)	0.045*
	Control	14	0 (0-0)		-0.5 (-2-3)	
Social Problems	Mindfulness	14	0 (-1-1)	0.578	0 (-3-0)	0.067
	Control	14	0 (0-1)		0 (-2-3)	
Total SPPAHI	Mindfulness	14	-5.5 (-37-(-2))	< 0.001*	-11.5 (-47-(-5))	< 0.001*
	Control	14	0.5 (-1-10)		-1 (-4-2)	

\*Significant

**Table 6: Normal distribution test results for serum serotonin level differences.**

Group	n	p-value
Mindfulness	14	0.524
Control	14	0.097

**Table 7: Differences in serum serotonin levels before and after treatment.**

Group	n	Mean ± Standard Deviation of Serum Serotonin Levels	p-value
Mindfulness	Pre	702,289.29 ± 277,514.956	0.319
	Post	783,812.14 ± 365,907.364	
Control	Pre	719,095.71 ± 189,901.076	0.405
	Post	618,064.93 ± 311,851.372	

**Table 8: Differences in serum serotonin levels between mindfulness and control groups**

Group	n	Mean ± Standard Deviation of Difference in Serum Serotonin Levels	p-value
Mindfulness	14	81,522.86 ± 294,569.910	0.210
Control	14	-101,030.79 ± 439,494.683	

**Table 9: Normal distribution test results for CAMM score differences**

Group	n	p-value
Mindfulness	14	0.002
Control	14	0.961

**Table 10: Differences in CAMM scores before and after treatment.**

Group	n	Mean ± Standard deviation median (min-max) CAMM score	p-value
Mindfulness	Pre	28 (10-38)	0.002
	Post	32 (23-39)	
Control	Pre	26.57 ± 8.419	0.955
	Post	26.64 ± 8.270	

**Table 11: Differences in CAMM scores between mindfulness and control groups.**

Group	n	Median (min–max) CAMM score	p-value
Mindfulness	14	3 (-1–19)	0.045*
Control	14	0.5 (-8–8)	

\*Significant

## DISCUSSION

### Data Characteristics of Research Subjects

Data on the characteristics of research respondents serve to describe their demographic conditions, as well as assess factors that may influence the improvement of ADHD symptoms during the intervention, such as age, gender, and parental education level. Most respondents were male in both the treatment and control groups. The average age of the research subjects in the treatment group was  $14.86 \pm 1.027$  years, and in the control group, it was  $14.64 \pm 0.745$  years. Parental education in both groups was predominantly high school graduates. The characteristics of age, gender, and parental education level all had p-values greater than 0.05, indicating that the data were homogeneously distributed across the characteristics of the research subjects.

The mindfulness training (MT) model was adapted to assist children and adolescents with ADHD by incorporating an array of breath meditations (like focusing on the sensations of breathing), brief activities that promote concentration (such as attentive listening, yoga, and mindful eating), sensory-driven movement exercises, experiential learning techniques, highly organized sessions (which included comprehensive agendas and mindful homework), and enhanced involvement from parents through training, psychoeducation, and engagement in key activities at home.<sup>10</sup>

### Differences in SPPAHI scores rated by parents and teachers in adolescents with ADHD clinical symptoms before and after mindfulness therapy

In the SPPAHI scores rated by parents, there was a substantial variation in the subscores of inattention, impulsive hyperactivity, oppositional attitude, and the total SPPAHI score between the mindfulness intervention group and the control group ( $p < 0.05$ ). However, no substantial variation was found in social problems between the two groups ( $p > 0.05$ ). Similarly, in the SPPAHI scores rated by teachers, there was a substantial variation in the subscores of inattention, impulsive hyperactivity, oppositional attitude, and the total SPPAHI score between the mindfulness intervention group and the control group ( $p > 0.05$ ), while no substantial variation was found in social problems as rated by teachers ( $p > 0.05$ ).

According to the study, there was a notable difference in the SPPAHI test results reported by both teachers and parents between the treatment and control groups. These findings align with a meta-analysis conducted by Xue et al. (2019),<sup>8</sup> which demonstrated that mindfulness-based interventions (MBIs) successfully alleviate symptoms of ADHD. This meta-analysis involved 682 participants, including 210 children and 472 adults, with MBIs varying in duration, frequency, and components (19). The results of our study are also in line with a previous study by Abdolazadeh et al. (2021), which highlighted the beneficial effects of mindfulness in reducing clinical symptoms in adolescents diagnosed with ADHD. Our study, as indicated by the SPPAHI questionnaire results post-mindfulness intervention, showed promising improvements in the clinical symptoms of adolescents with ADHD.<sup>11</sup>

Parents have reported that MBIs lead to a decrease in impulsivity, inattention, and hyperactivity in their children.<sup>12</sup> A study by Soamya &

Singh (2015) found that mindfulness therapy effectively reduced ADHD symptoms and improved self-esteem in adolescents with ADHD, making it a valuable therapeutic tool.<sup>13</sup> Additionally, a meta-analysis by Cairncross & Miller (2016) showed that mindfulness-based therapy (MBT) appears to provide benefits in alleviating ADHD symptoms. A systematic review and meta-analysis further confirm that MBIs significantly impact the severity of key symptoms, namely inattention, impulsivity, and hyperactivity.<sup>14</sup> However, insufficient methodological evidence led the authors to conclude that the effectiveness of MBIs cannot be fully endorsed, owing to the few studies available, variability between those studies, and a high potential for bias.<sup>15</sup>

### Differences in serum serotonin in adolescents with ADHD clinical symptoms before and after mindfulness therapy administration

In our study, there was no substantial variation in serum serotonin levels between the mindfulness treatment group and the control group ( $p = 0.210 > 0.05$ ). Findings related to circulating serotonin in ADHD patients have been inconsistent in previous studies. Evidence from multiple studies reveals that children with ADHD usually have diminished blood serotonin levels when compared to control groups (Saul and Ashby, 1986; Spivak et al., 1999; Banerjee & Nandagopal, 2015; Wang et al., 2018). Research conducted by Setiawati in 2020 reported that the blood serotonin (5-HT) levels of children with ADHD were higher than those of normal children. Another study did not find such differences, showing no substantial variations in blood serotonin between groups of normal children and children with ADHD.<sup>16</sup>

Additionally, the clinical evaluation of behavioral signs in individuals with ADHD was carried out, utilizing various behavioral scales for comparison against control dogs. The results obtained in the animal study showed that behavioral signs consistent with ADHD-like disorders were associated with decreased concentrations of serum serotonin and dopamine neurotransmitters in dogs.<sup>17</sup>

### Differences in CAMM scores in adolescents with ADHD clinical symptoms before and after mindfulness Therapy Administration

There was a substantial variation in CAMM scores between the mindfulness intervention group and the control group ( $p = 0.045 < 0.05$ ). These results support the findings of a systematic review conducted by Lee et al. (2022), which demonstrated the benefits of MBIs for children with ADHD.<sup>18</sup> According to Abdolazadeh et al. (2017), adolescents with ADHD showed improved levels of mindfulness, as assessed by the Mindful Attention Awareness Scale (MAAS).<sup>11</sup> Our study yielded similar outcomes, with substantial variations observed in CAMM questionnaire scores between the treatment and control groups.

Sustained mindfulness is essential for maintaining attentive states and achieving positive outcomes related to ADHD. Studies indicate that engaging in mindfulness practices enhances an individual's capacity for attention and concentration, which are common impairments in individuals with ADHD, who experience diminished attention to conflict, which is critical for self-regulation. Mindfulness training improves this cognitive process. An investigation into conflict attention through brain imaging have shown that the prefrontal cortex plays a role, and parallel studies examining brain activity in ADHD individuals revealed that the same prefrontal region was activated before and after mindfulness training. Studies reveal that mindfulness training can help lower impulsivity, a typical characteristic of those who have ADHD. Individuals with ADHD score lower on trait mindfulness measures than individuals without ADHD. Participants in a study focused on adults with ADHD reported that mindfulness played a crucial role in boosting their overall functioning.<sup>19</sup>

Research utilizing neuroimaging has indicated that emotion dysregulation in ADHD patients practicing mindfulness meditation is linked to overlapping regions of the brain. Improved emotion regulation following mindfulness training was linked to specific brain regions, including the prefrontal cortex, hippocampus, and amygdala. Patients with ADHD are known to experience emotional functioning linked to these areas. As demonstrated, the utility of mindfulness training as a treatment for ADHD in adolescents is underscored by its ability to enhance emotional regulation and mitigate inattention.<sup>20</sup>

## LIMITATIONS OF THE STUDY

In this study, no analysis was conducted to determine the presence or absence of changes in serotonin levels in relation to clinical sub-symptoms (inattention, hyperactivity, impulsivity) in adolescents with ADHD after the mindfulness intervention.

## CONCLUSION

There was no substantial variation in serum serotonin levels between the mindfulness treatment group and the control group. However, a substantial variation was found in the subscores for inattention, impulsive hyperactivity, oppositional attitude, and total SPPAHI scores from parents between the mindfulness treatment group and the control group, while there was no substantial variation in social problems. Similarly, substantial variations were observed in the subscores for inattention, impulsive hyperactivity, oppositional attitude, and total SPPAHI scores from teachers between the mindfulness treatment and control groups, although there was no substantial variation in social problems. Furthermore, a substantial variation was found in CAMM scores between the mindfulness treatment group and the control group.

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## DISCLOSURE

The authors have stated their absence of any conflicts of interest regarding this study.

## AUTHORS' CONTRIBUTIONS

DD, SY: Conceptualization and design of the study. DD, AF, YA: Data collection. KR, SY: Analysis. AA: Statistical consultant. MA: Proofreading and methodological consultant.

## ETHICAL CONSIDERATION

This research has met the ethical approval of the Ethics Committee of the Faculty of Medicine, Universitas Airlangga No.109/EC/KEPK/FKUA/2023.

## DATA AVAILABILITY

This Article contains all the necessary data to support the results; no supplementary source data is needed.

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