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EFFECTS OF CUEVAS MEDEK EXERCISES ON BALANCE AND POSTURE CONTROL IN CHILDREN WITH AUTISM SPECTRUM DISORDER

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ABSTRACT

Background: Autism Spectrum Disorder affects individuals' social interaction, communication, and behavior. It affects individuals across their lifespan and is typically diagnosed in early childhood.

Objective: To find-out the effect of Cuevas Medek Exercises (CME) on the balance and posture control of children diagnosed with autism spectrum disorder

Methods: The study was single blinded randomized controlled design in which non-probability convenience sampling technique was utilized to recruit 32 ASD patients. Using lottery method, the participants were randomly divided in to two groups, the control group and treatment group. Pediatric balance scale and posture and postural ability scale was used to assess the balance and posture in autistic children. Data was analyzed by using SPSS v 26.

Results: The mean age of the children was 4.56±1.014 years. Independent sample t-test of PBS showed significant with a p-value of 0.002, thus accepting the alternate hypothesis i.e. Cuevas Medek exercises are effective in improving balance among autistic children. The mean value for PBS in treatment group was improved from 34.19±5.671 (pre-test) to 45.56±4.70 (post-test). However, Man-Whitney U test on PPAS showed that both the treatments were equally effective in improving postures in both groups i.e. treatment and control group, as p-value was greater than 0.05 for all the sub-scales of PPAS i.e. Standing, Sitting, Supine and Prone position.

Conclusion: From the results of the study, it was concluded that both the conventional treatment and Cuevas Medek exercises improved posture in patients with ASD. Cuevas Medek was not found to be superior to conventional treatment. However, Cuevas Medek exercises were more effective in improving balance in ASD then the conventional treatment.

Key words: Autism Spectrum disorder, Autism, Balance, Cuevas Medek Exercises, Postural Ability, Postural Quality.

Trial registration: NCT, NCT06198166. Registered January 30, 2024, https://classic.clinicaltrials.gov/ct2/show/NCT06198166

INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition which is classified by broad range of sign & symptoms and challenges associated with aggressive behaviors, social anxiety and limited interests(1). It affects individuals across their lifespan and is typically diagnosed in early childhood.(2) The word "spectrum" refers to the reality that people with ASD can have a broad range of challenges and abilities, and their symptoms can differ widely from individual to individual(3, 4).

The incidence of ASD has been continuously increasing in last few years. As per latest data, about 1 in 54 children is diagnosed with ASD in the US. According to a study the 2022, the incidence of ASD has been increased up to 3.14% by 2020(5). However, it has been noted that incidence rates can vary according to different regions and populations. As per a systematic review conducted in 2022 the prevalence of West Asia was 0.51%(6).

Autism's origins are multifaceted, involving both genetic and environmental factors. While numerous genes are implicated in ASD, no single gene can fully explain its onset(7) . Furthermore, prenatal complications, maternal infections, and exposure to specific chemicals are believed to influence ASD development.(8)

Individuals with ASD frequently encounter challenges in social interactions, such as interpreting social cues, maintaining eye contact, and forming peer connections. These difficulties may stem from deficits in motor development and physical activity. Additionally, impairments in motor function often correlate with behavioral instability and difficulties in social communication, suggesting shared neurological origins with ASD symptoms. Trouble in apprehending and communicating using gestures, such as facial expressions and body language, are also observed.(9, 10) Autistic individuals often show in monotonous actions, such as continual movements (e.g., hand shaking. They may also display sensory sensitivities or aversions to certain sounds, textures, or lights(11, 12).

ASD-related motor deficiencies can be attributed to abnormalities in planning and controlling motor activities. Autistic children demonstrated to struggle with planning the first actions that lead to consequent movements and ultimate goals, and so were clearly challenged by multi-sequenced motor tasks.(13, 14)

Cuevas Medek Exercise (CME) is a therapeutic method designed to enhance postural control and balance in individuals with motor impairments, including those with neurological disorders like cerebral palsy.(15) Created by Chilean physical therapist Ramon Cuevas, CME focuses on fostering automatic postural responses and functional movement patterns through specific exercises and dynamic interactions with a therapist. It aims to challenge the individual's postural control system by introducing controlled perturbations and encouraging active responses, ultimately improving balance and functional mobility. The exercises in CME are designed to challenge the individual's postural control system in a progressive manner.(16)

Research on the effectiveness of CME in improving postural control and balance is limited but promising. Riquelme et al. investigated the effectiveness of CME on postural control in CP. The results showed that after a 12-week intervention of CME, the participants showed significant improvements in postural stability, as measured by changes in center of pressure displacement during quiet standing.(17) Another study by Riquelme et al. examined the effectiveness of CME on balance and functional mobility in CP. The results demonstrated improvements in functional mobility and balance, as assessed by the PBS and the Gross Motor Function Measure.(18)

It is important to note that CME should be implemented by trained and certified therapists who have expertise in this approach. The therapist's knowledge and experience are crucial in tailoring the exercises to the individual's specific needs and abilities, ensuring safety and maximizing therapeutic benefits.

Therefore, the current research is focused to ascertain the impact of Medek Exercises (CME) on the balance and posture control of children diagnosed with ASD. The outcome of this research could help the clinical practitioners to adapt this technique to enhance the balance and postural control in ASD children which will ultimately improve their overall quality of life.

1.1. Hypothesis

1.1.1 Null Hypothesis:

CME has no effect on balance and postural control in autistic children.

1.1.2 Alternate Hypothesis:

CME has an effect on balance and postural control in autistic children.

MATERIALS AND METHODS

Study design and participants

The study was structured as a Randomized Controlled Trial and determined its sample size through the use of G-Power software. This calculation, factoring in a 10% attrition rate, yielded a total sample size of 32 participants. To collect data, the researchers utilized a non-probability convenience sampling technique, conducting the study at two specific locations: International Therapy Services Lahore and Rehab Care Polyclinic Lahore. The study's duration spanned six months from the approval of the synopsis.

In selecting participants, strict inclusion and exclusion criteria were established. Inclusion criteria comprised children aged 2 to 6 years diagnosed with mild Autism Spectrum Disorder (ASD) using the CARS assessment tool, with scores falling between 15 to 30.(19) Additionally, participants had to exhibit postural and balance issues, as evidenced by scores between 22 to 45 on the pediatric balance scale. Furthermore, parental or caregiver reports indicating difficulties in planning and executing motor skills, and/or postural control were considered.(20)

Exclusion criteria were also defined to ensure the integrity of the study. Children scheduled for surgical or medical procedures during the study period were excluded, as were those with severe behavioral issues or unstable medical conditions. Additionally, participants with a history of neurological disorders such as seizures or epilepsy were not included in the study. These stringent criteria aimed to maintain the homogeneity of the sample and enhance the validity of the findings.

Intervention Protocol

Experimental Group (CME)

In this group, participants underwent Cuevas Medek Exercises (CME) according to the following protocol: The patient was supported at the leg level with slight posterior support to maintain balance. After being lifted off the ground for a few seconds, gentle up and down oscillations were applied. These oscillations served to reflexively increase the tone of the body's extensor muscles, including those in the lower limbs. Following this, gait movements were initiated from the same position. (21)

The study utilized three wooden boxes with identical dimensions measuring 20cm x 40cm x 60cm each, along with a larger box, a wooden plate, and two planks of equal size measuring 17cm x 80cm. These items were arranged in various configurations to create structures such as slides, piano flaps, and stairs. Once the child achieved the ability to stand with support from the hips or legs, the use of these materials allowed the therapist and parents to explore the full range of biomechanical functional possibilities, thereby stimulating integrated stability reactions in both standing and walking positions. These reactions were particularly employed when the child could maintain body support at the ankle joint level. The materials provided diverse sensory experiences in standing positions and facilitated guidance during walking, thus significantly contributing to the stimulation of walking by capturing the child's interest.(21)

Control Group (Conventional Therapy)

The control group participants were administered standard kinetic programs as part of the study protocol. These programs encompassed a range of interventions aimed at addressing specific aspects related to motor function and postural control. Here's a breakdown of the components of the standard kinetic programs:

Stretching for Calf Muscles: Participants performed stretching exercises targeting the calf muscles. This involved completing two sets of 15 repetitions with each repetition held for 5 seconds. The purpose of these stretches was to alleviate tightness and improve flexibility in the calf muscles, which can impact overall posture and gait mechanics.

Passive Mobilizations: Participants underwent passive mobilization exercises, completing two sets consisting of 20 repetitions each. Passive mobilizations involve gentle movements of the joints performed by an external force or therapist. These movements aim to improve joint range of motion and flexibility, particularly in areas that may be restricted due to muscular tightness or joint stiffness.

Ankle-Foot Orthoses (AFO): Participants were advised to wear ankle-foot orthoses (AFO) for a minimum of 6 hours per day. AFOs are orthotic devices designed to provide support and stability to the ankle and foot. They help maintain proper foot alignment, provide structural support, and assist in controlling excessive motion. Additionally, AFOs can address sensory processing difficulties by providing proprioceptive feedback and promoting a sense of stability and security, which may aid in relaxation and improved postural control. These methods and orthotic tools primarily target tense muscles, uphold correct foot alignment, address sensory processing challenges, and encourage relaxation(22).

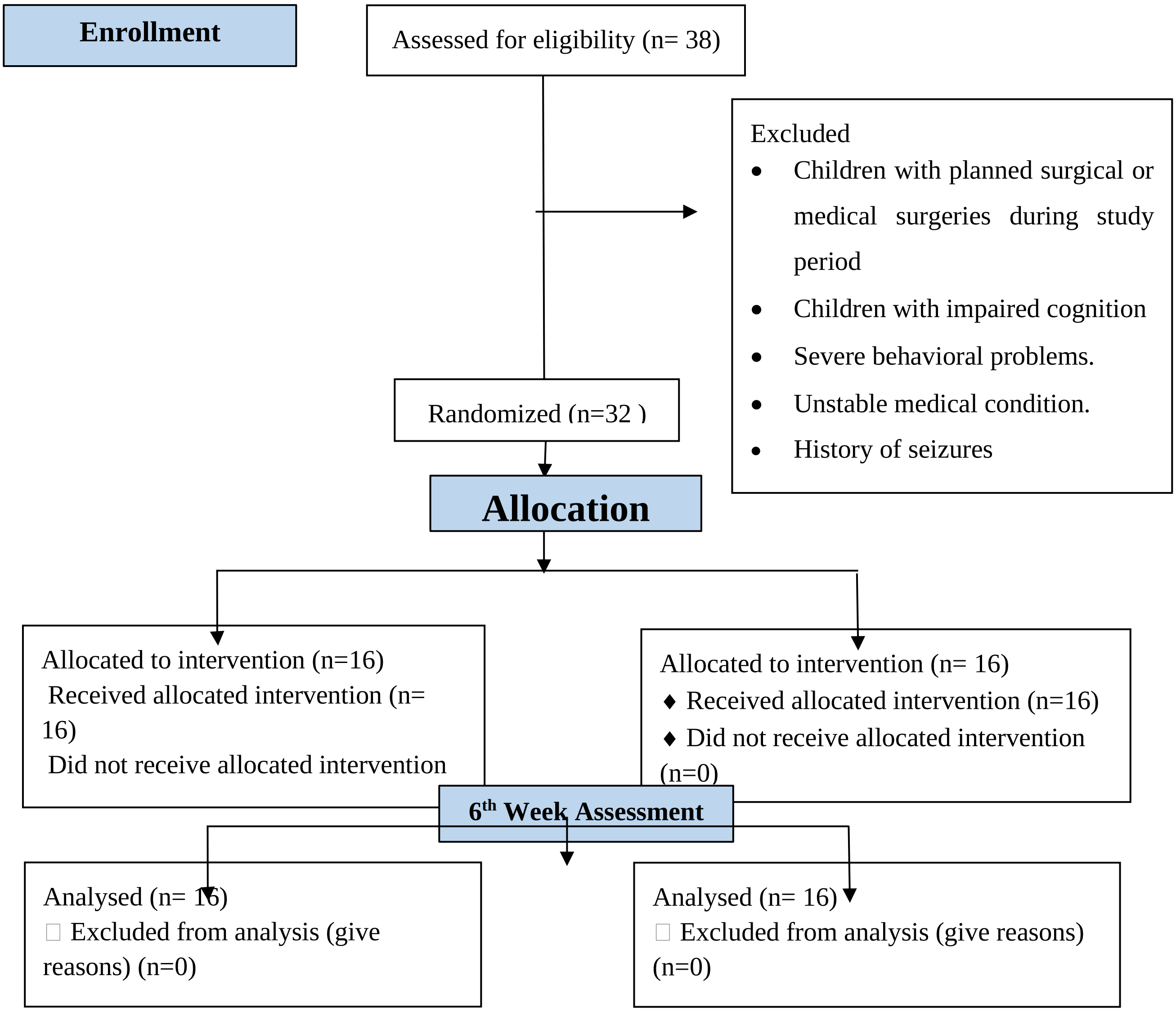
4.1 Data Analysis Procedure:

The data was analyzed by using SPSS for version 25. Statistical significance was be set at p- value ≤ 0.05.

After the normality of the data was assessed using the Shapiro-Wilk test, if the p-value was found to be greater than 0.05, the data was considered to be distributed normally, and parametric tests were applied. Conversely, if the p-value was less than 0.05, non-parametric tests were used.

- **Descriptive statistics** utilized frequency tables, pie charts, and bar charts to display a summary of group measurements taken over time.
- **When comparing differences between groups**, the normality of the data was assessed using the Shapiro-Wilk test. Depending on the results, either parametric or non-parametric tests were selected for within-group or between-group comparisons.

Figure No. 1 CONSORT Diagram



RESULTS

Baseline demographic characteristics of Experimental and Control group

The results showed that the mean age of the participants in experimental group was 4.81±1.047 years while in control group was 4.20±1.033 years. However, about the gender distribution, a greater frequency of boys was observed in both groups, suggesting higher prevalence of ASD in boys as compared to girls, as supported by different studies.

Variables	**Experimental Group (n=16)**	**Control Group (n=16)**
Age	4.81±1.047	4.20±1.033

Gender	**Boy:**	11 (68.7%)	13 (81.3%)
	Girl:	5 (31.3%)	3 (18.7%)
Socioeconomic Status	**Upper class**	5 (31.3%)	3 (18.7%)
	Middle class	9 (56.3%)	9 (56.3%)
	Lower Class	2 (12.5%)	4 (25%)
GMFMS Level	**Level I**	6 (37.5%)	5 (31.3%)
	Level II	10 (62.5%)	11 (68.7%)

Table No 1. Baseline demographic data of Experimental and Control groups.

IMPROVEMENT IN POSTURAL ABILITY

The table No 2 shows the distribution of postural ability level of PPAS scale among control and experimental groups in pre-test and post-test. The results showed non-significant values for the rest of all the sub-scales of PPAS i.e. Standing, sitting, supine and prone position. However, in post-test results showed significant values in standing, sitting and supine levels, showing significant improvement in levels (P-value<0.05), while non-significant values for the prone ability as p value >0.05.

Table No. 2 Distribution of Postural Ability among groups in Pre-test & Post-test (n=16 each)

Group	Postural Ability	Level (Pre-test)			P-value	Level (Post-test)				P-value
		Level 4	Level 5	Level 6		Level 4	Level 5	Level 6	Level 7	
CG	Standing	10	6	0	0.087	2	14	0	0	0.002
EG		6	8	2		0	8	6	2	
CG	Sitting	7	9	0	1.00	3	13	0	0	0.004
EG		8	7	1		8	7	1	1	
CG	Supine	8	8	0	0.246	4	12	0	0	0.000
EG		6	8	2		0	7	7	2	
CG	Prone	4	12	0	0.331	2	10	4	0	0.163
EG		8	7	1		0	10	5	1	

IMPROVEMENT IN BALANCE

Balance was assessed using pediatric balance scale. Paired sample t-test was used for within group analysis and independent sample t-test was used for between group analysis. The results showed significant improvement in balance in both the groups with a p-value of 0.000 for both groups. However, the results also showed that on initial examination i.e. pretest, both the groups mean were somehow equal and non-significant results were obtained (p-value >0.05) but significant results were obtained in post-test values (P-value <0.05) which rejects the null hypothesis and accepts the alternative hypothesis that Cuevas Medek exercises has improved the results of PBS in experimental group. The mean value for PBS in control group was improved from 33.13±5.854 (pre-test) to 38.00±5.88 (post-test) and that for Experimental group it was improved from 34.19±5.671 (pre-test) to 45.56±4.70 (post-test).

Group			Mean	SD	p-value
Control Group	Pair 1	Pre-test values of PBS	33.13	5.841	0.000
		Post-test values of PBS	39.00	5.888	
Experimental Group	Pair 1	Pre-test values of PBS	34.19	5.671	0.000
		Post-test values of PBS	45.56	4.704	

Table No. 3 Paired Sample t-test for Pediatric Balance Scale

	Group	Mean	Std. Deviation	P-value
Pediatric Balance Scale (Pre-test)	CG	33.13	5.841	0.605
	EG	34.19	5.671	
Pediatric Balance Scale (Post-test)	CG	39.00	5.888	0.002
	EG	45.56	4.704	

Table No. 4 Independent Sample t-test For Pediatric Balance Scale

IMPROVEMENT IN POSTURE

Posture and postural ability was assessed using PPAS scale. The data for PPAS was didn't follow normal distribution, so non-parametric tests were used. Wilicoxin signed rank test was used for within group analysis and Mann-Whitney U-test was used for between group analysis. The table No 5 shows significant results for both the group and p-value obtained was less than 0.05 for all the sub-scales in both groups, which means that significant improvement in posture was seen in respective groups and both the conventional treatment and Cuevas Medek exercises were effective. However, table no 6 shows that on initial examination i.e. pretest, both the groups mean were somehow equal and non-significant results were obtained for all the sub-scales assessing postural ability (p-value >0.05), however post-test results were also non-significant so both the conventional treatment and Cuevas Medek exercises were equally effective in improving postural ability in standing, sitting, supine and prone position. None of them was found superior as p-value was >0.05 for all.

Group		Median (50th percentile)	Mean Rank	p-values
Control Group	Pre-test PPAS Standing	10	.00	0.002
	Post-test PPAS Standing	11	5.50	
	Pre-test PPAS Sitting	10	5.50	0.005
	Post-test PPAS Sitting	11	6.59	
	Pre-test PPAS Supine	10	6.75	0.045
	Post-test PPAS Supine	11	5.57	
	Pre-test PPAS Prone	11	4.50	0.034
	Post-test PPAS Prone	12	4.50	
Experimental Group	Pre-test PPAS Standing	10	.00	0.001
	Post-test PPAS Standing	11	7.00	
	Pre-test PPAS Sitting	10	.00	0.000
	Post-test PPAS Sitting	11	7.50	
	Pre-test PPAS Supine	10	13.00	0.015
	Post-test PPAS Supine	11	6.50	
	Pre-test PPAS Prone	10	.00	0.001
	Post-test PPAS Prone	11	6.00	

Table No. 5 Wilicoxin Signed Rank Test for Sub-scales of Posture and posture Ability Scale (PPAS)

Group		Median (50th percentile)	Mean Rank	p-values
Pre-test PPAS Standing	CG	10	17.66	0.473
	EG		15.34	
Post-test PPAS Standing	CG	11	16.41	0.952
	EG		16.59	
Pre-test PPAS Sitting	CG	10	17.44	0.551
	EG		15.56	
Post-test PPAS Sitting	CG	11	16.47	0.984
	EG		16.53	
Pre-test PPAS Supine	CG	10	18.28	0.258
	EG		14.72	
Post-test PPAS Supine	CG	11	17.69	0.437
	EG		15.31	
Pre-test PPAS Prone	CG	11	18.66	0.173
	EG		14.34	
Post-test PPAS Prone	CG	12	17.81	0.366
	EG		15.19	

Table No. 6 Mann-Whitney U-test for Sub-scales of Posture and posture Ability Scale (PPAS)

DISCUSION

Cuevas Medek exercises are found to be effective in pediatric population and a number of studies supports this stance.(15, 23) A systematic review by Bartlett et al. evaluated the effectiveness of CME in children with cerebral palsy. The review included six studies and concluded that CME had positive effects on postural control, balance, and functional mobility in this population. However, the authors noted the need for more high-quality studies to further establish the efficacy of CME.(24)

The findings of a case study conducted in 2022 were consistent with those of the current study. This case study aimed to assess the impact of Cuevas Medek Exercises (CME) on a 6-year-old girl diagnosed with Cerebral Palsy and hip dysplasia. Over the course of 10 months and comprising 136 sessions, the girl underwent a series of CME interventions. Evaluation of her progress involved assessing the CME score, motor age, and hip radiography. The results indicated notable improvements, including an increase in the CME score from 55 to 61 points, advancements in motor age, and positive changes in hip radiography, particularly concerning the left hip transitioning from subluxated to at-risk status.(25)

Furthermore, the current study demonstrated significant enhancements in balance scores, as measured by the PBS (Posture and Balance Scale), which increased from 34.19±5.671 (pre-test) to 45.56±4.70 (post-test). Additionally, improvements were observed in posture, as assessed by the PPAS (Pediatric Postural Assessment Scale).

Another case study conducted in 2021, focusing on a child with corpus callosum abnormalities, provided additional evidence supporting the effectiveness of Cuevas Medek exercises. Despite the presence of underlying health conditions such as congenital heart disease, the CME-based intervention aided the child in reaching motor milestones and preventing developmental motor delays. Following one month of intensive intervention, the child's CME motor scale age increased by 2.87 months, reaching 9.37 months, slightly below her chronological age of 10 months. Although there was a notable improvement of 9 points on the AIMS (Ages and Stages Questionnaire Motor Scale), her score remained 11 points lower than the benchmark value associated with typical motor development for her age, indicating a deviation from the expected motor performance trajectory.(26)

Additionally, the current study highlighted significant improvement in posture and balance among children with Autism Spectrum Disorder (ASD) and delayed milestones.

These findings were further supported by a study conducted in 2018, which examined the effects of a visual-based biofeedback training program on balance challenges in youth with ASD. Significant balance improvements were noted, particularly in participants with milder stereotyped behaviors and better initial balance.(27)

However, the results of the current study diverged from those of a 2016 study by Sergiu Mitroi, which compared the effectiveness of Bobath and CME on tone and balance in Cerebral Palsy (CP) children. While the Medek exercises group exhibited significant improvements, both conventional treatment and Medek exercises demonstrated equal improvement in posture among ASD patients in the current study.

The results of the current study were in contrast with another study conducted by Sergiu MITROI in 2016 which compared the effects of Bobath and Medek exercises on tone and balance in CP children. The results showed that the group receiving Medek exercises has significant improvement in tone and balance then the group receiving Bobath technique. (21) How ever in the current study both the conventional treatment (CG) and Medek Exercises (EG) showed equal improvement in posture of ASD patients as assessed by PPAS but balance was improved on a greater extent in EG group receiving Medek exercises.

The effect of balance training on posture was studied by Cheldavi et al. on 20 Autistic children with an IQ greater than 80, the children were divided into a training group and a control group. After a six-week balance training program, which included different conditions of bipedal upright stance, it was found that the program effectively improved postural control in the children with ASD. Removing visual and plantar proprioceptive information led to increased sway in both groups, and the training group outperformed the control group across all conditions. (28) However the current study showed that Cuevas Medek exercises also improve posture in autistic children as assessed by PPAS scale but it was not found superior to conventional treatment as p-value was >0.05

Takeuchi and Izumi demonstrated that a rehabilitation program aiming to enhance neural plasticity and motor recovery should incorporate exhaustive, monotonous, and evocative exercises within an improved environment. The intensity of the exercises is considered crucial for successful rehabilitation, as extensive movement repetition can lead to significant changes in cortical motor representations, including increased dendritic branching and synaptic growth (29).

Regarding treatment by CME protocol, exercises are iterated either three, five or eight times, relying on the efficacy and anticipated response's quality. Additional repetitions are executed for superior reactions.(16) Moreover, engaging in diverse and more demanding exercises is crucial for prompting the brain to respond in novel ways, thereby supporting the concept of neuroplasticity progression. Bowdena et al. have illustrated that innovative movements, in contrast to familiar ones, are associated with the most profound neuroplastic changes.(30)

The incorporation of thousands of diverse exercises within CME aligns with the concept of enriched environment (EE) interventions, which have been shown in previous studies to be essential for optimal neuroplastic outcomes(31). By providing a variety of exercises that stimulate the same functional goals in unique and playful ways, CME promotes a voluntary, active, and challenging routine, contributing to meaningful functional motor recovery driven by neuroplasticity. This approach makes the rehabilitation process playful and motivating, in line with the principles of enriched environment interventions.

CONCLUSION

The current study concluded that Cuevas Medek exercises were more affective in improving balance and postural control in autistic children then the conventional treatment as indicated by the significant results obtained from the paired sample t-test for both groups.

RECOMMENDATIONS

It is recommended to consider implementing Cuevas Medek exercises as part of rehabilitation programs aimed at improving balance in similar patient populations. Future studies incorporating larger sample sizes and extended intervention duration could offer a more comprehensive insight into the enduring effectiveness of CME on balance and postural ability. Exploring the comparative effectiveness of Cuevas Medek exercises with other rehabilitation approaches could further inform clinical decision-making.

DECLERATIONS

Ethical Approval and Consent to Participate

The study adhered to ethical standards and received approval from the Research and Ethics Committee (REC) of Riphah College of Rehabilitation and Allied Health Sciences, Riphah International University Lahore. The approval was granted under reference number REC/RCR & AHS/23/0752, ensuring that the research was conducted in accordance with ethical guidelines and principles. This endorsement underscored the commitment to safeguarding the welfare and rights of participants throughout the study.

Informed consent was obtained from the parents or legal guardians of all participating children before their inclusion in the study. Parents were provided with detailed information about the study objectives, procedures, potential risks, benefits, and their rights as participants. They were given ample time to review this information and ask any questions they might have had before providing their consent. Additionally, it was emphasized that participation was voluntary, and parents had the freedom to withdraw their child from the study at any time without repercussions. This ethical practice ensured transparency, autonomy, and respect for the participants' rights and well-being throughout the research process.

Consent for Publications

All the authors have reviewed and approved the manuscript for publication. Additionally, all the participants included in the study have provided consent for their data to be published in the final manuscript.

Availability of Data and Materials

All the data and materials used and analysed during the course of study are available from the corresponding author on reasonable request.

Competing Interests

All the authors declare that they have no competing interests.

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No Funding was received.

Authors Contribution

“IA Physically conducted the study and collected data regaring the study, while the data was analysed and results were interpreted by **AA and UA**. **RI and KF** drafted the initial manuscript and coordinated the writing process, while **AA and WR** provided critical revisions and contributed to the final version of the manuscript. **RY** managed the literature searches and provided additional data resources to respective group members. **HR** Conceptualized the study, designed the methodology, and supervised the project. All the autors read and approved the final manuscript”.

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LIST OF FIGURES AND TABLES