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EFFECT OF PERTURBATION BASED TRAINING AND TREADMILL TRAINING ON GAIT AND BALANCE AMONG ATTENTION DEFICIT HYPERACTIVITY DISORDER: A PILOT STUDY

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ABSTRACT
Background: Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental condition associated with difficulties in attention, coordination, gait, and balance. These motor deficits may affect children's daily activities and participation, while conventional management primarily focuses on cognitive and behavioral symptoms. Perturbation-Based Training (PBT) and Treadmill Training (TT) may help improve gait and balance in children with ADHD.
Aim: To compare the effects of Perturbation-Based Training and Treadmill Training on gait and balance in children with ADHD.
Methodology: An experimental pre-test and post-test comparative study was conducted in the Paediatric Physiotherapy Rehabilitation Unit, Faculty of Physiotherapy, ACS Medical College and Hospital, over a period of six months. Twelve children aged 9–15 years diagnosed with ADHD according to DSM-5 criteria, with proprioceptive and vestibular deficits and mild-to-moderate gait and balance impairments, were included. Participants were randomly divided into two groups: Group A received PBT, while Group B received TT. Both groups received 45-minute treatment sessions and continued their activities of daily living. Balance Assessor and Euleria Riablo were used to assess balance and gait parameters.
Results: Group A demonstrated greater improvement in proprioception (1.7±0.76 to 5.1±0.90) and vestibular scores (13.1±2.19 to 20.4±2.23) compared with Group B, which improved from 1.7±0.76 to 2.9±0.90 and 13.4±2.30 to 15.9±2.12, respectively. Significant between-group differences were observed in gait and balance outcomes ($p<0.05$), with Group A showing superior improvement.
Conclusion: Perturbation-Based Training was more effective than Treadmill Training in improving gait, balance, proprioception, and vestibular function in children with ADHD.

KEYWORDS: Attention Deficit Hyperactivity Disorder, Balance, Gait, Perturbation-Based Training, Treadmill Training, BTrackS.

INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is a multifaceted neurodevelopmental condition that can impact people at any age1.This disorder has three subtypes: combined, inattentive, and hyperactive ADHD demands more attention because of its widespread2.

The DSM identifies three types of ADHD: (1) Inattentive, (2) Hyperactive-impulsive, and (3) Combined (American Psychiatric Association, 1980). Individuals with the inattentive subtype often seem disengaged and dreamy, experiencing difficulties with information processing and maintaining focus. They struggle to sustain attention, are prone to distraction, lack persistence, and are typically disorganized. Those with the hyperactive-impulsive subtype tend to be easily distracted, show low persistence (Garralda, 1992), engage in excessive movement, and have trouble controlling impulses. The combined type presents all these characteristics3.

Children and adults with ADHD may experience a range of symptoms, including issues with impulse control (such as oppositional defiant, borderline personality, and antisocial personality traits), mood disorders (like depression, dysthymia, bipolar disorder, and cyclothymia), anxiety disorders (including generalized anxiety, agoraphobia, PTSD, and social phobia), substance use problems (like alcohol and drug dependence), learning difficulties (in reading, writing, and mathematics), and sleep disorders (such as rhythm disturbances, excessive daytime sleepiness, obstructive sleep apnoea, and restless legs or periodic limb movement4.

ADHD has multiple causes, involving gestational, perinatal, and genetic factors. However, each individual with ADHD typically experiences only a few of these contributing factors.5

Environmental Factors Linked to ADHD: ADHD has been associated with several environmental influences that affect different stages of central nervous system (CNS) development, especially during the gestational and perinatal phases. In this section, we examine some of the environmental factors that are linked to ADHD.6,7

Preconceptional, Gestational, and Perinatal Conditions Premature birth is a key risk factor for ADHD, as research shows that it occurs 2.6 to 4 times more frequently in infants with low or very low birth weight. Prematurity is linked to disruptions in neurogenesis and cell death, which can result in reduced cortical expansion, a feature seen in ADHD patients. One possible reason for the higher ADHD risk in preterm infants may be inflammation, as elevated levels of inflammation-related molecules are associated with a greater likelihood of developing ADHD symptoms. Perinatal hypoxia is another environmental factor that increases the risk of ADHD, likely by affecting dopaminergic transmission and neurotrophic signalling. during pregnancy is essential for proper brain development. One important nutrient is Nutrition docosahexaenoic acid (DHA), a polyunsaturated fatty acid that aids in neural proliferation and differentiation. Low DHA levels during brain development have been linked to ADHD and other neurodevelopmental disorders. Furthermore, reduced DHA levels have been found in the serum of adult ADHD patients. Malnutrition or immune activation in the mother during pregnancy also heightens the risk of ADHD and other neurodevelopmental issues8.

Heavy Metal Exposure: Exposure to neurotoxic heavy metals is another well-established environmental risk factor for ADHD. A study of schoolchildren showed that those with ADHD had higher levels of mercury in their saliva9.

In India the prevalence of ADHD in school children was found to be 11.3%, whereas it was 6% in 9–10 and 10–15year age group, respectively. The global prevalence of ADHD among children and adolescents is estimated at 2.2% (ranging from 0.1% to 8.1%), while in adults it stands at 2.8% (ranging between 0.6% and 7.3%). In the United States, the prevalence is reported at 9.4%, 7% in Western countries, and between 1.6% and 17.9% in India10.

In a UK-based study, the prevalence of diagnosed ADHD among children aged 5 to 11 years increased over the study period. In 2007, the prevalence was 2.96%, rising to 3.74% by 2016. This upward trend indicates that more children in this age group were being diagnosed with ADHD over time, possibly due to increased awareness, improved screening practices, or evolving diagnostic guidelines in the UK healthcare system. This study reveals that the global rate of ADHD is higher among younger children (ages 3–12) than among older youth (ages 12–18)11.

In a global prevalence study, ADHD prevalence was higher in boys (10%) than in girls (5%). Among ADHD subtypes, the inattentive type (ADHD-I) was the most prevalent at 3%, followed by the hyperactive-impulsive type (ADHD-HI) at 2.95%, and the combined type (ADHD-C) at 2.44%. Across genders, the inattentive subtype (ADHD-I) was the most common, with a prevalence of 4.05% in males and 2.21% in females. This was followed by the combined type (ADHD-C) at 3.63% in males and 1.52% in females, and the hyperactive-impulsive type (ADHD-HI) at 3.61% in males and 1.50% in females. The difference was not statistically significant ($p = 0.439$)12.

The prevalence of ADHD ranges from 11% to 25.8% in preschool children, from 3.17% to 17.3% in school-aged children, and from 3.9% to 25.1% in adults13.

Selecting children with an IQ above 70 allows for a more reliable assessment of the effects of Perturbation Based Trainings and treadmill training on gait and balance, as these participants are better equipped to engage with structured physiotherapeutic tasks, comprehend instructions accurately, and adapt to new motor learning challenges. Children with higher cognitive functioning demonstrate better attention, understanding, and problem-solving skills, which are essential for following complex movement patterns, maintaining postural control, and actively participating in repetitive training exercises. By ensuring that participants possess an IQ level above 80, the study minimizes variability related to cognitive limitations, thereby focusing specifically on the intervention's impact on gait and balance rather than on factors influenced by lower intellectual capacity14.

Children with ADHD often experience difficulties with gait (the way they walk) and balance due to underlying issues with motor coordination, sensory processing, and attention. These issues can affect their daily functioning and participation in activities.

Over the last decade, numerous studies have explored how Attention-Deficit/Hyperactivity Disorder (ADHD) affects motor functions, particularly balance control, in children. The research consistently demonstrates that children with ADHD tend to have significantly reduced postural stability and coordination skills when compared to typically developing children15

Children diagnosed with ADHD may exhibit abnormalities in gait that influence their overall walking patterns. These may include decreased step and stride lengths, as well as irregularities in walking rhythm and cadence. Such motor impairments often result in inconsistent and uncoordinated movements. Consequently, these challenges can negatively affect balance, stability, and overall functional mobility16

Children with ADHD often experience difficulties with motor coordination, impulse control, and attention regulation, which may manifest in their gait. For example, they might show signs of excessive movement, difficulty maintaining a smooth and controlled walking pattern, or an imbalance in their stride.

The Balance Assessor can consequently be incorporated as a quantitative assessment approach to obtain objective information regarding postural stability and balance performance. This approach is particularly relevant for children aged 9–15 years because balance performance is still undergoing maturation during this developmental period17.

Euleria Riablo is a technology-assisted movement assessment and rehabilitation system that uses inertial measurement units (IMUs) and audio-visual biofeedback to quantify body-segment and joint movements. Its measurements have been compared with stereophotogrammetric gait analysis, with the reported mean difference between systems being generally less than 5° during standard rehabilitation tasks. Thus, the combination of a Balance Assessor for quantitative balance assessment and Euleria Riablo for objective gait/movement assessment may provide complementary information regarding balance and motor performance in children aged 9–15 years with ADHD18.

To support balance in children with ADHD, two specific Perturbation Based Trainings were being used in this intervention. The first technique is Hopscotch Retriever, a game-based activity where children jump through numbered squares to retrieve a small object like a marble. This task promotes balance, coordination, and motor planning by

combining structured movement with a clear goal. It also boosts attention and body control, offering a playful yet purposeful way to strengthen essential motor skills often affected in children with ADHD19,20.
The exercise where children walk slowly and carefully along series of taped stripes on the floor while carrying a ball. This activity is designed to improve gait and postural stability by encouraging focused, deliberate movement. The added weight increases body awareness and activates the vestibular and proprioceptive systems, which are essential for maintaining balance. Mindful March promotes concentration, rhythm, and coordination.
Treadmill walking is a targeted therapeutic intervention designed to address gait abnormalities commonly observed in children with ADHD. The consistent, rhythmic movement provided by the treadmill offers a stable platform to practice and enhance key aspects of walking patterns, including step length, stride length, and cadence. This repetitive motor activity helps improve walking symmetry, rhythm, and overall gait efficiency. As a result, treadmill training can lead to noticeable enhancements in walking stability, coordination, and functional mobility in daily life21,22
The treadmill surface was be visually enhanced with striped and curved lines, providing external visual cues to help guide foot placement and promote more rhythmic, symmetrical walking patterns. These visual stimuli are intended to engage the child's attention and support better spatial orientation and motor planning. By incorporating structured visual elements into treadmill walking, the training aims to improve gait parameters such as step length, balance, and timing, ultimately enhancing functional mobility in children with ADHD23

METHODOLOGY

This study is an experimental study with pre and post comparative type and the study setting area is Paediatric Physiotherapy Rehabilitation unit, Faculty of Physiotherapy, ACS Medical College and Hospital over a period of 6 months. Participants were selected based on specific inclusion and exclusion criteria. Both male and female participants aged 9 to 15 years with ADHD, Children diagnosed with ADHD according to DSM-5 criteria, proprioception and vestibular problem, functional and cognitive abilities, mild to moderate gait and balance deficit, were included for the study. Nervous system disorders (e.g., cerebral palsy, Epilepsy, Autism), Developmental disorder (e.g., Down syndrome, delayed milestones), Musculoskeletal issues (e.g., bone deformities, limb deformities), Hearing & vision impairments were excluded. The outcome tools were Balance assessor (BTrackSTM) and Euleria Riablo (IMUs). A total of 14 participants were selected and divided into two groups, Group A is a study group, receive Perturbation Based Training and Group B receive Treadmill Training for a treatment duration of 50 minutes, and continued their activities of daily living (ADL).

Procedure:

Before each session, participants underwent a health check, confirmed informed consent, received session orientation, and completed pre-test assessments. Both the groups had 5-minutes of warm-up session, 40 minutes of interventions customized to individual abilities, and 5-minutes of cool down session. Throughout the program, participants gait and balance were monitored using the Euluria Riublo and Balance Assessor, with assessments conducted at the beginning, intermediate, and at the end of each session. Pre- and post-intervention evaluations focused on gait and balance improvements.
Each session lasted for 50 minutes 3 sets & 5 min for each exercise for 4 sessions for 8 week and was follow the sequence outlined below:

5-Minute Warm- Up:

The session began with a 5-minute warm-up period, which included slow walking and dynamic stretching exercises to gradually increase heart rate, prepare the muscles for activity, and improve joint mobility. This phase also helped the children become familiar with activity and prepare physically and mentally for the training session.

GROUP-A

40- Minute Perturbation Based Training

The child performed a series of exercises to improve lower-limb strength, balance, coordination, and proprioception. Lateral band walking was performed by walking sideways with resistance bands placed around the thighs. During step-ups with an unstable load, the child stepped onto a box while holding a shifting weight such as a sandbag. Wobble board squats involved performing mini squats on an unstable wobble board to challenge balance and postural control. In bungee-cord tether walking, the child walked while attached to a forward bungee tether to provide resistance and improve dynamic stability. Heel-to-toe walking on foam required the child to walk in a straight line across a foam mat, challenging balance and proprioception. Ankle circles were performed in a seated or standing position by slowly rotating the foot in circular movements to improve ankle mobility. During foot targeting with visual shifts, the child stepped on marked targets while the therapist changed the visual cues to improve coordination and reaction. Finally, toe gripping with ball rolls involved using the toes to roll a small ball or pull a towel, helping strengthen the intrinsic muscles of the foot.

GROUP B

40-Minute Treadmill Training (TT):

The treadmill activities were performed as follows: normal walking involved walking at a comfortable, self-selected speed; brisk walking was performed at a moderately increased speed; speed-variation walking involved alternating between slow and moderate speeds; incline walking was performed by gradually increasing the treadmill incline; interval walking consisted of alternating faster and slower walking periods; backward walking was performed at a slow speed under close supervision; side-stepping involved controlled lateral steps on the treadmill at a low speed; high-knee walking was performed by alternately raising the knees during walking; heel-to-toe walking involved maintaining a controlled heel-to-toe gait pattern.

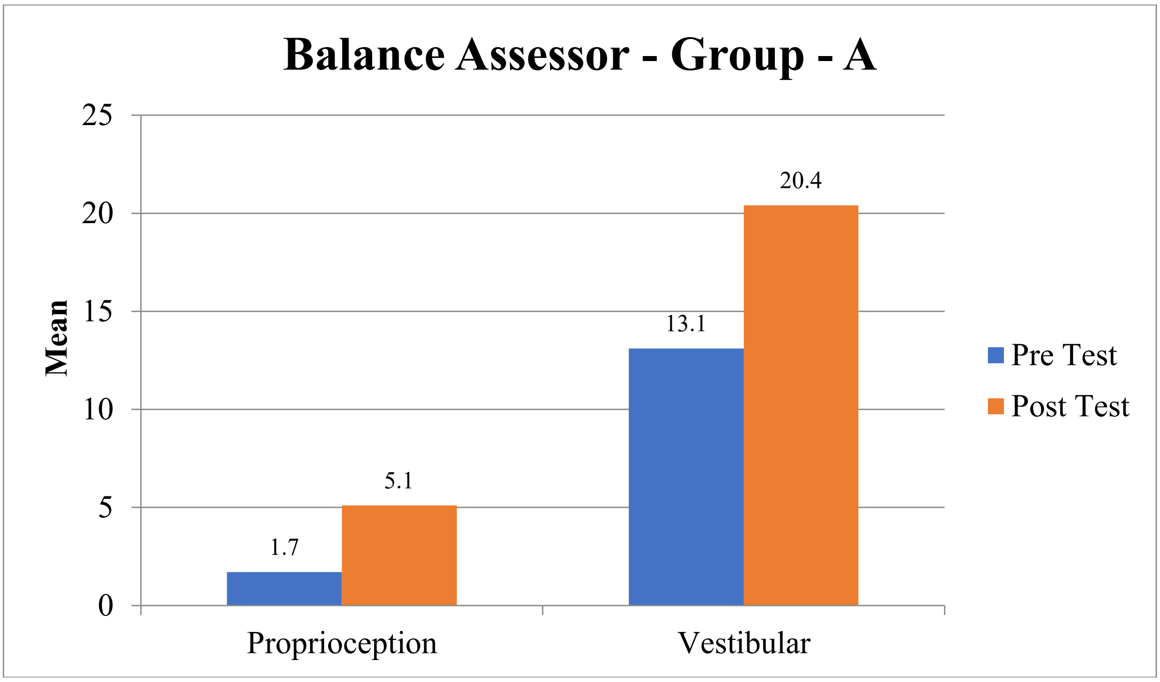
5-Minute Cool-Down:
The session concluded with a 5-minute cool-down period, which involved slow walking and stretching exercises to gradually lower the heart rate and promote muscle relaxation. This phase also provides an opportunity for the children to discuss how they felt during the session and reflect on their experiences.
Session Frequency and Duration:
•The children completed 4 sessions per week for a total duration of 8 weeks.
•The sessions were scheduled in such a way that each participant had consistent attendance without excessive gaps between training days to ensure the interventions effects are consistent.
Monitoring and documentation
•During each session, data were collected on the participant's performance and behaviour, including metrics such as physical engagement, attention, and emotional responses.
•Observational assessments were made at the beginning, middle, and end of each session to track progress.
Data Analysis
The collected data were tabulated and analyzed using both descriptive and inferential statistics. All the parameters were assessed using statistical package for social science (SPSS) version 24, with a significance level of p value less than 0.05 and a 95% confidence interval set for all analysis. The Shapiro Wilk test was used to determine the normality of the data at $P > 0.05$.
In this study, Data on the Balance Assessor, Step Length, Stride Length and Cadence can yield both parametric and non-parametric statistical methods were considered appropriated depending on the nature and distribution of the variables.
As several variables showed p-values less than 0.005, the data did not follow a normal distribution. Even though some variables showed a normal distribution, the presence of non-normal data, ordinal scale, and sample size violated the assumption of parametric test. Hence, non-parametric test (Wilcoxon Signed-Rank Test and Mann–Whitney U Test) were used for statistical analysis.
Wilcoxon signed rank test was adopted to find the statistical difference within the groups & Mann–Whitney U test was adopted to find statistical difference between the groups.
P value and statistical significance:
The P value with two tails is less than 0.001. This difference is deemed to be very statistically significant by traditional standards.

Table-1: Comparison of pre-test & post-test values for Group A

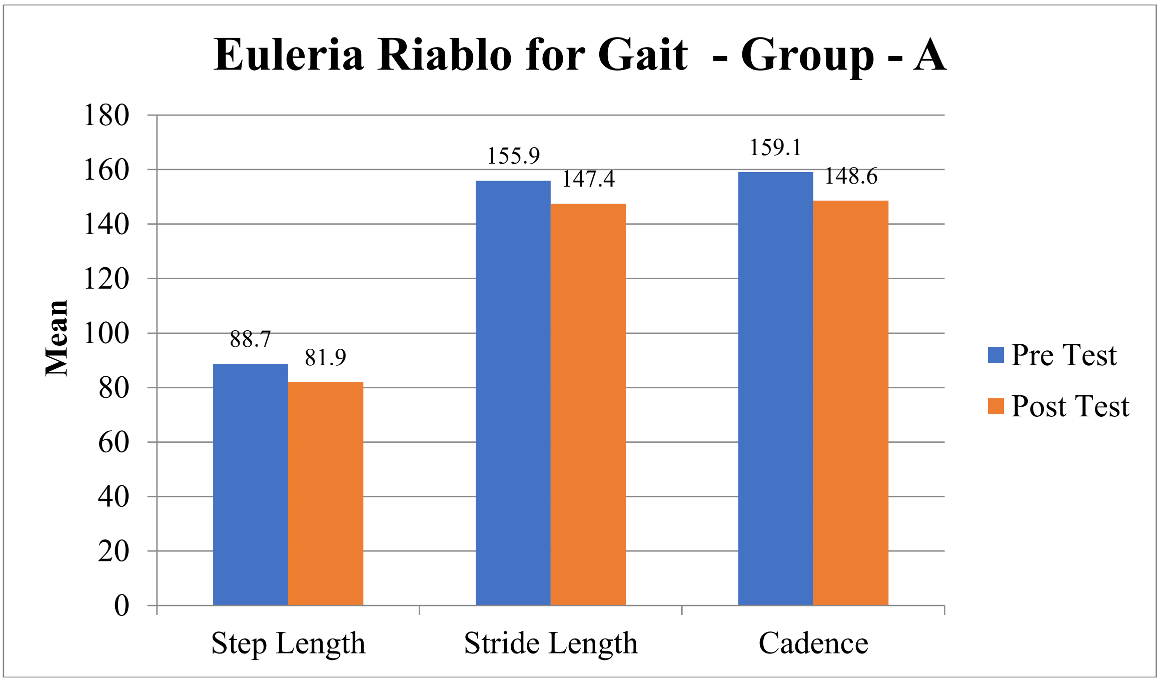
<table>
<tr><th colspan="3">Group A</th><th>Mean</th><th>SD</th><th>Z test</th><th>p value</th></tr>
<tr><td rowspan="4">Balance Assessor</td><td rowspan="2">Proprioception</td><td>Pre</td><td>1.7</td><td>0.76</td><td rowspan="2">-2.428</td><td rowspan="2">0.015</td></tr>
<tr><td>Post</td><td>5.1</td><td>0.9</td></tr>
<tr><td rowspan="2">Vestibular</td><td>Pre</td><td>13.1</td><td>2.19</td><td rowspan="2">-2.401</td><td rowspan="2">0.016</td></tr>
<tr><td>Post</td><td>20.4</td><td>2.23</td></tr>
<tr><td rowspan="6">Euleria Riablo for Gait</td><td rowspan="2">Step Length</td><td>Pre</td><td>88.7</td><td>2.56</td><td rowspan="2">-2.414</td><td rowspan="2">0.016</td></tr>
<tr><td>Post</td><td>81.9</td><td>1.95</td></tr>
<tr><td rowspan="2">Stride Length</td><td>Pre</td><td>155.9</td><td>2.91</td><td rowspan="2">-2.388</td><td rowspan="2">0.017</td></tr>
<tr><td>Post</td><td>147.4</td><td>2.88</td></tr>
<tr><td rowspan="2">Cadence</td><td>Pre</td><td>159.1</td><td>4.02</td><td rowspan="2">-2.375</td><td rowspan="2">0.018</td></tr>
<tr><td>Post</td><td>148.6</td><td>4.12</td></tr>
</table>

(*P value < 0.05 - Statistically Significant)

The above table reveals the Mean, SD, z-value and p-value between pre-test and post-test. This Group A table shows that there is highly significant difference between pre-test and post-test.



Graph - 1: Comparison of pre-test & post-test values for Group A



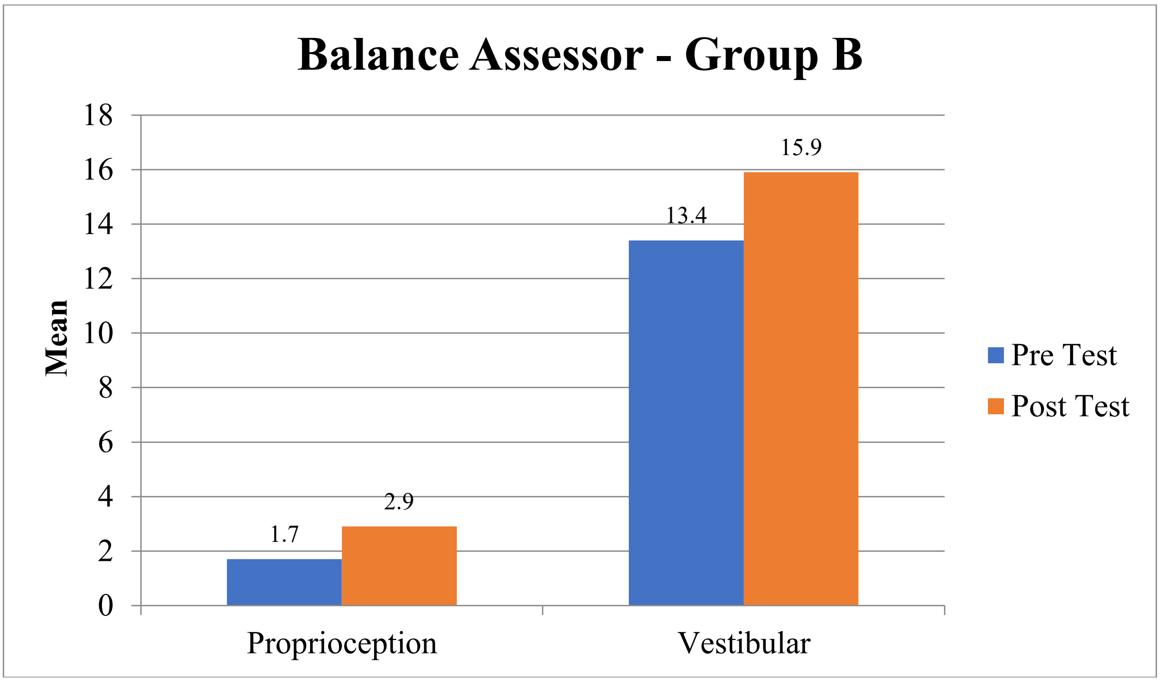
Graph - 2: Comparison of pre-test & post-test values for Group A

Table-2: Comparison of pre-test & post-test values for Group B

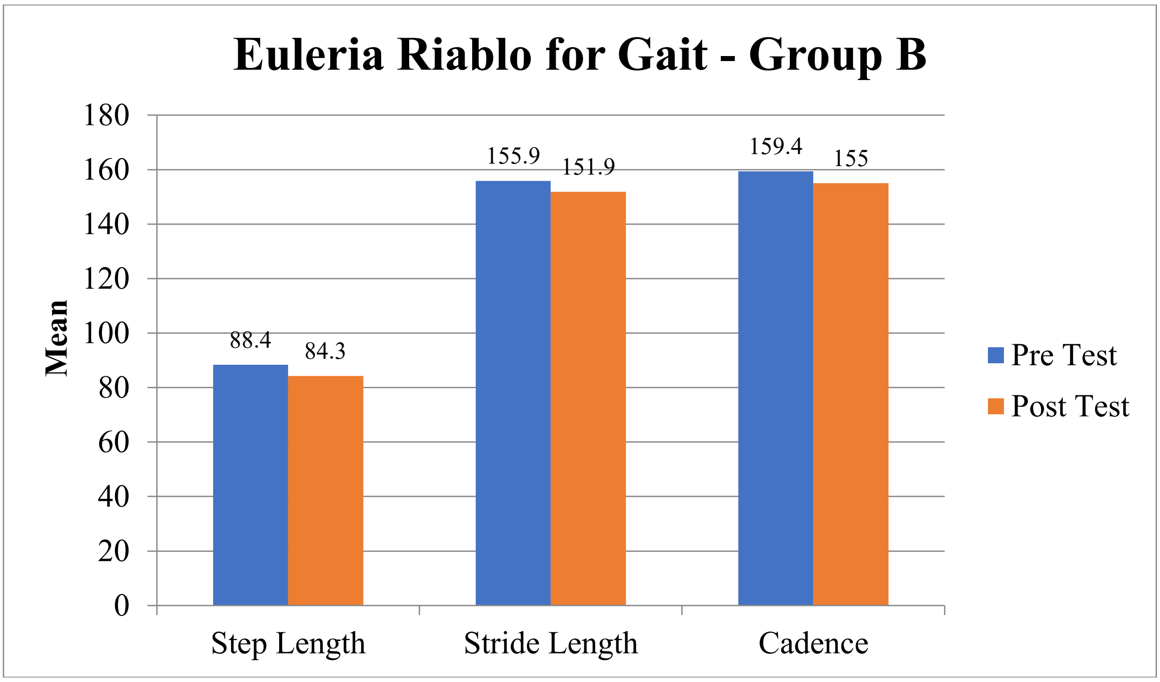
Group B			**Mean**	**SD**	**Z test**	**p value**
Balance Assessor	Proprioception	Pre	1.7	0.76	-2.53	0.011
		Post	2.9	0.9		
	Vestibular	Pre	13.4	2.3	-2.428	0.015
		Post	15.9	2.12		
Euleria Riablo for Gait	Step Length	Pre	88.4	3.21	-2.388	0.017
		Post	84.3	2.36		
	Stride Length	Pre	155.9	2.67	-2.392	0.017
		Post	151.9	2.12		
	Cadence	Pre	159.4	2.99	-2.392	0.016
		Post	155.0	3		

(*P value < 0.05 - Statistically Significant)

The above table reveals the Mean, SD, z-value and p-value between pre-test and post-test. This Group B table shows that there is highly significant difference between pre-test and post-test.



Graph - 3: Comparison of pre-test & post-test values for Group B

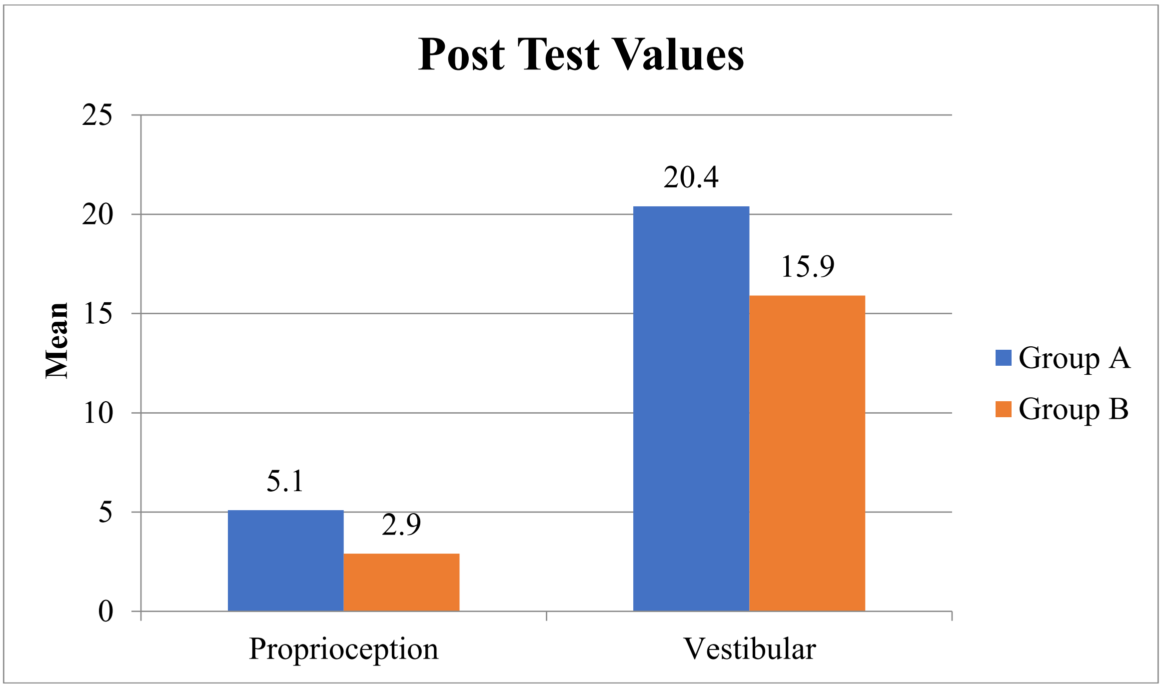


Graph - 4: Comparison of pre-test & post-test values for Group B

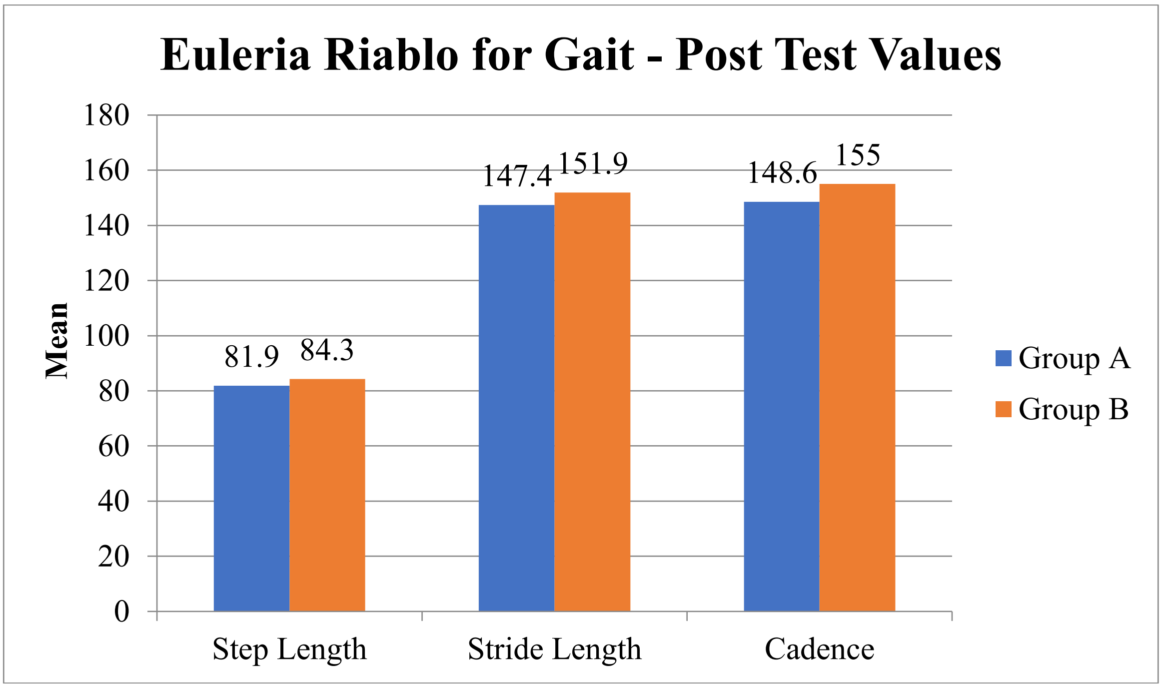
Parameter		**Post Test Values**				**Z Score**	**Significance**
		Group A		**Group B**			
		Mean	**SD**	**Mean**	**SD**		
Balance Assessor	Proprioception	5.1	0.9	2.9	0.9	-2.940	0.003
	Vestibular	20.4	2.23	15.9	2.12	-2.827	0.005
Euleria Riablo for Gait	Step Length	81.9	1.95	84.3	2.36	-1.998	0.046
	Stride Length	147.4	2.88	151.9	2.12	-2.447	0.014
	Cadence	148.6	4.12	155.0	3	-2.652	0.008

(*P value < 0.05 - Statistically Significant)

The above table reveals the Mean, SD, Z score and p-value between pre-test and post-test within Group – A & Group – B. There is a statistically significant difference between the post-test values of Group A and Group B.



Graph- 5: Post Test Values of Group A & Group B



Graph- 6: Post Test Values of Group A & Group B

RESULT

A statistically significant difference between Group A and Group B, as well as within each group, was found by statistical analysis of the quantitative data.

In Group-A pre intervention mean to Balance Assessor of Proprioception was 1.7(±0.76), and Vestibular was 13.1(±2.19), Euleria Riablo for Gait for Step Length was 88.7(±2.56), Stride Length was 155.9(±2.91), and Cadence was 159.1(±4.02). After treating the subject with Perturbation Based Training, the mean value Balance Assessor of Proprioception was 5.1(±0.9), and Vestibular was 20.4(±2.23), Euleria Riablo for Gait for Step Length was 81.9(±1.95), Stride Length was 147.4(±2.88), and Cadence was 148.6(±4.12), which show statistical significant difference within the groups.

In Group-B pre intervention mean to Balance Assessor of Proprioception was 1.7(±0.76), and Vestibular was 13.4(±2.3), Euleria Riablo for Gait for Step Length was 88.4(±3.21), Stride Length was 155.9(±2.67), and Cadence was 159.4(±2.99). After treating the subject with Treadmill Training, the mean value Balance Assessor of Proprioception was 2.9(±0.9), and Vestibular was 15.9(±2.12), Euleria Riablo for Gait for Step Length was 84.3(±2.36), Stride Length was 151.9(±2.12), and Cadence was 155(±3), which show statistical significant difference within the groups.

The results of the post-test statistical analysis for the Balance Assessor, Euleria Riablo (Step Length, Stride Length and Cadence) showed that there was a significant statistical difference between groups A and B. The research is thus deemed to be statistically significant there by adopting the alternative hypothesis since Group-A (Perturbation Based Training) has a large statistical difference than Group-B (Treadmill Training).

DISCUSSION

In this study, the effects of a combination intervention that included treadmill training and Perturbation Based Training on enhancing gait and balance in kids with attention deficit hyperactivity disorder (ADHD) were examined. A control group, which carried on with their regular activities under the supervision of a therapist, and an experimental group, which got the intervention, were the two randomly selected groups of thirty children, ages ten to fourteen. The results were assessed using two validated instruments: The Balance Assessor for balance and the Euleria Riablo for gait assessment.

The results showed that, in comparison to the control group, children who received the structured intervention showed notable improvements in both gait and balance measures. These enhancements imply that movement-based therapies can successfully address the motor coordination deficiencies frequently seen in children with ADHD, particularly when they are made to be interesting, task-oriented, and customized.

Numerous motor impairments, such as poor postural stability, irregular gait patterns, and coordination issues, are known to be present in children with ADHD. These impairments can make it difficult for them to participate in everyday activities and move around functionally.

A key component of this study was the application of Perturbation Based Training. In addition to being entertaining, methods like Mindful March and Hopscotch Retriever offered task-specific training that focused on proprioception, balance control, and gait rhythm. The principles of neurodevelopmental therapy, which emphasize motor planning, multisensory stimulation, and repetition to promote neuromotor learning, are in line with these activities. Exercise-based therapy for ADHD can greatly enhance cognitive flexibility, inattention, and inhibitory control, all of which tangentially help motor learning and functional performance 23,24

On the other hand, treadmill training used visual cues and a rhythmic, repeating motor exercise to help guide foot placement and encourage symmetry in gait. The effectiveness of treadmill-based therapies for enhancing motor control and gait consistency in kids with neurodevelopmental problems has been demonstrated by numerous studies. Specifically, discovered that controlled treadmill walking helps stabilize these motor deficiencies by streamlining the environment and encouraging predictable movements. When walking in dual-task or complicated scenarios, gait abnormalities in ADHD become more noticeable.25

In contrast, the control group, which continued daily activities under supervision without any structured intervention, did not show notable improvements in balance or gait. This highlights a critical gap in conventional ADHD management, which often overlooks motor coordination and physical function

From a neurological standpoint, these motor gains can be explained by the enhancement of sensory integration, cerebellar function, and improved dopaminergic modulation through physical activity. ADHD has been linked to impaired cerebellar volume and connectivity, which are essential for motor coordination. Exercise-induced neuroplasticity, such as that triggered by treadmill walking and coordinated movement games, can stimulate these brain regions, promoting better sensorimotor control. Moreover, physical activity has been shown to increase dopamine and norepinephrine levels, which are crucial neurotransmitters involved in attention and movement regulation.

The use of standardized outcome measures such as the Euleria Riablo and Balance Assessor provided objective insights into the participants' motor improvements. The Euleria Riablo allowed for structured analysis of gait abnormalities, while the Balance Assessor assessed functional balance through common activities. The significant improvements in these scores further validate the reliability and applicability of these tools in ADHD rehabilitation.

In Group-A pre intervention mean to Balance Assessor of Proprioception was 1.7(±0.76), and Vestibular was 13.1(±2.19), Euleria Riablo for Gait for Step Length was 88.7(±2.56), Stride Length was 155.9(±2.91), and Cadence was 159.1(±4.02). After treating the subject with Perturbation Based Training, the mean value Balance Assessor of Proprioception was 5.1(±0.9), and Vestibular was 20.4(±2.23), Euleria Riablo for Gait for Step Length was 81.9(±1.95), Stride Length was 147.4(±2.88), and Cadence was 148.6(±4.12), which show statistical significant difference within the groups. Hence the null hypothesis is rejected.

In Group-B pre intervention mean to Balance Assessor of Proprioception was 1.7(±0.76), and Vestibular was 13.4(±2.3), Euleria Riablo for Gait for Step Length was 88.4(±3.21), Stride Length was 155.9(±2.67), and Cadence was 159.4(±2.99). After treating the subject with Treadmill Training, the mean value Balance Assessor of Proprioception was 2.9(±0.9), and Vestibular was 15.9(±2.12), Euleria Riablo for Gait for Step Length was 84.3(±2.36), Stride Length was 151.9(±2.12), and Cadence was 155(±3), which show statistical significant difference within the groups. Hence the null hypothesis is rejected.

Furthermore, the results support the integration of physiotherapy-based interventions into the holistic management of ADHD. Traditionally, ADHD treatment has focused heavily on pharmacological and behavioural interventions. However, physical therapy remains an underutilized yet promising domain that addresses overlooked motor impairments.

Despite the promising findings, several limitations must be acknowledged. The sample size of 30 participants, while adequate for initial evaluation, may limit the generalizability of the results. Future studies should include larger cohorts and consider multi-site trials to strengthen the validity of the intervention outcomes. Additionally, the study duration was limited to 8 weeks. While short-term improvements were evident, it remains unclear whether the gains in gait and balance are sustained over time. Longitudinal follow-up assessments are necessary to examine the persistence of these motor benefits.

Another consideration is the potential variability in the delivery of Perturbation Based Training based on the therapist's expertise and the child's daily condition. Although the activities were structured, individual responsiveness may vary

depending on attention levels, fatigue, or motivation on any given day. Ensuring consistent delivery and standardizing the intensity of the intervention could enhance replicability in future research.
Moreover, while this study focused solely on physical outcomes, future investigations could incorporate neurocognitive assessments to evaluate the secondary benefits of motor training on attention, impulsivity, and academic performance. Integration of tools like the Conners' ADHD Rating Scale or neuroimaging data (e.g., EEG) might provide a more holistic view of the intervention's impact on ADHD symptomatology.
In conclusion, this study highlights the positive effects of combining Perturbation Based Training and Treadmill Training in improving gait and balance in children with ADHD. These motor-based interventions address a significant yet often neglected component of ADHD physical and sensory motor functioning. By adopting a structured, engaging, and individualized approach, physiotherapists can play a vital role in enhancing functional outcomes and overall quality of life in children with ADHD. Future research should continue to explore integrative, interdisciplinary strategies that combine physical, cognitive, and behavioural components to deliver comprehensive care to this population.
Despite the positive outcome observed in the present study, several limitations should be acknowledged. The study had a small sample size and short intervention duration, which may limit the generalizability and long term interpretation of the finding. Lack of blinding may have introduced bias, and comorbidities were not extensively considered.
Based on the findings and limitations of the present study, several recommendations can be proposed for future research and clinical practice. Future studies should include a large sample size and long term follow up. Intervention intensity and progression should also be individualized according to participants needs.

CONCLUSION

The study finds that using a combination of treadmill training and Perturbation Based Training helps children with ADHD with their gait, balance, and motor control. This supports the function of physiotherapy in the overall management of Attention Deficit Hyperactivity Disorder ADHD.

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Conflict of Interest
The authors declare that they have no conflicts of interest related to this study or its publication.

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