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THE EFFECT OF SENSORY INTEGRATION AND TREADMILL THERAPY ON SENSORY AND BEHAVIORAL IMPROVEMENT IN CHILDREN WITH ATTENTION DEFICIT AND HYPERACTIVITY DISORDER

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ABSTRACT
Attention-Deficit Hyperactivity Disorder (ADHD) is a common neuropsychiatric disorder in children, characterized by inattention, hyperactivity, and impulsivity, which significantly impact daily functioning. Sensory Processing Disorder (SPD) is often observed in children with ADHD, affecting their ability to process and respond to sensory stimuli appropriately. Sensory integration therapy and treadmill exercise have been suggested as potential interventions to improve sensory processing and behavioral regulation in children with ADHD. This study aims to evaluate the effect of sensory integration therapy combined with treadmill exercise on sensory processing and behavior in children with ADHD. This was an experimental study with a pre-test and post-test design was conducted with 61 children diagnosed with ADHD. Participants underwent sensory integration therapy and treadmill exercise. Sensory processing and behavioral outcomes were measured using standardized assessments before and after the intervention. Data were analyzed using the Wilcoxon test. Results: The results showed a significant improvement in sensory processing, with pre-test sensory scores averaging 97.62 and post-test scores increasing to 152.90 ($p = 0.000$). Behavioral outcomes also improved significantly, with pre-test behavior scores of 82.57 decreasing to 67.62 in the post-test ($p = 0.000$). Sensory criteria shifted from 95.1% in the "Definite Performance (severe)" category to 44.3% in the "Typical Performance (mild)" category. Behavioral criteria improved from 75.4% in the "Very High" category to 83.6% in the "High" category. Sensory integration therapy combined with treadmill exercise effectively improves sensory processing and behavioral outcomes in children with ADHD. This intervention provides a promising non-pharmacological approach to managing ADHD symptoms and enhancing children's functional abilities. Further studies with larger samples and long-term follow-ups are recommended to validate these findings

Keywords: adhd; behavior; sensory integration therapy; sensory processing disorder; treadmill exercise

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INTRODUCTION

Sensory Processing Disorder (SPD), also known as sensory integration disorder (Bundy & Lane, 2020), sensory regulation dysfunction, sensory integration dysfunction, or sensory dysfunction disorder, occurs when the brain does not process sensory input correctly. This results in inappropriate behavioral and motor responses, affecting learning, coordination, behavior, and language. SPD can lead to stress, anxiety, or even depression and poses a risk for psychopathology (Galiana-Simal et al., 2020). Children with SPD are generally healthy but often exhibit behaviors that seem unusual or inconsistent with their environment (Ptak et al., 2022).SPD is commonly found in children with developmental coordination disorder (DCD) and attention deficit and hyperactivity disorder (ADHD). However, there is limited knowledge regarding the variability of sensory processing in these disorders (Delgado-Lobete et al., 2020). According to Brain Balance (2023), SPD symptoms vary and are typically classified into hypersensitivity or hyposensitivity. However, the same child may exhibit both over-responsiveness to certain stimuli and sensory-seeking behaviors in other situations. One common sign is poor balance and frequent falls. Sensory integration has been recognized as

an effective therapeutic approach to help children with SPD regulate and process sensory information more efficiently. This therapy aims to enhance sensory integration and responsiveness to sensory stimuli. Additionally, treadmill exercises have shown benefits in improving balance, coordination, and motor skills in children with SPD. Alongside sensory integration, treadmill therapy is another intervention that can be beneficial. A study by Alipour et al. (2022) concluded that moderate exercise might be a useful protocol for treating autism spectrum disorder (ASD).

One of the conditions associated with SPD is ADHD, defined as a persistent pattern of inattention accompanied by hyperactivity and impulsivity. Due to its subtle presentation, ADHD is often undiagnosed, leading many parents to unknowingly handle their child's condition inappropriately (Ayub, 2022). ADHD is a common neurodevelopmental disorder characterized by inattention and hyperactivity-impulsivity (Faraone & Radonjić, 2023). It affects approximately 5% of children across different geographic and cultural populations and often coexists with mood, anxiety, behavioral, learning, and substance use disorders. Longitudinal studies suggest that two-thirds of adolescents with ADHD continue to experience symptoms into adulthood. Individuals with ADHD are at risk of various functional impairments, including academic failure, peer rejection, accidental injuries, criminal behavior, job loss, divorce, suicide, and premature death. Although the exact pathophysiology of ADHD remains unclear, neuropsychological and neuroimaging studies indicate involvement of brain circuits related to executive function, reward processing, timing regulation, and temporal information processing (Faraone & Larsson, 2019).

One promising intervention for children with SPD is treadmill training. Physical exercise using a treadmill has been shown to provide benefits for both physical and mental health in individuals with sensory disorders. However, research specifically examining the effects of treadmill therapy on sensory and behavioral improvements in children with SPD remains limited. Treadmill training may help enhance sensory integration in children with SPD. According to Bella (2023), a treadmill is an exercise device used for walking or running in a fixed location. As outdoor air quality declines, treadmill-based exercise has become increasingly popular for home use.Although sensory integration therapy and treadmill training have individually proven beneficial, limited research has explored their combined effects on sensory and behavioral improvements in children with SPD and ADHD. However, in clinical settings, the integration of both therapies is commonly practiced for children with these conditions. Therefore, further research focusing on the combined impact of sensory integration and treadmill therapy on sensory and behavioral improvements in children with SPD and ADHD is essential for enhancing understanding and developing more effective interventions for these children. This study aims to evaluate the effectiveness of combining sensory integration therapy and treadmill training in improving sensory processing and behavioral outcomes in children with SPD and ADHD.

METHOD

This study employs a quasi-experimental design with a pre-test and post-test one-group approach. It aims to analyze the effect of sensory integration and treadmill intervention on sensory and behavioral improvement in children with ADHD.The conceptual framework is a structured and measurable theoretical model developed in healthcare and other disciplines to link findings with scientific knowledge. The research framework is systematically arranged to derive conclusions.This study was conducted at Kreasi Center Bogor, focusing on children diagnosed with ADHD. The research population comprised children with ADHD at the center, with a sample consisting of randomly selected children aged 5–12 years. Using random sampling with a 5% margin of error, the minimum sample size was determined to be

60 children based on the Krejcie-Morgan table.The study examined two independent variables: sensory integration therapy and treadmill therapy. Sensory function and behavior were assessed as dependent variables. Sensory function was measured using the Sensory Profile, while behavior was evaluated through the Behavior Intervention Rating Scale.

Sensory integration therapy targeted vestibular, visual, and proprioceptive sensory processing through activities involving mushroom swings, gym balls, peanut balls, and wedges. This intervention was conducted twice a week for six weeks, with sensory outcomes assessed using the Sensory Profile. Meanwhile, treadmill therapy aimed to improve motor coordination, muscle strength, and focus through direct observation and measurement-based interventions. It was also conducted twice a week for six weeks and evaluated through therapist assessments and parent reports using standardized questionnaires.Data collection involved interviews and questionnaires, with sensory function and behavior assessments conducted before and after the intervention. The study took place from November to December 2024. Data processing included editing, coding, entry, and cleaning to ensure accuracy. Statistical analysis involved univariate and bivariate tests, with normality testing using the Shapiro-Wilk test. Parametric tests (paired t-test) were applied for normally distributed data, while non-parametric tests (Wilcoxon test) were used otherwise, all analyzed using SPSS version 26.Ethical considerations were strictly followed, ensuring informed consent from participants and guardians, maintaining anonymity and confidentiality, and securely storing collected data. The study findings were specific to the research population and not intended for generalization beyond the study scope.

RESULT

Table 1. shows that based on gender; the number of males exceeds the number of females. Based on age, the largest group consists of children aged 6-12 years. Based on type, Type 3 is the most common.

Table 1.
Respondent Characteristics (n = 61)

Characteristics	f	%
Gender		
a. Male	48	78.3
b. Female	13	21.3
Total	61	100.0
Age		
a. 1-5 years	11	18.0
b. 6-12 years	50	82.0
Total	61	100.0
Type		
a. Type 1	8	13.1
b. Type 2	13	21.3
c. Type 3	40	65.6
Total	61	100.0

Table 2.
Sensory Criteria Before and After Sensory Integration and Treadmill Therapy

Sensory Criteria	Pre-test		Post-test	
	f	%	f	%
a. Typical Performance (mild)	0	0.0	27	44.3
b. Probable Difference (moderate)	3	4.9	21	34.4
c. Definite Performance (severe)	58	95.1	3	21.3
Total	61	100.0	61	100.0

Table 2 shows that in the pre-test, most of the participants (95.1%) were in the definite performance (severe) category, while in the post-test, the majority (44.3%) were in the typical performance (mild) category.

Table 3.
Behavior Criteria Before and After Sensory Integration and Treadmill Therapy

Behavior Criteria	Pre-test		Post-test	
	f	%	f	%
a. Low	0	0.0	2	3.3
b. Moderate	2	3.3	6	9.8
c. High	13	21.3	51	83.6
d. Very High	46	75.4	2	3.3
Total	61	100.0	61	100.0

Table 3 above shows that in the pre-test, most participants (75.4%) were in the very high category, while in the post-test, the majority (83.6%) were in the high category.

Table 4.
Sensory Scores Before and After Sensory Integration and Treadmill Therapy

Sensory Score	f	Mean	SD	p-value
Pre-test	61	97.62	23.432	0.000*
Post-test	61	152.90	12.609	
Difference	61	55.28	22.297	

Note: Wilcoxon test

Based on Table 4, it can be explained that after the administration of sensory integration and treadmill therapy, the pre-test sensory score was 97.62, while the post-test score increased to 152.90. This indicates a significant improvement in sensory processing. The Wilcoxon test resulted in a p-value of 0.000 (<0.05), meaning that sensory integration and treadmill therapy have a significant impact on sensory processing.

Table 5.
Behavior Scores Before and After Sensory Integration and Treadmill Therapy

Behavior Score	**f**	Mean	SD	p-value
Pre-test	61	82.57	7.647	0.000*
Post-test	61	67.62	8.660	
Difference	61	14.95	6.990	

Based on Table 5, it can be explained that after the administration of sensory integration and treadmill therapy, the pre-test behavior score was 82.57, while the post-test score decreased to 67.62. This indicates a significant improvement in behavior. The Wilcoxon test resulted in a p-value of 0.000 (<0.05), meaning that sensory integration and treadmill therapy have a significant impact on behavior.

DISCUSSION

The implementation of sensory integration and treadmill therapy resulted in a pre-test sensory score of 97.62 and a post-test score of 152.90. This indicates a significant improvement in sensory processing. The Wilcoxon test yielded a p-value of 0.000 (<0.05), meaning that sensory integration and treadmill therapy have a significant effect on sensory processing in children with ADHD.ADHD is a common neuropsychiatric disorder associated with significant impairments and distress throughout life (Leffa et al., 2022). It is one of the most frequently diagnosed disorders in child and adolescent psychiatry, with a prevalence of over 5% (Drechsler et al., 2020). This study aligns with the findings of Sholeha et al. (2023), which stated that sensory integration has an impact on gross motor skill changes at the Yamet Child Development Center, East Surabaya branch, with a p-value of 0.001 (p<0.05).

The combination of sensory integration and treadmill therapy has been proven effective in improving sensory processing in children with ADHD. Sensory integration therapy focuses on stimulating the vestibular, proprioceptive, and tactile systems, helping children better understand their body position in space and respond to sensory information in a more organized manner. Meanwhile, treadmill exercises provide aerobic activity that stimulates the release of neurotransmitters such as dopamine and norepinephrine, which play a crucial role in enhancing focus, attention, and behavioral regulation. The synergy between these two therapies helps improve gross motor skills, body coordination, and energy regulation, which often triggers hyperactive behavior. This holistic approach benefits children with ADHD in terms of sensory processing, cognitive function, and behavioral regulation.The implementation of sensory integration and treadmill therapy resulted in a pre-test behavior score of 82.57 and a post-test score of 67.62, indicating a significant improvement in behavior. The Wilcoxon test yielded a p-value of 0.000 (<0.05), meaning that sensory integration and treadmill therapy have a significant effect on behavioral improvement in children with ADHD.

Sensory integration involves activities that regulate the sensory system by providing vestibular, proprioceptive, auditory, and tactile input, which helps reduce hyperactive behavior and promote constructive behavior in children with ADHD (Watari et al., 2021). Research by Durgut et al. (2020) reported that treadmill exercises could be used as part of ADHD treatment, although further research is needed to provide stronger evidence of their effectiveness in ADHD management.Sensory integration and treadmill therapy play a crucial role in improving the behavior of children with ADHD, particularly in emotional regulation, reducing impulsivity, and enhancing focus. Sensory integration helps children better organize sensory input through vestibular, proprioceptive, and tactile stimulation, teaching them to respond to stimuli in a more controlled and adaptive manner. On the other hand, treadmill therapy provides aerobic physical stimulation that helps channel excess energy in children with ADHD. This activity promotes the release of neurotransmitters such as dopamine and norepinephrine, which improve attention, behavioral regulation, and mood.The combination of these two approaches works synergistically to improve children's behavior, reduce hyperactivity and impulsivity symptoms, and enhance emotional regulation skills. With consistent therapeutic intervention, children can develop calmer, more responsive behaviors and better adapt to social and academic environments.

CONCLUSION

The combination of sensory integration therapy and treadmill exercise significantly improves sensory processing and behavioral outcomes in children with ADHD. The intervention effectively reduces sensory dysfunction, enhances motor coordination, and helps regulate hyperactive and impulsive behaviors. The results indicate that this approach can serve as a beneficial non-pharmacological intervention for children with ADHD.

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