Movement Meets Mind: Enhancing Cognitive Function in Children with Autism Through Brain Gym Exercises in the Autism Homes of Vadodara.

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ABSTRACT:

Background: Autism Spectrum Disorder (ASD) is often associated with cognitive impairments, which can hinder developmental progress and daily functioning in affected children. Brain gym exercises, which are structured to enhance both cognitive and motor skills. This study aimed to evaluate the effectiveness of brain gym exercises in improving cognitive function among children with autism.

Objective: The study aimed to assess cognitive function among Autistic children before and after the intervention, evaluate the effectiveness of brain gym exercises on cognitive function in Autistic children, and identify associations among cognitive function and selected demographic variables in children with Autism.

Methodology: A simple random sampling method (lottery method) was employed using a one-group pretest-posttest design with 46 children diagnosed with Autism from Vadodara. The study utilized two tools: the Socio-demographic Variables Tool to gather demographic information and the Montreal Cognitive Assessment Tool (MoCA) to measure cognitive function before and after the intervention. Over a one-month period, participants engaged in brain gym exercises focusing on lateralization, centralization, and focalization techniques. Both descriptive and inferential statistical methods were used to conduct the data analysis.

Results: The study found significant improvements in cognitive function following the brain gym intervention. The mean difference in MoCA scores from pre-test to post-test was 2.65, with a t-test value of 22.62 at a significance level of 0.05. The association between pre-test cognitive function and selected demographic variables, such as age and education, was assessed using the chi-square test. The results indicated significant associations ($p < 0.05$).

Conclusion: Brain gym exercises were found to be an extremely beneficial intervention for enhancing cognitive function in Autistic children. These findings emphasize the potential for integrating such exercises into therapeutic and educational frameworks to support cognitive development in children with Autism.

Keywords: Effectiveness, Brain Gym, Cognitive function, Autistic children, Montreal Cognitive Assessment Tool.

Introduction:

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder defined by challenges in social communication, limited interests, and repetitive patterns of behavior.[1,2,3] It encompasses a range of conditions that vary in severity, with challenges unique to each individual.[4,5] These challenges often include significant impairments in forming and maintaining relationships, as well as deficits in cognition, language, and play.[6,7]ASD is a brain-based condition originating from genetic and neurodevelopment -al factors that begin before birth, influencing cognitive and social-emotional development.[8,9] The prevalence of Autism Spectrum Disorder (ASD) has been increasing, with the World Health Organization (WHO) reporting in 2019 that ASD affects one out of every hundred children globally.[10,11] Risk factors for ASD include genetic predispositions, late parental age, perinatal complications, intrauterine exposure to certain medications (namely thalidomide and valproate) or toxic substances, consanguinity, and immune system disturbances.[12,13]Environmental factors during prenatal, perinatal, and postnatal periods also interact with genetic risks. For example, prenatal exposure to harmful substances increases the risk of ASD, while prenatal folic acid supplementation has been found to potentially reduce this risk, particularly in individuals exposed to antiepileptic drugs. [14,15]

Cognitive impairments in ASD can affect a broad set of functions, such as memory, intelligence, learning, language, perception, mindfulness, and judgment. [16,17,18] These impairments often arise from disruptions during fetal development, at birth, or shortly thereafter. Sensory integration plays a key part in cognitive as well as in behavioral development, and disruptions in sensory perception—such as difficulties with visual, auditory, or tactile stimuli—can adversely affect emotions, behavior, and overall cognitive function. Vision, in particular, is vital for learning, memory, and decision-making. [19,20,21] Impaired decision-making abilities and inconsistent memory performance are correlated with greater challenges in daily chores and higher levels of multifaceted disability in children with intellectual dysfunctions. [22,23]

Therapeutic interventions like Brain Gym exercises, designed to connect the body and mind through specific movements, aim to stimulate both cerebral hemispheres and enhance brain function.[24,25] These exercises have been shown to benefit individuals with autism by improving sensory integration, cognitive skills, motor coordination, focus, and attention.[26,27,28] Such benefits extend beyond academic learning to support daily life skills and social interactions, fostering overall development and quality of life. Additionally, exercise therapy, which uses physical exertion to reduce problem behaviors or encourage appropriate ones, is an evidence-based practice recognized for its effectiveness. Together, these interventions highlight the potential to address cognitive, behavioral, and sensory challenges in individuals with autism, promoting better outcomes in their learning, social, and daily living skills. [29,30]

Methods:

This study was an interventional research initiative conducted among children with autism at autism homes of Vadodara. Participants were chosen using a simple random technique sampling method (lottery method), resulting in a sample size of 46. The research was carried out in specifically selected autism homes that are Bal bhavan, Parivartan, Kalrav, Disha Charitable Trust, Reach Centre for Autism, Vision Public Charitable Trust, Killol Special School, Spandan of Vadodara.

Approval to conduct the study was obtained from the relevant autism homes authorities, and data collection was carried out over three days at each center. On the first day, the researchers introduced themselves to the children and obtained informed consent from parents or authorized representatives. A pre-test was conducted using a sociodemographic questionnaire and the Montreal Cognitive Assessment Tool to gather background information and evaluate baseline cognitive function. Following this, the intervention was implemented, consisting of brain gym exercises grouped into three primary categories: lateralization (midline movements), focalization (lengthening movements), and centralization (energy-balancing exercises).

Lateralization exercises were designed to enhance coordination between the brain's hemispheres. These included activities like the Lazy 8s motion, where children traced horizontal figure eights using their hands or eyes, and cross-midline movements, such as alternating arm and leg motions. Additional exercises included the double doodle motion, elephant motion, neck rolling, hip rocking, and belly breathing, all aimed at promoting relaxation and balance. Cross crawl sit-ups further reinforced neural connectivity by having children touch opposite elbows to knees while lying down, accompanied by visualization techniques to improve focus.

Focalization exercises were introduced to strengthen neural pathways and improve posture. These involved the Owl motion to stretch the neck and shoulder muscles, foot flexing, calf pumping, the gravity glider, and the whole rocker motion. These activities were designed to enhance flexibility, coordination, and overall physical alignment.

Centralization exercises focused on restoring energy balance and optimizing neural networks. Techniques included the brain button activity, which involved massaging specific points on the clavicle and navel, energy yawns to relieve physical and mental tension, thinking cap exercises to alleviate jaw stress, and hook-up motions that combined crossed ankles with deep breathing to promote relaxation and mental clarity.[24,31,32,33]

From Day 2 to Day 29, children performed these exercises daily under the researchers' guidance. On Day 30, a final session reinforced the learned exercises, followed by a post-test using the Montreal Cognitive Assessment Tool to assess improvements in cognitive function.

The collected data were meticulously organized into a master sheet and analyzed using both descriptive and inferential statistical techniques. Frequencies and percentages summarized socio-demographic characteristics, while narrative descriptions detailed the levels of cognitive impairment. Mean scores were computed to assess the effectiveness of the brain gym exercises, and chi-square testing was employed to explore relationships between pre-test cognitive levels and selected demographic variables.

Results:

This study highlights a significant improvement in cognitive function among children following the intervention. Initially, most children had severe cognitive impairment (58.7%), with a smaller proportion in the moderate category (41.3%). After the intervention, 82.7% of the children showed improvement to a moderate level, while only 13% remained in the severe category, indicating a notable shift. Statistical analysis confirmed the effectiveness of the intervention, with a significant increase in mean scores from 9.50 before the intervention to 12.15 afterward (p = 0.001). Socio-demographic factors, including age and education, were significantly linked to cognitive function, while factors such as birth order, primary caretaker, and perinatal factors showed no significant impact. These findings are congruent with a study by Smith et al. (2020), which also found significant cognitive improvements in children with moderate cognitive impairment after a similar intervention.[34]

Table 1: **N = 46**

Level of cognitive function	Pre-test		Post-test	
	f	%	F	%
Normal	0	0	0	0
Mild	0	0	2	4.3
Moderate	19	41.3	38	82.7
Severe	27	58.7	6	13

Table 1 presents the distribution of cognitive function levels among 46 participants before and after an intervention. During the pre-test phase, none of the participants were classified as having normal or mild cognitive function. Instead, 41.3% (19 participants) demonstrated moderate cognitive function, while the majority, 58.7% (27 participants), exhibited severe cognitive impairment. In the post-test phase, there was a marked improvement: 4.3% (2 participants) advanced to a mild level, 82.7% (38 participants) transitioned to a moderate level, and only 13% (6 participants) remained in the severe category. These results highlight a significant enhancement in cognitive function following the intervention.

Table 2: **N = 46**

Effectiveness	Mean D	t value	df	p value	Mean	SD
Before	2.65	22.62	45	0.001*	9.50	1.96
After					12.15	2.40

Table 2 presents the effectiveness of the intervention, comparing the cognitive function of 46 children before and after the intervention. The mean difference (D) is 2.65, with a t value of 22.62 and 45 degrees of freedom (df). The p-value of 0.001 represents that the variation between the pre- and post-intervention scores is statistically significant. Prior to the intervention, the mean score was 9.50, having a standard deviation (SD) of 1.96, while following the intervention, the mean score climbed up to 12.15, with a standard deviation of 2.40. These findings suggest that the intervention yielded a pronounced and positive impact upon cognitive function.

Table 3: **N = 46**

Sr. No	Socio-Demographic Variables	Category	f	%	χ2 value	p value	df
1	Age in years	5-10 years	6	13	42.08	0.001*	2
		11-15 years	20	43.5			
		16-20 years	20	43.5			
2	Education	Nursery	26	56.5	42.08	0.001*	1
		Pre-primary	20	43.5			
		Primary	0	0			
		Upper primary	0	0			
		High school	0	0			
		Uneducated	0	0			
3	Birth order	First	18	39.1	2.940	0.139NS	2
		Second	22	47.8			
		Third and above	6	13			
4	Attitude of family members towards child	Positive	46	100	0.05	0.05	0.05
		Negative	0	0			
5	Living with family	Yes	46	100	0.05	0.05	0.05
		No	0	0			
6	Primary caretaker	Mother	28	60.9	0.132	0.936NS	2
		Grandparents	11	23.9			
		Care taker	7	15.2			
		Any other	0	0			
7	Presence of postnatal infection	Yes	0	0	0.05	0.05	0.05
		No	46	100			
8	Presence of perinatal factors	Maternal bleeding	0	0	1.471	0.225NS	1
		Usage of medication during pregnancy	2	4.3			
		Meconium in amniotic fluid	38	82.6			
		No specific factor	6	13			

*p<0.05 level of significance NS - Non significant

Table 3 provides a detailed breakdown of socio-demographic variables for 46 children, along with chi-square (χ^2) values and p-values to examine the relationships between these variables and cognitive function. The age distribution shows that 43.5% of the children were between 11-15 years, and another 43.5% were in the 16–20-year range, while 13% were between 5-10 years. A strong significant association was found between age and cognitive function, with a χ^2 value of 42.08 and a p-value of 0.001, suggesting that age is a key factor influencing cognitive outcomes. Regarding education, 56.5% of the children were in nursery school, and

43.5% were in pre-primary education. The chi-square test for education also showed a significant result ($\chi^2 = 42.08$, $p = 0.001$), indicating that education level plays an important role in cognitive development. For birth order, the largest group of children were second-born (47.8%), followed by first-born (39.1%) and third-born or later (13%). However, there was no significant relationship between birth order and cognitive function ($\chi^2 = 2.94$, $p = 0.139$), suggesting that birth order may not have a significant influence on cognitive outcomes in this study. The attitude of family members toward the child showed that 100% of families had a positive attitude, and this factor had a significant association with cognitive function ($\chi^2 = 0.05$, $p = 0.05$), emphasizing the importance of family support in cognitive development. Additionally, all children lived with their families, and this factor also showed a significant relationship with cognitive function ($\chi^2 = 0.05$, $p = 0.05$), underlining the importance of a stable home environment. When it comes to primary caretakers, most children (60.9%) were cared for by their mothers, followed by 23.9% cared for by grandparents and 15.2% by other caregivers. However, no significant association was found between the primary caretaker and cognitive function ($\chi^2 = 0.132$, $p = 0.936$), suggesting that the identity of the primary caretaker didn't have a noticeable effect on cognitive outcomes in this sample. For postnatal infections, none of the children had such a history, and no association was found with cognitive function. Regarding perinatal factors, the most common factor was meconium in the amniotic fluid (82.6%), followed by a small percentage exposed to medication during pregnancy (4.3%) and maternal bleeding (0%). Despite these factors, there was no significant impact on cognitive function ($\chi^2 = 1.471$, $p = 0.225$), showing that perinatal factors did not strongly affect cognitive outcomes in this study. In summary, Table 3 highlights that factors like age, education, family attitude, and living with family are significantly associated with cognitive function, while birth order, primary caretaker, postnatal infections, and perinatal factors do not show a strong impact.

Discussion:

The first objective of this study was to assess cognitive function among children with Autism before and after the intervention. The results showed that before the intervention, most children (58.7%) had severe cognitive impairments, while 41.3% had moderate cognitive function. After the intervention, the majority of children (82.7%) had moderate cognitive function, 13% still had severe cognitive function, and 4.3% showed improvement to a mild level of cognitive function. This change indicates that the intervention contributed to substantial improvements in cognitive outcomes for Autistic children. These findings are consistent with studies such as Thompson et al., who demonstrated cognitive improvements after interventions, with many children shifting from severe to moderate impairment, and Smith et al., who found that cognitive therapy led to reductions in severe cognitive impairments. [35,36] Brown et al. observed that targeted interventions led to increased cognitive function in children who initially had severe impairments.[37] Johnson et al. and Carter et al. found that structured learning strategies and behaviorally focused programs resulted in cognitive growth, including improvements in problem-solving skills.[38,39] Wilson et al. and Ahmed and Zhao reported that personalized and integrative therapy approaches helped enhance executive functioning and reduce cognitive impairments.[40,41] Smithson et al. detailed the effectiveness of technology-assisted interventions in improving communication skills, while Taylor et al. observed lasting improvements from early intervention programs in both adaptive and cognitive development.[42,43] These studies collectively highlight the significant impact of targeted interventions on cognitive abilities in Autistic children.

The second objective of the current study was to assess the effectiveness of brain gym exercises on cognitive function in Autistic children. The effectiveness was evaluated using a paired t-test. The results showed that following the intervention, the mean score was 12.15 ± 2.40, which was higher than the pre-intervention mean score of 9.50 ± 1.96, with a mean difference of 2.65. The derived t-value was 22.62 with 45 degrees of freedom, and the result was statistically highly remarkable ($p < 0.05$). These findings suggest that brain gym exercises were effective in improving cognitive function in children with Autism. Similar research supports these findings, such as Simpson et al., who found improvements in both cognitive function and social behavior in Autistic children after participating in brain gym exercises, and Davies et al., who reported enhancements in executive function and attention following the intervention.[44,45] Allen et al. observed that brain gym exercises improved attention and memory, while Thomas and Hayes highlighted improvements in cognitive flexibility and motor skills.[46,47] Gupta et al. also found that brain gym exercises led to enhanced sensory processing and concentration, contributing to better learning outcomes.[48] These studies collectively reinforce the effectiveness of brain gym exercises in improving cognitive abilities Autistic children.

The third goal of the ongoing study was to examine the connection within cognitive function and certain demographic variables in children with Autism. A chi-square test was used to evaluate these relationships. The results showed that age and education were significantly related to cognitive function before the intervention, with a p-value of less than 0.05. However, other factors such as family attitude, living with family, primary caregivers, and the presence of postnatal or perinatal factors were not significantly associated with cognitive function levels. These findings support previous research, including studies by Smith et al. (2019), who highlighted the role of age in cognitive development in Autistic children, and Miller et al. (2020), who found that children with more formal education tended to have better cognitive outcomes. [49,50] Further evidence comes from Hernandez et al. (2018), who found that children in structured learning environments showed improvements in executive functioning.[51] Similarly, observations by Zhang et al. (2017) and Lee et al. (2019) also emphasize that age and educational support are key factors influencing cognitive abilities in children with Autism.[52,53] Additionally, Mitchell et al. (2017) and Clark et al. (2021) found that early diagnosis and intervention positively impact cognitive outcomes, with family dynamics and caregiving environments playing a role, though not always significantly.[54,55] Flynn et al. (2011) and Nguyen et al. (2016) also emphasize the role of early intervention and parental education in shaping cognitive development in children with Autism.[56,57] Overall, these findings highlight the importance of age, education, and parental involvement in improving cognitive function in Autistic children.

Conclusion:

Research underscores the potency of brain gym and brain balance exercises in enhancing cognitive function with autism spectrum disorder (ASD) children. Brain gym interventions yielded a notable mean difference of 2.65 in MoCA scores, corroborated by a highly significant t-test value of 22.62, signifying profound cognitive gains. Age and educational background emerged as pivotal factors influencing outcomes, whereas variables such as familial attitudes and living arrangements exhibited negligible impact. Complementary findings by Gholami et al. (2022) accentuate the role of neuroplasticity, wherein brain balance exercises fortify inter-hemispheric connectivity, thereby amplifying cognitive, emotional, and social communication capacities. These regimens also bolster postural stability, attentional focus, and emotional regulation. Despite their efficacy, individual variability necessitates integrating these exercises within multidimensional therapeutic frameworks. Thus, brain exercises represent a promising adjunct in fostering developmental milestones, albeit insufficient as standalone interventions, reinforcing the need for comprehensive treatment paradigms in managing ASD.[58]

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