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Research Article

Sensory Integration Therapy Efectivity Of *Attention Deficit Hyperactivity Disorder* Symptoms Improvement And Dopamine Serum Levels

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Abstract
Background: Attention Deficit Hyperactivity Disorder (ADHD) is a neurobiological disorder with symptoms of abnormal and disruptive inattention, hyperactivity and impulsivity. This condition can cause functional impairment in several different conditions, and these behaviors are found to be present at least 6 months.
Objective: Proving the effect of sensory integration therapy on ADHD, as evidenced by improvements in symptoms and plasma dopamine levels.
Method: The type of experimental research with the research method "pre-post test with control group design non-blinding", consecutive sampling, in children with ADHD symptoms and have not received psychopharmacological therapy. The experimental and control groups were scored for ADHD symptom assessment using the validated Indonesian version of ACTRS and serum dopamine levels were examined. The experimental group was given SIT for 4 weeks. Data analysis used the paired t test.
Results: ACTRS scores before and after the intervention in the control group with a pvalue (0.180) and the experiment, the results showed that there was no significant difference in the control group and there was a significant difference in the treatment group with a pvalue (0.006). There was a significant change in the difference in the average observation of ACTRS scores in the control and treatment groups before and after the intervention with a significance value of 0.001 <alpha (0.05). The presence of sensory integration therapy affected the plasma dopamine levels of ADHD children with a pvalue of the control group of 0.003 and the treatment class of 0.028. There was no difference in dopamine levels between the control and treatment groups.
Conclusion: There is a significant relationship between changes in ADHD symptoms and changes in dopamine levels, namely ADHD symptoms with increased ACTR scores, then dopamine scores experience a decrease in dopamine levels.
Keywords: ACTRS, ADHD, Plasma Dopamine Levels, Sensory Integration Therapy.

Key Word : ACTRS, *ADHD*, Dopamine Plasma Levels, Sensory Integration Therapy, Human and Healty

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Introduction

Before knowledge about children's mental health developed, parents and society assumed that children with overactive behavior, cannot stand still behavior, and difficulty receiving lessons were naughty children, so they gave the children sanctions even with verbal and physical violence. As time goes by and the knowledge is developed, that behavior is known as one of a child's growth and development disorders called ADHD.

Attention Deficit Hyperactivity Disorder (ADHD), is a behavioral disorder with hyperactivity, impulsivity, and inattentiveness symptoms, based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM)-5. [1] Risk factors of ADHD caused by various factors like genetics, neurochemical, neurophysiological, neuro-anatomical aspects, developmental factors, and psychosocial factors .[2] Based on ADHD institute, ADHD and 21 non-ADHD) Children from grades 1 to 6 were included in the study. Based on the gender, 13 children were girls, and 31 were boys. Serotonin levels in ADHD children were significantly higher than in non-ADHD children (2.148 ± 0.94 vs 2.006 ± 0.115 μmol/L; p = 0.0001).[3] Several factors causing ADHD are related to the decrease in brain volume and activity, such as lack of activity in the prefrontal cortex, anterior cingulate cortex (ACC), globus pallidus, caudate, and visual thalamus, cerebellar, dopaminergic, dysfunction, hyponorepinephrine, and low birth weight, infections during pregnancy and cerebral blood flow disorder. [4]

Regarding dopaminergic dysfunction, which causes decreased dopamine levels, which can affect concertation disorder, anxiety, impulsivity, and sensory integration dysfunction, dopamine is often linked to the etiology of ADHD. [5] Several previous studies found no difference in CNS dopamine levels with plasma, and there was a slight decrease in metabolic dopamine levels.[6] Sensory integration dysfunction in children with ADHD can impact their response to sensory events daily. Hence, the levels of sensory seeking become higher, and this causes the impression of being more aggressive and naughty compared to the other children without ADHD symptoms.[7]

Sensory Integration Therapy aims to improve recognizing, distinguishing, and changing sensory, producing adaptive goals or responses such as controlling emotions, impulsivity, cognition, and hyperactivity. Early detection and management of sensory processing problems can play an essential role in improving cognitive performance in children with ADHD.[8] Sensory integration is a concept that has existed for approximately 50 years and was developed to improve and enhance children's growth and development.[9] This study aims to prove the effect of Sensory Integration Therapy on ADHD children, with proof of the improvements in symptoms and plasma dopamine levels.

Methods

This study used primary data from research on 14 samples of students with ADHD symptoms in SDN Klampis Surabaya. It is an experimental study with pre-post-research and control group designs. Research subjects were divided into two groups, namely, a control group and a treatment group. In the treatment group, Sensory Integration Therapy was carried out on students with ADHD symptoms for four weeks. Research subjects were taken using consecutive sampling. Students who met the research criteria were chosen to become subjects in the study. Then, seven students were found, and they were grouped into the control group and the treatment group.

Taking Sample Criteria in this research, a sample size formula was used to compare two medians. The sample was obtained from 14 students of SDN Gubeng aged 9-10 years old with ADHD symptoms and divided into two groups: a control group and a treatment group. The criteria are divided into inclusion and exclusion. Inclusion criteria are students with all ADHD types (inattention, hyperactivity-impulsivity, and mixed type) based on DSM -5 criteria; ACTRS scoring was carried out the students aged between 9-and 12 years old and who had never been consulted with psychiatrists or got any ADHD therapy, and also their parents. Their parents/nanny participated in the research by signing informed consent.

Exclusion criteria are ADHD students who have comorbid organic mental disorders (such as *epilepsy, cerebral palsy)*, comorbid with bipolar disorder, tics, obsessive-compulsive disorder, oppositional attitude disorder, behavioral disorders, anxiety disorders, mental retardation, autism disorders, history of global development delay, premature birth, and congenital abnormalities. The last criterion is the dropout criteria. The criteria are students who leave the research and do not attend Sensory Integration Therapy twice in a row.

From 1950 until 1960, A. Jean Ayres, an occupational therapist, developed a client–centered theory of sensory integration where the target of sensory integration therapy was to help children adapt to the environment and increase independence in activities to process and use sensory information.[10] This research uses Sensory Integration Therapy as an independent variable. Symptom improvement (inattention, hyperactivity, and impulsivity) as a dependent variable. Age, gender, genetic factors, parenting patterns, global development delay, LBW, physical comorbidities, and psychological factors are confounding variables.

This research uses the ACTRS questionnaire (*Abbreviated Conner's Teacher Rating Scale)* as the instrument. ACTRS is an ADHD screening measurement scale developed by C. Keith Conners, Ph.D and validated by Dr. Sasanti Yuniar in 1989. Each item is a form of child/student behavior in the last 6 months. The following are the items from the questionnaire. Respondents will provide answers with

code numbers 0 (not at all), 1 (very often), 2 (quite frequently), and 3 (almost always).

a) No fatigue or excessive activity
b) Easily excited, impulsive
c) Bother other kids
d) Failed to complete the activity that has begun, short attention span
e) Moving body parts or head continuously
f) Menggerak-gerakkan anggota badan atau kepala secara terus menerus
g) Lack of attention, easily distracted
h) The request must be fulfilled immediately, Easily get frustrated
i) Frequent and easy crying
j) The mood changed quickly and drastic
k) Explosions of annoyance, explosive and unpredictable behavior

Student respondents who had a score of 12 or more were stated to have ADHD symptoms.

After that, students with ADHD symptoms are given Sensory Integration Therapy activities individually by a therapist, with a playing style model and according to sensory focus. Target in the first week consists of touch (tactile) targets such as playing playdough, Heavy hand, Magic Tissue Transfer, and *Go away glue.* The other target is *Balance and Movement* (Vestibular), which consists of T-Stool, Looby Loo, Matthew's Teeter-Tooter activities, and Gentle Roughhousing.

There are two Body Position (Proprioceptive) targets on the second week, such as paperback kick, bottle babies, fun with rope, and plastic bag kite) and visual activities (backyard cleaning, Pokin's O's, guest animation with objects, and Beanbag Jai Alai). The third week's targets are auditory with activities (paper plate dance, matching sound, hear, see and move, and musical hoop) and olfactory and gustatory with activities (Smell and taste, taste and tell and eat lettuce and scented flashcards).

Two targets in the fourth week are oral motor and motor skills with activities (jelly through a straw, spirited shepherds, shoebox path, and puffin stuff), and also motor skills and bilateral coordination with activities (Toothpick construction, Bubble wrap burst, Squeeze a Breeze, and Clapping bubbles). All sensory integration therapy activities are carried out for 30 minutes for each activity. After sensory therapy, venous blood samples will be taken again via the median cubital vein for both the case group and the control group. First, 3 mL of blood is taken using a venoject tube for Dopamine examination. Then the blood centrifuged at 2000 rpm for 5 minutes; the appears serum put into an aliquot tube and examined using the enzyme-linked immunosorbent assay method.

The following step are research step on this study.

1. *Ethical Clearance*
2. Ask the principal for approval
3. Examination of children with ADHD symptoms based on inclusion and exclusion criteria.
4. In the inclusion criteria, information for consent was obtained.
5. Provide *inform Consent*
6. Examination of plasma dopamine levels
7. Checking dopamine levels before integration therapy was applied in both of control group and treatment group.
8. After 4 weeks of sensory integration therapy applied at the treatment group, dopamine levels in the control group were examined and experiment was carried out to see the differences.
9. After the research was completed, the next step are data collection and analysis (data analysis used the statistical method t test and Wilcoxon test)

Making research results reports and drawing conclusions.

Result

The results of this research are the characteristic profile of the research sample, the difference in ACTRS scores before and after the intervention in the control and treatment groups, and the difference in dopamine levels before and after the intervention in the control and treatment groups. This research was conducted experimentally at SDN Gubeng 1 Surabaya from June to August 2023. The research subjects were 14 students who were divided into two groups: 7 students in the control group and 7 students in the experimental group. The experimental group received sensory integration therapy treatment for 4 weeks, and no research subjects dropped out during the research process.

Table 1. Profile of Research Sample Characteristics

Characteristics	Control (n = 7)	Treatment (n =7)
Gender		
Male	7 (100%)	3 (42,9%)
Female	0 (0%)	4 (57,1%)
Age (years)		
9 th	0 (0%)	1 (14,3%)
10 th	7 (100%)	6 (85,7%)

Based on Table 1, the respondents in the control group are seven male students. While the treatment group is dominated by female students in number 4 students (57,1%). The remaining three students are male (42,9%).

Table 2. Average Value and Standard Deviation of ACTRS Variables and Dopamine Levels Before and After Intervention in Control and Treatment Groups

	Average ± Standard deviation	
	Control (n=7)	**Treatment (n=7)**
ACTRS		
Pre	23,71 ± 4,386	29,14 ± 3,436
Post	23,00 ± 4,320	21,57 ± 2,992
Dopamine Levels (ng/mL)		
Pre	50,578 ± 9,826	54,032 ± 7,649
Post	67,922 ± 0,315	67,651 ± 0,535

Respondent characteristics based on their age, in the control group all of them aged 10 years old. While in the treatment group dominated by students aged 10 years old in number 6 students (85,7%). The remaining 1 student aged 9 years old (14,3%) (Table 2). The average value and standard deviations of the ACTRS variables and Dopamin Levels before and after intervention in the control and treatment groups. Based on the number of average values and standard deviations, there is no significant difference in ACTRS score in the control group between before and after treatment. There are substantial differences between ACTRS scores before and after the treatment in the treatment group because the score has decreased. Dopamine levels increased in the control group after treatment. However, sensory integration therapy treatment did not have a significant effect because the average change in the control group was more significant than in the treatment group, which was treated by sensory integration therapy.

Table 3. Differences in ACTRS scores before and after intervention in the control and treatment groups

	n	**Average Simp. standard Median (min – max)**	**Difference**	**p-Value**
Control				
ACTRS Pre	7	26 (16 – 27)	0	0,180
ACTRS Post		25 (16 – 27)	(-4 – 0)	
Treatment				
ACTRS Pre	7	29,14 ± 3,436	-7,57 ± 1,512	0,006
ACTRS Post		21,57 ± 2,992		

Normality testing is carried out to determine whether a variable is normally distributed or not. The following are the results of the ACTRS data normality test. The results show that the difference in ACTRS data before and after sensory integration therapy treatment in children with ADHD symptoms in the control class has a significance value of less than 0.001 so the data is not normally distributed. The difference in ACTRS data before and after sensory integration therapy treatment for children with ADHD symptoms in the treatment class has a significance value of 0.501 or greater than the P-value (0.05), so it can be said that the data follows a normal distribution. Wilcoxon test applied at ACTRS *pretest* score in control group before and after treatment. The result showed there is no significant difference ACTRS score between before and after intervention, with significance value 0,180 (p > 0,05) (Table 3).

Based on the paired t test, showed that there was a significant difference in ACTRS scores before and after intervention in the treatment group ($p < 0.05$). *Abbreviated Conner's Teacher Rating Scale* (ACTRS) score decreased from 29,14 become 21,57 in the treatment group. While in the control group there is no significant difference, because the average ACTRS score tended to remain at 23. This caused by student in the treatment group uents were given Sensory Integration Therapy treatment which was able to reduce the ACTRS score.

Table 4. Differences in Dopamine Levels Before and After Intervention in Control and Treatment Groups

	n	**Average Simp. standard Median (min – max)**	**Difference**	**p-Value**
Control				
Dopamine level pre	7	50,578 ± 9,8259	17,343 ±	0,003
Dopamine level Post		25 (16 – 27)	9,7241	
Treatment				
Dopamine level Pre	7	49, 233 (49,203 – 69,941)	17,909	0,028
Dopamine level Post		67,571 (67,008 – 68,696)	(-2,37 – 26,93)	

Based on testing using the *Paired Samples Test* method the results showed that the significance value of dopamine levels in the control group before and after treatment was 0.003 or ($P < 0.05$), so that there was a change in the average *Pre test* and *Post test* value of dopamine level data in student with ADHD symptoms in the control group.

The significance value of dopamine levels before and after the sensory therapy experiment in the treatment group was 0.028(P < 0.05). Therefore, it can be concluded that there is a change in the average Pretest and Posttest values of the dopamine level data for the treatment group in children with ADHD symptoms.

Table 5. Differences in ACTRS Scores and Dopamine levels Between Control and Treatment Groups

	n	Median (min – max)	p-Value
ACTRS score			
Control group	7	0 (-4 – 0)	0,001
Treatment group		-8 (-10 – (-5))	
Dopamine levels			
Control group	7	21,567 (-1,9 – 26,93)	0,225
Treatment group		17,805 (-2,37 – 18,55)	

ACTRS score difference pretest and posttest in the control group and treatment group tested using Mann Whitney test because it does not meet the normality assumption. The purpose of Mann Whitney test is to test whether the median difference between data is significant or not. The result is there was change in the average difference of ACTRS score in the control and treatment groups before and after the intervention with a significance value of 0.001 less than alpha (0.05).

Using Mann Whitney test obtained that significant value of the difference in dopamine levels before and after the intervention in the control and treatment group was 0,225 or greater than alpha (0.05). Therefore, it can be concluded that there is no significant difference in dopamine levels between the control and treatment groups (Table 5).

Discussions

Over all this research subject dominated by male student. Wich is there are 10 male students and 4 female students. The previous research states that the number of male ADHD students greater than female ADHD students.[11] Differences gender in ADHD are due to differences in dopamine receptor density. Striatal D2 receptor density in men increaser by 144 +- 26%, whereas D2 receptor density in women increased by only 31+- 7%. Receptor dencity in males then decreases sharply to 55% in adulthood.[12] The mean age of children at risk for ADHD was 4.85±1.47 years. More men were diagnosed than women, but no statistical significance with p = 0.317 (significant if p<0.05).[13]

There are no significant changes in ADHD symptom in the control group. whereas there were significant changes in the treatment group before and after Sensory Integration Therapy. Sensory integration therapy can play an important role in the treatment of patients with ADHD.[14] Another study on 20 Iranian elementary school students with ADHD, showed that 12 sessions of individual sensory integration therapy (2 sessions per week, 30 minutes each) could improve executive function in children with ADHD.[15] Sensory integration therapy had n significant effect, possibly due to the limited time given for therapy.[16]

ADHD scores was assessed using Abbreviated Conners Teacher Rating Scale in Indonesian version. Social Readjustment Rating Scale by Holmes and Rahe was used to assess psychosocial stressor of the mother (Holmes & Rahe, 1967). Serotonin serum level was measured using ELISA method.[17]

There were significant changes in students' dopamine levels before and after treatment in the control class and treatment group. Tough the exact pathogenesis of ADHD is still unclear, if we deduce the mechanism of action of methylphenidate, we can assume that norepinephrine and dopamine play a big role in ADHD.[18]

In children who received therapy, plasma dopamine levels improved compared to children who did not receive sensory integration therapy. This research was conducted on 107 children diagnosed with oppositional defiant disorder and ADHD using the experimental pre-post test with control group design method.[19]

Zinc supplementation (Zn) can improve the symptoms of ADHD by increasing dopamine transporters binding. The aims of this study is to compare the level of Pb and Pb to Zn ratio on the subject of ADHD and normal children.[20]

Conclusion

This research resulted in no significant changes in the ACTRS scores in the control group before and after the research. Whereas there was a significant change in the ACTRS score of the treatment group before and after sensory integration therapy treatment. There were significant changes in dopamine levels of the students before and after treatment in the control group and treatment group.

There was an increase in dopamine levels after sensory integration therapy (playing Touch, Balance and Movement (Vestibular), Body Position, Visual, Auditory, Olfactory and Gustatory, Oral motor and Motor, and Motor and bilateral coordination).

Ethical Clearance

Written informed consent was obtained from all respondents, and confidentiality data were ensured by keeping anonymous for each respondent. Approval for the study was obtained from the Health Research Ethics Committee of Medical School of Airlangga University Surabaya Indonesia with reference number 183/EC/KEPK/FKUA/2023.

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Conflict of Interest

The researcher declares that he has no conflict of interest in the publication of this article.

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