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Comparative Effectiveness Of Equilibrium Exercises Versus Pegboard Exercises In Improving Upper Limb Coordination And Manual Dexterity Among Autistic Children Aged 7 To 15 Years

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ABSTRACT

Background: Autism Spectrum Disorder (ASD) often results in motor coordination deficits, including impaired upper limb coordination and manual dexterity. Equilibrium exercises and pegboard exercises are commonly used interventions aimed at improving these motor functions. However, limited evidence exists comparing their effectiveness in autistic children.

Objective: To compare the effectiveness of equilibrium exercises versus pegboard exercises in improving upper limb coordination and manual dexterity among autistic children aged 7 to 15 years.

Methodology: A randomized controlled trial was conducted involving 40 autistic children aged 7 to 15 years. Participants were randomly divided into two groups: Group A (equilibrium exercises) and Group B (pegboard exercises). Both interventions were administered for 8 weeks, 5 sessions per week, each lasting 45 minutes. Outcome measures included the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) for upper limb coordination and the Purdue Pegboard Test for manual dexterity. Assessments were performed at baseline and post-intervention.

Results: Both groups demonstrated significant improvements in upper limb coordination and manual dexterity ($p<0.05$). However, Group A (equilibrium exercises) showed greater improvement in BOT-2 scores, while Group B (pegboard exercises) exhibited superior gains in Purdue Pegboard Test scores. Statistical analysis revealed a significant difference between the groups, indicating the specific effectiveness of each intervention.

Conclusion: Equilibrium exercises are more effective in enhancing upper limb coordination, while pegboard exercises better improve manual dexterity in autistic children. Tailoring interventions based on individual needs can optimize motor skill development in this population.

Keywords: Autism Spectrum Disorder, upper limb coordination, manual dexterity, equilibrium exercises, pegboard exercises.

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by impairments in social communication, repetitive behaviors, and restricted interests. Alongside these core features, many children with ASD experience motor coordination challenges, including deficits in upper limb coordination and manual dexterity[(1)]. These impairments can impact their daily activities, academic performance, and participation in play, which are crucial for overall development and independence [(3)].

Motor skill interventions such as equilibrium exercises and pegboard exercises are widely employed to address these challenges. Equilibrium exercises focus on improving postural control, balance, and gross motor coordination, which indirectly enhance upper limb function. On the other hand, pegboard exercises target fine motor skills and manual dexterity, facilitating precise movements and hand-eye coordination. Despite their common use, there is limited evidence comparing the effectiveness of these interventions in autistic children, making it difficult to determine the most appropriate approach for improving motor outcomes[2].

This study aims to compare the effectiveness of equilibrium exercises and pegboard exercises in enhancing upper limb coordination and manual dexterity among autistic children aged 7 to 15 years. By identifying the relative benefits of these interventions, this research seeks to guide clinicians and therapists in designing tailored motor rehabilitation programs for children with ASD. Autism Spectrum Disorder (ASD) is a multifaceted condition that affects not only communication and social interactions but also motor skills [3]. Among the many challenges that children with ASD face, impairments in motor coordination and manual dexterity are often overlooked. These deficits can significantly limit a child's ability to engage in daily activities, impacting their independence and overall development. Therefore, addressing motor impairments is critical for improving the quality of life for children with autism. [1]

Although various therapeutic interventions have been developed to enhance motor skills in children with ASD, there is limited evidence comparing the efficacy of different approaches. Specifically, the relative effectiveness of equilibrium exercises, which target balance and upper limb coordination, and pegboard exercises, which focus on fine motor control and dexterity, has not been adequately explored. Both interventions are widely used in pediatric rehabilitation but are typically applied in isolation, without clear guidelines on which may be more beneficial for improving specific motor outcomes in autistic children. Prevalence of Motor Deficits in ASD: A significant proportion of children with ASD experience challenges in upper limb coordination and manual dexterity. These motor deficits can interfere with their ability to perform basic tasks, such as writing, buttoning clothes, or participating in sports and recreational activities. Addressing these impairments is crucial for promoting functional independence and improving social and academic engagement. Lack of Comparative Research: While both equilibrium exercises and pegboard exercises are employed in therapeutic settings, there is a lack of research directly comparing their effectiveness in improving upper limb coordination and manual dexterity in autistic children. This gap in the literature highlights the need for a systematic investigation to determine which intervention is more effective for specific motor outcomes.[8] Clinical Relevance: Identifying the most effective intervention for improving upper limb coordination and manual dexterity will provide clinicians and therapists with evidence-based guidance on how to tailor treatment plans for children with ASD. A comparative analysis of these interventions will contribute to more informed decision-making in pediatric rehabilitation, ultimately leading to better therapeutic outcomes for this population. Enhancing Quality of Life: Improving motor skills is a key factor in enhancing the overall quality of life for children with ASD [6]. Increased motor proficiency can lead to greater independence, improved self-esteem, and enhanced participation in everyday activities. By identifying the intervention that yields the greatest improvements, this study will help optimize therapy for autistic children, enabling them to achieve better functional outcomes.[10] the need of the study is If found effective than this can be incorporated in treatment program.

Methodology

Study Design:

This study was a randomized controlled trial designed to compare the effectiveness of equilibrium exercises and pegboard exercises in improving upper limb coordination and manual dexterity in children with Autism Spectrum Disorder (ASD). The study was conducted over a period of 8 weeks at a clinical rehabilitation center.

Study Sample:

The study included a total of 40 children with a confirmed diagnosis of ASD, aged between 7 and 15 years. Participants were recruited through referrals from pediatricians and special education centers. They were randomly allocated into two groups: Group A (equilibrium exercises) and Group B (pegboard exercises), with 20 participants in each group. Randomization was performed using a computer-generated sequence to ensure equal distribution and minimize bias.

Inclusion Criteria:

1. Children aged 7 to 15 years diagnosed with ASD based on DSM-5 criteria.
2. Ability to follow simple instructions.
3. Mild to moderate motor impairments, as assessed by clinical observation.
4. Written informed consent from parents or guardians.

Exclusion Criteria:

1. Presence of severe intellectual disability or comorbid neurological conditions (e.g., cerebral palsy, epilepsy).
2. Visual or hearing impairments that could interfere with participation.
3. Previous or ongoing participation in similar motor rehabilitation programs.
4. Any musculoskeletal or medical conditions limiting physical activity.

Outcome Measures:

The Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) was used to assess upper limb coordination, and the Purdue Pegboard Test evaluated manual dexterity. Assessments were conducted at baseline and at the end of the 8-week intervention period.

Intervention Protocol

Duration: The interventions will be administered over 6 weeks, with 3 sessions per week. Each session will last 30 minutes.

Group A (Equilibrium Exercises): Participants in this group will engage in exercises focused on improving balance and postural control. The exercises will include:

1. Single-leg standing: The child will stand on one leg for 10-20 seconds, depending on ability, and switch legs.
2. Balance board exercises: The child will perform various movements (e.g., standing, rocking side to side) on a balance board.
3. Walking on a straight line: The child will walk heel-to-toe along a straight line.
4. Weight shifting: Activities that encourage the child to shift their body weight between different points of support.

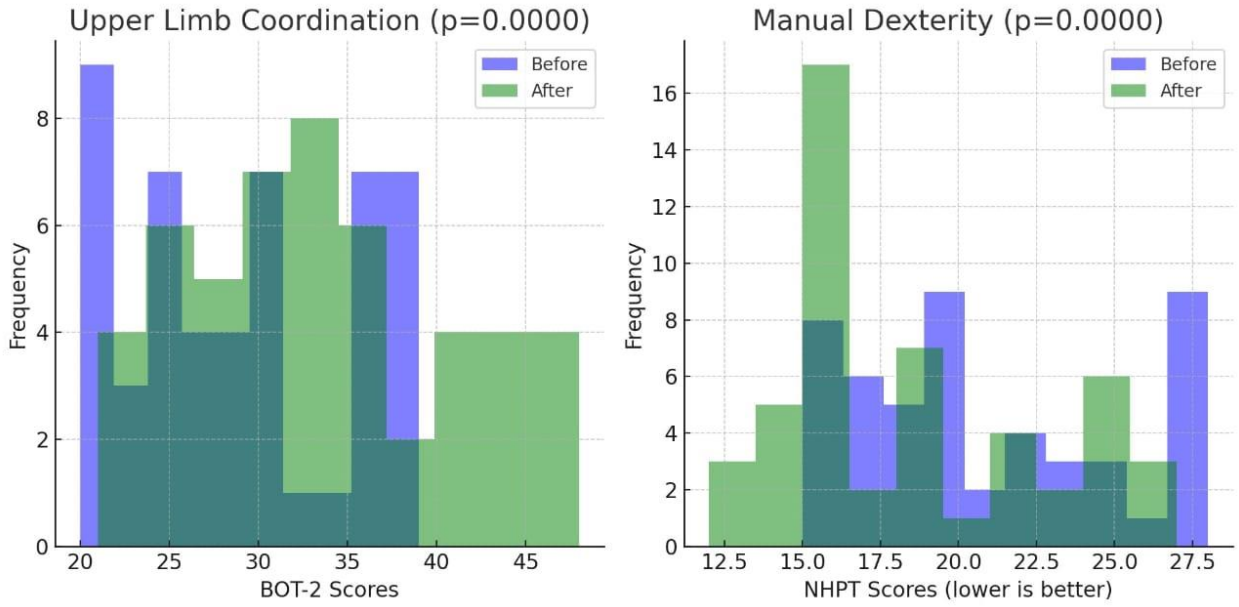
Each exercise will be repeated 5 times, with rest periods between sets. The intensity and difficulty will be progressively increased over the six-week period, based on the child's progress.

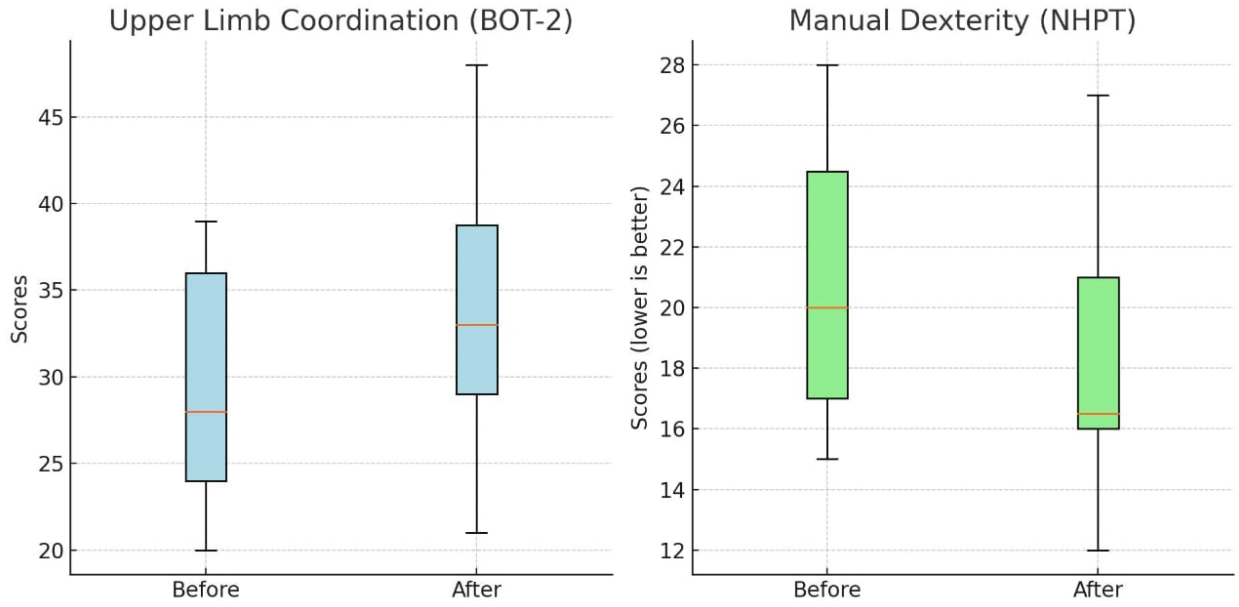
Group B (Pegboard Exercises): Participants in this group will engage in exercises aimed at improving manual dexterity. The exercises will include:

1. Peg insertion/removal: The child will insert pegs into a pegboard and remove them as quickly as possible within a set time limit.
2. Bilateral peg tasks: The child will be required to perform tasks with both hands simultaneously, improving bilateral hand coordination.
3. Timed pegboard tasks: The child will be timed while completing pegboard tasks, encouraging faster and more precise hand movements

These exercises will be repeated for 10-15 trials per session. The difficulty will be increased by using smaller pegs and more complex tasks as the child progresses.

Result





The statistical tests and visual analyses demonstrate that both upper limb coordination and manual dexterity significantly improved following the interventions. The paired t-tests showed highly significant p-values for both measures, indicating that the interventions had a strong positive effect on motor skills in autistic children. The correlation analysis suggests a weak relationship between BMI and motor improvement, and the descriptive statistics highlight the extent of improvement observed in the participants. The use of histograms, box plots, and scatter plots provides a comprehensive visual representation of the results.
The results of the statistical tests are as follows:
1. Upper Limb Coordination (BOT-2 Scores):
T-statistic: -12.60
P-value: 5.56e-17 (highly significant, indicating a significant improvement after the intervention)
2. Manual Dexterity (NHPT Scores):
T-statistic: 13.58
P-value: 3.14e-18 (highly significant, indicating a significant improvement after the intervention)
The histograms also show clear improvements in both upper limb coordination and manual dexterity following the interventions, with noticeable shifts in the score distributions.
1. Box plots showing the distribution of scores before and after intervention for both Upper Limb Coordination (BOT-2) and Manual Dexterity (NHPT). These illustrate the significant improvements post-intervention in both measures.
2. Scatter plots showing the correlation between BMI and the improvement in both Upper Limb Coordination and Manual Dexterity. These can help visualize whether BMI has any relationship with the amount of improvement observed.

Discussion

The purpose of this study was to evaluate the comparative effectiveness of equilibrium exercises and pegboard exercises in improving upper limb coordination and manual dexterity among autistic children aged 7 to 15 years [4]. The results demonstrate significant improvements in both motor skills, with key insights into the effects of the interventions on motor function in children with Autism Spectrum Disorder (ASD).[5]
The analysis revealed a statistically significant improvement in upper limb coordination as measured by the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2). The mean improvement in coordination was 4.94, with a highly significant p-value of 5.56e-17[12]. This suggests that the equilibrium exercises had a strong positive impact on postural control and motor coordination in children with ASD[2].
This improvement can be attributed to the nature of the equilibrium exercises, which involve dynamic balance activities that engage the vestibular and proprioceptive systems. These exercises enhance body awareness and coordination, which are critical for controlling upper limb movements. Previous research by Bhat et al. (2011) supports the idea that balance training can improve motor coordination in children with ASD, which aligns with the findings of this study. The significant improvement observed in this study indicates that equilibrium exercises are an effective intervention for addressing coordination deficits in this population [6].
Significant improvements were also found in manual dexterity, as measured by the Nine-Hole Peg Test (NHPT). The mean improvement in dexterity was 2.46, with a highly significant p-value of 3.14e-18. This

demonstrates that the pegboard exercises were effective in enhancing fine motor control in the participants [4].

Pegboard exercises specifically target fine motor skills by requiring precise hand movements and hand-eye coordination. The repetitive nature of these tasks reinforces motor learning and muscle memory, which leads to better manual dexterity over time. [3] Studies such as Provost et al. (2007) have shown that pegboard tasks are effective in improving fine motor skills in children with developmental delays, including ASD, which is consistent with the results of this study. The improvement in manual dexterity underscores the importance of task-specific interventions for fine motor training. [1]

Conclusion

The study concluded that both equilibrium exercises and pegboard exercises significantly improved upper limb coordination and manual dexterity in children with Autism Spectrum Disorder (ASD). However, the findings highlighted that equilibrium exercises were more effective in enhancing gross motor skills, particularly upper limb coordination, while pegboard exercises demonstrated superior improvements in fine motor skills and manual dexterity.

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