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TO DETERMINE THE EFFECTIVENESS OF BRAIN GYM ACTIVITIES IN IMPROVING MOTOR PERFORMANCE SKILLS AMONG CHILDREN WITH AUTISM.

S. Mercy Clara* Vumika Pani**
**M.P.T.(ORTHO), M.I.A.P. Professor, NIEPMD(Divyangjan), College of Physiotherapy, ECR Road, Muttukadu, Chennai,*
*** BPT Intern At NIEPMD (Divyangjan), College of Physiotherapy, ECR Road, Muttukadu, Chennai (Affiliated to The Tamil Nadu Dr. M.G.R. Medical University, Tamil Nadu).*

Abstract
Background*: Autism Spectrum Disorder is a neurodevelopment disorder. It is characterized by affection in social communication, social interaction, constrained repetitive pattern of behavior and restricted interest in activities and motor problems that involves motor planning deficits, motor coordination abnormalities, clumsiness, and postural instability.*

Method*: 10 subjects with age 6-15years with Autism Spectrum Disorder with scores 70-106 on ISAA scale participated in the experiment study underwent treatment duration for four weeks after giving their informed consent. They were evaluated and randomize into group A (control group) receiving conventional physiotherapy and group B (Intervention group) receiving Brain gym exercises. Pre- and post-intervention values were evaluated using Bruininks oseretsky test of motor proficiency subtests and scoring.*

Conclusion*: The findings of this study "Effectiveness of Brain Gym Activities In Improving Motor Performance Skills Among Children With Autism" showed that how the Brain Gym Activity helps in improving the motor performance skills in children with autism spectrum disorder.*

Keywords: BOT-2-Bruininks-Oseretsky Test of Motor Proficiency, Second Edition, And ASD: Autism Spectrum Disorder.

Introduction

"IF THEY CAN'T LEARN THE WAY WE TEACH; WE TEACH THE WAY THEY LEARN"
Autism Spectrum Disorder is a neurodevelopment disorder. It is characterized by affection in social communication, social interaction, constrained repetitive pattern of behavior and restricted interest in activities and motor problems that involves motor planning deficits, motor coordination abnormalities, clumsiness, and postural instability. Autism affects the normal functioning of the brain too. These characteristics clinical signs of the children with autism disorders are the most important areas and are paid much less attention to their motor involvement, body composition and nutritional conditions. [1]

Children with autism spectrum disorder generally demonstrate poor motor skills, consequently rehabilitation programs should emphasize on fundamental motor skills and patterns of movement, individual games and sports and developmental activities that increase physical skill, Studies have shown that muscle weakness and abnormal muscle tone in ASD may play a role in the limitations in daily activities, such as locomotion and reaching and grasping activities.[1]

Children with autism are not always involved in play with children of similar age but even if they are, they generally have difficulties in making and keeping friends. Apart from that the autistic child have problem with attention, listening to the teacher, problem solving, focus, following directions which may hamper their academic growth.

The rate of occurrence is 5 cases per 10000 children. ASDs ranging have shown poor upper limb coordination and manual dexterity tasks and poor lower limb coordination during tasks requiring balance, agility and speed. These difficulties can be overcome by the use of exercises like brain gym activities.[2]

The autism children mostly have gross-motor problems, such as a clumsy, uncoordinated gait; and difficulties with fine-motor control, such as manipulating objects and writing. Some may have trouble coordinating movements between the left and right side of the body among different limbs, making it difficult to do actions like pumping their legs on a swing, jumping, skipping, or hopping. Others may have low muscle tone and problems maintaining their posture or balance. Still others seem to have trouble with actions requiring hand-eye coordination, such as catching a ball or imitating the movements of others, and with planning a series of movements or gestures, known as praxis. These difficulties can range from mild to severe and can impact any motor system of the body.[3]

Brain gym is an intervention planned by educators Mr. Paul and Mrs. Gail Dennison, in 1970s to improve various outcomes along with attention, memory and academic skills by stimulating both hemispheres of brain through neurological repatterning to boost whole brain learning. Brain Gym is an educational kinesiology program that is promoted and implemented internationally in over 87 countries. Additionally, Brain Gym materials have been translated into over 40 languages. According to the Brain Gym International website, introductory training courses in the use of Brain Gym are available in ten countries.

Throughout recent decades, several theories that align with the theoretical foundations of Brain Gym have been developed and promoted. These theories include, neurological repatterning as put forth in the Doman-Delacato Theory, cerebral dominance, and perceptual-motor training.[6] These theories promote movement and physical activity in order to increase concentration, mental cognition, and academic performance. According to Mahar et al., (2006) there is evidence that daily classroom-based physical activity increases on-task behavior during instruction.[5]

As mentioned earlier, muscle weakness and abnormal muscle tone in ASD may play a role in the limitations in daily activities, such as locomotion and reaching. Muscle weakness may be a factor in the difficulties that children with ASD encounter in ordinary activities of daily living, such as in turning a doorknob or twisting a bottle cap. It is possible that the functional ability of these children could improve with muscle strengthening. A study by Kern et al. found that handgrip strength in participants diagnosed with an ASD was related to the severity of the disorder. The grasp and the grip strength of these children are commonly affected as well as the dexterity due to poor strength of the upper limb muscles. These children have problem also in the coordination of use of hand functions.[7]

The results suggest that ASD is a medical disorder in which physical aspects of the disorder, such as muscle weakness, need to be considered. Understanding the extent of each child's muscle weakness may provide more insight into the child's physical limitations and plan of care.
Physiotherapy for Autism will, in general, focus on developing the gross motor skills. These skills may be impaired in some Autistic children as a result of low muscle tone. Problems with gross motor skills and co-ordination can interfere with the child's basic day to day functioning as well as affecting social and physical development.

Differences in connectivity between brain regions could help explain some autistic people's motor difficulties. For instance, children with autism have decreased synchrony in the activity between their visual and motor regions; the less synchronization there, the more severe their social deficits, based on a standard scale. Their motor issues may also stem from less connectivity between the inferior parietal lobe, a region involved in hand-eye coordination; and the cerebellum, which helps guide and correct movements. Other evidence implicates weak connections between sensory and motor regions and atypical activity in a network important for motor planning.[8] As ASD children have poor muscle strength in both upper limbs and lower limbs, it is necessary to strengthen it which in turn will stimulate and improve the brain functioning. This will in turn improve the child's memory as well as will strength the muscles.

This study includes use of Brain gym exercises to check its effectiveness in the motor performance of the children which is evaluated through BOT-2 scale and this study compares whether the impact of these activities on the autism children can help in the boosting of functioning of brain and make the child functionally independent.

Aim of the Study
To find out the effectiveness of Brain Gym Activity in improving motor performance skills in children with Autism.

Objective of the Study
1. To assess motor performance using the BOT-2 scale.
2. To find out the effectiveness of Brain Gym Activity in improving motor skills in Autistic children.

Hypotheses
Null Hypothesis (H0): There was no significant difference in improvement of motor performance skills in children with autism spectrum disorder (ASD) through brain gym activities.

Alternative Hypothesis (H1): There was a significant difference in improvement of motor performance skills in children with autism spectrum disorder (ASD) through brain gym activities

Material and Method
Study design: Experimental study (pre-test andpost-test design)
Sampling Technique: The subjects were selected by Random Sampling.

Study setting: NIEPMD, Chennai
Materials and tools used:

- BOT-2 scale
- pen
- paper
- Examiner's manual booklet
- Pennies
- Chalk
- Ball
- Stop watch

Selection Criteria

Inclusion Criteria:

- Participants in the age group of 6-15 years
- Boys and girls
- Children with mild autism (according to ISAA Scale) i.e., 70-106
- Able to follow simple verbal commands

Exclusion criteria:

-Severe (>153) and moderate (107-153) autism (according to ISAA Scale)
-Children with Epilepsy/Seizures
- Auditory and visual problem
- Autism with mental retardation
-Autism with Intellectual Disability
-Children with physical disability
- Known case of any cardiorespiratory problems

Procedure

The study involves pre-test evaluation, intervention, and post-test evaluation.

(i)**Pre-Test Evaluation**

All the participants from NIEPMD Centre for Autism were screened according to inclusion and exclusion criteria. Parents were briefed about the study and an informed written consent was obtained from the parents. The children were divided based on random lots into 2 groups, one group was GROUP A which received the conventional interventions and was assessed for BOT-2 subtests both pre and post values and the other group received the interventions for a period of 4 weeks and the pre and post values were noted during 1st week and 4th week and was compared.

General Assessment was done for the children and the sub-tests were performed under BOT-2 scale. The values were taken PRE-INTERVENTION for both the GROUP A and GROUP B.

THE CLIENT IS EVALUATED FOR "FINE MOTOR PRECISION ACTIVITY"

THE CLIENT IS EVALUATED FOR "ONE LEGGED STATIONARY HOP"

(ii)**Intervention**

The participants after the pre-test evaluation were prepared for the intervention as follows-

GROUP A- 5 participants were treated with conventional physiotherapy and occupational therapy as per regular sessions.

GROUP B- 5 participants were given the 26 BRAIN GYM ACTIVITIES as the intervention for improving motor performance skills.

Brain Gym consists of 26 simple and pleasant movements aiming at improving learning skills through the use of both brain hemispheres. The 26 BRAIN GYM EXERCISES are-

- cross-crawl
- sit-up cross crawl
- think of an 'X'
- lazy 8's
- alphabet 8's
- the elephant
- double doodle
- neck rolls
- the owl
- the rocker
- belly breathing

- the energizer
- arm activation
- foot flex
- calf pump
- gravity glider
- the grounder
- water
- brain buttons
- earth buttons
- balance buttons
- space buttons
- energy yawn
- thinking cap
- hook-ups
- positive points

THE CLIENT IS BEING GIVEN THE BRAIN GYM INTERVENTION "**LAZY 8**"

THE CLIENT IS BEING GIVEN THE BRAIN GYM INTERVENTION "**THINK OF X"**

THE CLIENT IS BEING GIVEN THE BRAIN GYM INTERVENTION "**CROSS CRAWL**"

(iii)**Post-Test Evaluation**
After the Intervention, post-test measurements were taken for Motor Performance Skills by using The Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT™-2) for both GROUP A and GROUP B which evaluates four sub-tests (manual dexterity, bilateral coordination, running speed & agility, upper limb coordination).

Thus, the pre-test and post-test values were collected for all the 10 participants and were tabulated for the data analysis.

Data Analysis and Interpretation
All the data analyses in the present study were performed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM, Chicago, IL, USA). A one-sample z-test was performed to determine whether the mean of the motor scores of the ASD group statistically differed from the corresponding normative mean derived from the standardisation sample, as available in the BOT-2 manual.

t-test was used to analyze the mean difference of BOT-2 SCALE scores between the two groups at the end of intervention. Paired sample t test was used to examine the changes in outcome variables prior to and after the intervention in each group. The level of significance was fixed at $p < 0.05$.

Table 1-Characteristics of the Participants of Group A and Group B

Characteristics	**Group A**	**Group B**
Number of participants	5	5
sex	Male-4 Female-1	Male -4 Female -1
Age in years (mean)	9	9.4

Graph 1- The mean age for the GROUP A was 9 and for the GROUP B was 9.4

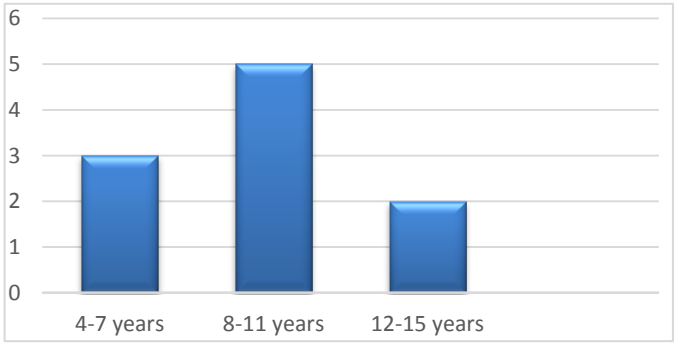


TABLE 2- WITHIN GROUP ANALYSIS OF GROUP A

GROUP	ANALYSIS	MEAN	STANDARD DEVIATION	t-VALUE	p-VALUE	LEVEL OF SIGNIFICANCE
GROUP A	PRE-TEST	31.80	1.483	2.359	0.078 (>0.05)	NS
	POST-TEST	33.40	1.140			

GRAPH 2- (PRE-TEST AND POST-TEST VALUES FOR GROUP A)

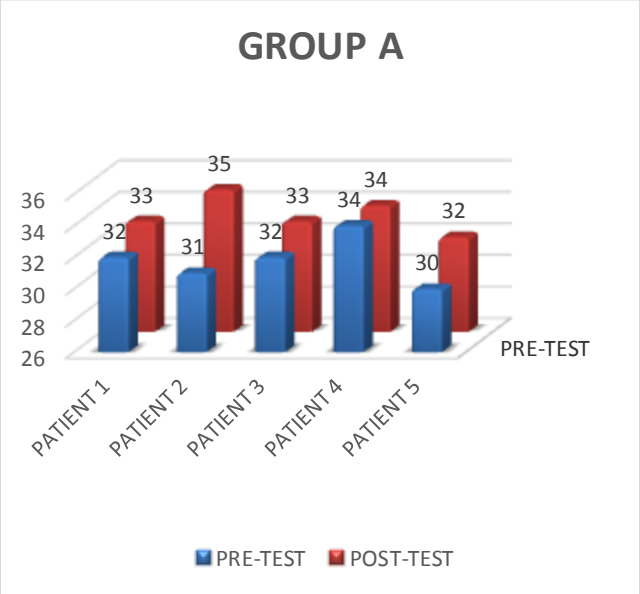


Table 3- Within Group Analysis of Group B

GROUP	ANALYSIS	MEAN	STANDARD DEVIATION	t-VALUE	p-VALUE	LEVEL OF SIGNIFICANCE
GROUP B	PRE-TEST	31.20	3.114	6.0	0.004 (<0.05)	**
	POST-TEST	36	2.121			

Graph 3- (Pre-Test and Post-Test Values for Group B)

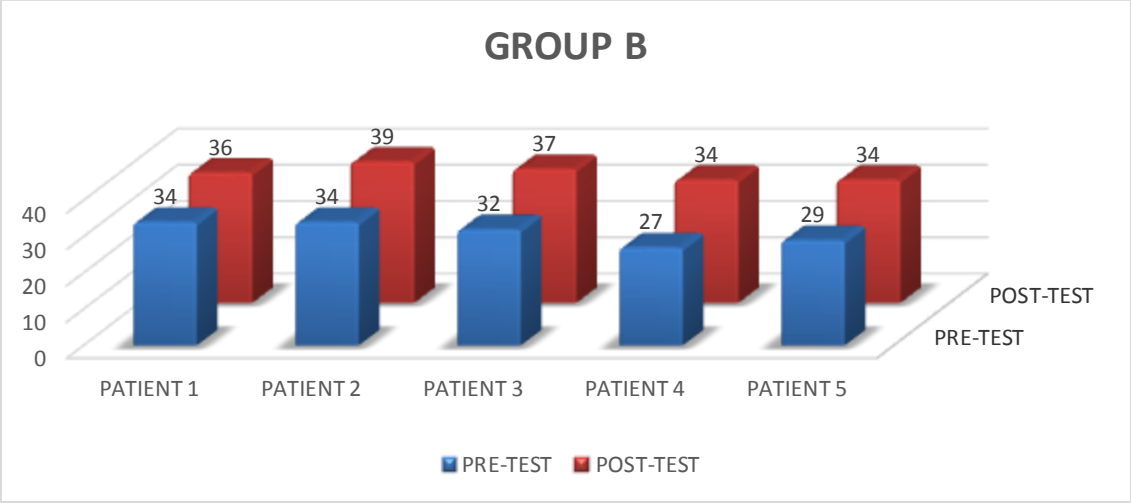
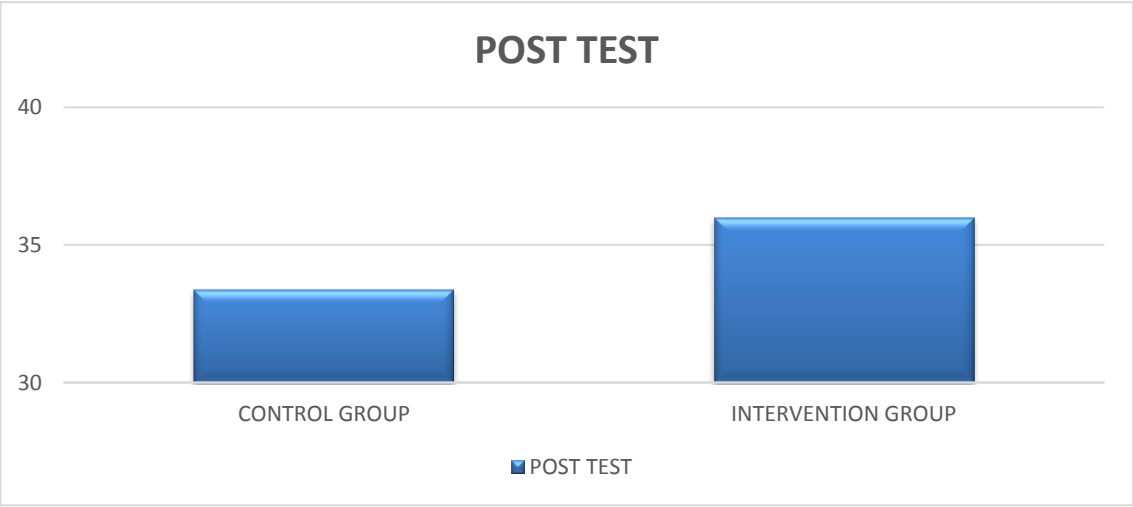


Table 4- Between Group Analysis of Group A and Group B

Group	Analysis	Mean	Standard Deviation	T-Value	P-Value	Level Of Significance
GROUP A	POST-TEST	33.4	1.140	2.414	0.042 (<0.05)	**
INTERVENTION GROUP	POST-TEST	36.0	2.121			

Graph 4- (Post-Test Values for Group A and Group B)



The BOT-2 diagnostic tool was used to evaluate four areas of psychomotor development: fine manual control (fine motor precision and integration), manual coordination (manual dexterity and upper-limb

coordination), body coordination (bilateral coordination and balance), strength and agility (running speed and agility, strength).[14]

Result

The data analysis shows that after the Brain Gym Activity intervention there was marked increase in the score of BOT-2 scale motor scores in the 5 participants of the GROUP B when compared with the GROUP A. According to the scoring of BOT-2 scale, higher score of the scale indicates better performance and lesser the score indicated decreased motor performance skills. Thus, according to the result of post intervention score, there is marked increase in the motor performance skills after the brain gym activity as the intervention with p value as 0.042(*)

Discussion

The data analysis of this study showed that the participants those who received BRAIN GYM exercises as intervention have a significant increase in motor performance skills. The minimum age group was 4 years and maximum was 15 years with more male participants than female. In some studies, it showed that with increasing age the motor difficulties increase in children along with other cognitive problems.
Many Articles showed the prevalence of children with ASD who exhibited clinically significant motor abnormalities.[15] The results indicated that the majority of the ASD sample fell outside the normal range in terms of motor performance. Indeed, the prevalence of children with ASD who exhibited clinically significant motor performance problems was found to be 88%.[16] These children had a score of 40 or less on the total composite, which indicates deficits in their motor skills. These results regarding the motor impairments seen in children with ASD are consistent with our expectations, since they reflect the motor abnormalities seen in those with autism.

Additionally, such findings regarding deficient motor functioning in children with ASD are in line with the findings of several prior studies that relied on a similar measure to the BOT-2. [17] The mean standard score for the overall motor composite in these previous studies ranged from 33.0 to 39.6, indicating the existence of motor impairments among children with ASD. A similar pattern of results was also found in the clinical sample of 45 individuals with autism aged 4 –21 years described in the BOT-2 manual (M = 37.0; SD = 8.4).[16] The present results are also in line with those of other studies that used different measures.[18] However, our results contrast with those found in a study by Hilton et al. (2014)[20] that used the BOT-2 but did not identify a significant deficit in the motor skills of individuals with ASD, however the sample size involved in this study was only with 7 children with ASD.

The motor disruptions seen in children with ASD may be attributed to the increase in the total brain volume seen in such children, as well as to certain affected brain regions that are regularly suspected to be involved in the neural underpinnings of autism, including the cerebellum, basal ganglia, brain stem functions, and alterations in the frontostriatal and frontocerebellar pathways. However, the brain mechanisms underlying the motor disruptions observed in those with autism are not conclusive, meaning that they warrant further investigation.[15]

It is important to note, however, that the prevalence of motor performance abnormalities identified in the context of our research was high when compared to the prevalence reported in other studies.[22] It is possible that the high frequency of motor performance abnormalities seen in the children with ASD in the present study could be attributed to several factors.[23]

First, low levels of physical activity can contribute to reducing the motor proficiency of children with ASD. The relationship between an individual's motor proficiency level and his/her level of physical activity was confirmed by Wrotniak, Epstein, Dorn, Jones, and Kondilis (2006). [25]

According to an article, the majority of families in the Gulf region depend on domestic servants to help care for their children and to do the housework.[28] These domestic servants also typically assist the children with numerous tasks associated with daily living, especially in the case of children who have been diagnosed with a disability. This assistance could involve, for example, buttoning up clothes, zipping up zippers, tying shoes, bathing, feeding, cleaning teeth, and combing hair. Hence, it is possible that the children might come to overly rely on the domestic servants to help them perform everyday activities. This could in turn have a negative impact on the physical activity levels of the children, and therefore adversely affect their motor development.

Second, a lack of opportunities to engage in physical activity/practice responding to physical stimuli could stem from various familial factors. The negative relationship between motor development and insufficient physical activity has been confirmed in the literature.

Finally, children with ASD typically lack exercise partners of the same age and are frequently isolated from their peers, which means that they generally lack opportunities to engage in social interactions. Unfortunately, children with ASD are particularly susceptible to social exclusion due to both the stigma experienced by their families (i.e., feelings of shame about their child's condition) and the rejection and lack of acceptance shown by their peers (i.e., evasion and discrimination). Some families attempt to keep their children's condition a secret, and hence prevent their children from attending social events and engaging in social interactions with their peers. It has been reported that the lack of a peer exercise partner represents one of the key barriers to physical activity experienced by children with ASD. Such non-participation in peer activities may limit children's opportunities to develop their motor proficiency.[15]

This study also sought to examine the differences between the motor performance, as assessed using the BOT-2, of children with ASD after the BRAIN GYM intervention and children in the GROUP A with the conventional therapy ongoing. The results demonstrated that the children with ASD exhibited weaker motor skills performance which indicated deficits in their motor proficiency. The results, therefore, support the findings of prior studies concerning motor behaviours, which indicated a general impairment of motor functioning in individuals with ASD. The results contribute to our understanding of definitive areas of motor dysfunction among children with ASD and their long-term developmental consequences. Further, the results add weight to previous insights intended to assist caregivers and therapists in addressing such issues.

When considering all eight subscales used to evaluate the overall motor proficiency of the children with ASD, it appears that the identified motor deficits manifested with different degrees of severity.

For instance, fine motor precision tasks require precise control over finger and hand movements.[26] Our results indicated that the children with ASD experienced difficulties drawing lines through paths and folding paper. This finding is in accordance with the notion that individuals with ASD experience difficulties completing tasks that require the planning and sequencing of movement. Such difficulties may lead to problems during many activities associated with daily living, including buttoning clothes

and writing. In these cases, the Brain Gym intervention like "Alphabet 8", "Think of an X", "Lazy 8's" are helpful and hence increase the fine motor precision.

The bilateral coordination subtest concerns the capacity to use both sides of the body in a controlled and organized manner to accomplish a functional task. The results indicated that the children with ASD experienced problems when attempting movements involving both sides of the body.[27] This finding is consistent with the fact that individuals with ASD are typically characterised by poor bilateral coordination. Further, Staples and Reid found that children with ASD experienced difficulty coordinating both sides of their body, or both arms and legs, while performing motor tasks. Such difficulties are overcomed by Brain Gym intervention such "Cross Crawl" and "Sit up Cross Crawl".

The balance subtest evaluates the motor control skills integral to an individual's posture when standing. Balance is necessary for both movement and stillness, which is why it is sometimes referred to as postural control.[28] The balance subtest consists of movement activities that measure the stability of the trunk support as well as stasis and movement. Our results suggested that the balance skills of the children with ASD were significantly impaired when compared with the typically developing children, which is in line with the findings of previous studies. Intervention such as "Cross Crawl", "The Rocker" helps in improving them. Moreover, BRAIN GYM interventions when given to ASD children like "Double Doodle", "The Owl", "Belly Breathing", "The Energizer" relaxes the mind and body and increases the concentration of the child.

Thus ,the study done shows positive effects on the motor skills performance of these children especially in helping in improving fine manual control ,fine motor precision and integration; manual coordination i.e. manual dexterity, and upper-limb coordination in terms of bilateral coordination and balance; strength and agility in terms of speed and strength Thus, Brain Gym Activity in turn improves quality of life for children through its approach and is widely used because of its ability to establish calm and gentle behaviour for these autistic children also. The intervention therefore, helps the children to cope up with a normal routine and the treatment protocol helps them to be functionally independent and improves their quality of life. Hence, it can be recommended to use Brain gym exercises along with Normal Therapy regime for the improvement of these children.[4]

Conclusion

The findings of this study "EFFECTIVENESS OF BRAIN GYM ACTIVITIES IN IMPROVING MOTOR PERFORMANCE SKILLS AMONG CHILDREN WITH AUTISM" showed that how the Brain Gym Activity helps in improving the motor performance skills in children with autism spectrum disorder. The results showed significant difference in the p- value using the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) hence, This marked improvement is seen in terms of Fine motor precision, Fine motor Integration, Manual dexterity, Bilateral coordination, Balance, Upper limb coordination and Strength after the brain gym as intervention when compared with the GROUP A participants.

Thus, it can be concluded that these strategies can be applied on a regular basis for helping such autistic children to overcome their motor skills issues and to cope up effectively with the environment.

Limitations of this study are: -

- The duration of the study was for shorter duration i.e, 4weeks
- The study has smaller sample size
- The long effects of Brain gym activities on motor performance skills were not carried out
- Only children with ASD who exhibited an average or above-average IQ according to ISAA scale were included in the study.

Recommendations of this study are: -
Further, it is recommended that this study can be conducted for a larger sample size and for longer duration of time.

Source of funding: No funding was obtained for the study.
Conflict of Interest: No conflicts of interest are present.
Ethical clearance: The research was conducted in accordance to the ethical standards of National Institute for Empowerment of Person with Multiple Disabilities in Chennai. Written informed consent were provided by all participants prior to participation

References

1. Motor Development in Children with Autism Spectrum Disorder by Andrea Watson (2019)
2. Autism Spectrum Disorder: Review Article by American Psychological Association (2018).
3. Autism and Developmental Disabilities Monitoring (ADDM) Network. Community report on autism. MMWR Surveillance Summaries. (2020).
4. Is Brain Gym an Effective Educational Intervention by Lucinda S. Spaulding(2015).
5. The Effect of Brain Gym® On Academic Engagement for Children with Developmental Disabilities Andrea Watson (2018).
6. The effects of 'Brain Gym' as a general education intervention: Improving academic performance and behaviours Nussbaum (2017).
7. Children with Autism Spectrum Disorder and Patterns of Participation in Daily Physical and Play Activities Amir Hossein Memari, Nekoo Panahi (2019)
8. Comparing motor performance, praxis, coordination, and interpersonal synchrony between children with and without autism spectrum disorder (ASD) Maninderjit Kaur (2018).
9. Prevalence of motor tests in autism spectrum disorder people by José Irineu Gorla (2012).
10. Fundamental movement skills in children with autism spectrum disorder: A systematic review by Aditi Gandotra(2018).
11. Evaluation of the validity of the MAND in assessing motor impairment in young children by Sarah Brantner(2009)
12. Motor coordination in autism spectrum disorders: a synthesis and meta-analysis by Kimberly A Fournier(2011)
13. Assessments of Motor-Sensory Bruininks Oseretsky Test-of Motor Proficiency (2018)
14. Reliability and Concurrent Validity of the Bruininks-Oseretsky Test in Children with Cerebral Palsy (2020)
15. An Assessment of the Motor Performance Skills of Children with Autism Spectrum Disorder in the Gulf Region Rehab H. Alsaedi (2020)

16. Haibach, P.; Reid, G.; Collier, D. Motor Learning and Development, 2nd ed.; Human Kineticsl: Champaign, IL, USA (2017)
17. Piek, J.P.; Hands, B.; Licari, M.K. Assessment of motor functioning in the preschool period. Neuropsychol.Rev22 (2012)
18. Catama Bryan, V.; Calalang Wield Mae, S.; Cade Renz Karlo, D.; Balog Angelica, C.; Batton Kaylee, B.; Begay Ma Lourdes, R.; Borje Denice Jan, J. Motor intervention activities for children with autism spectrum disorders. Int. J. Res. Stud. Psychol. (2017)
19. Libertus, K.; Haul, P. Motor skills and their foundational role for perceptual, social, and cognitive development. Front. Psychol (2017)
20. Gowen, E.; Hamilton, A. Motor abilities in autism: A review using a computational context. J. Autism Dev.Disord. (2013)
21. Abu-Dahab, S.M.N.; Skidmore, E.R.; Holm, M.B.; Rogers, J.C.; Minshew, N.J. Motor and tactile-perceptual skill differences between individuals with high-functioning autism and typically developing individuals ages 5–21. J. Autism Dev. Disord. (2013)
22. Dowd, A.; Rinehart, N.; McGinley, J. Motor function in children with autism: Why is this relevant to psychologists? Clin. Psychol. (2010)
23. Hilton, C.L.; Zhang, Y.; Whilte, M.R.; Klohr, C.L.; Constantino, J. Motor impairment in sibling pairs concordant and discordant for autism spectrum disorders. Autism (2012)
24. Fournier, K.A.; Hass, C.J.; Naik, S.K.; Lodha, N.; Cauraugh, J.H. Motor coordination in autism spectrum disorders: A synthesis and meta-analysis. J. Autism Dev. Disord. (2010)
25. Green, D.; Charman, T.; Pickles, A.; Chandler, S.; Loucas, T.; Simono_, E.; Baird, G. Impairment in movement skills of children with autistic spectrum disorders. Dev. Med. Child Neurol. (2009)
26. Liu, T.; Breslin, C.M. Fine and gross motor performance of the MABC-2 by children with autism spectrum disorder and typically developing children. Res. Autism Spectr. Disord. (2013)
27. Moseley, R.L.; Pulvermueller, F. What can autism teach us about the role of sensorimotor systems in highercognition? New clues from studies on language, action semantics, and abstract emotional concept processing.Cortex (2018)
28. Whyatt, C.P.; Craig, C.M. Motor skills in children aged 7–10 years, diagnosed with autism spectrum disorder.J. Autism Dev. Disord. (2012)
29. McCleery, J.P.; Elliott, N.A.; Sampanis, D.S.; Stefanidou, C.A. Motor development and motor resonance diffculties in autism: Relevance to early intervention for language and communication skills. Front. Integreted Neurosci. (2013)
30. Ming, X.; Brimacombe, M.; Wagner, G.C. Prevalence of motor impairment in autism spectrum disorders.Brain Dev.(2007)
31. Dewey, D.; Cantell, M.; Crawford, S.G. Motor and gestural performance in children with autism spectrum disorders, developmental coordination disorder, and/or attention deficit hyperactivity disorder. J. Int.Neuropsychol. Soc. (2007)