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Effects of Simulated Equestrian Therapy in Improving Motor Proficiency among Down Syndrome Children - A Randomized Controlled Trial

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ABSTRACT

International Journal of Exercise Science 17(1): 1193-1207, 2024. The objective of this study was to investigate the effectiveness of Simulated Equestrian Therapy and Neuro-Motor Therapy in improving Motor Proficiency among Down syndrome children using a double-blinded Randomized Controlled Trial. This study was conducted at Dar-ul-Sukun Institute and Dr. Ziauddin Hospital from April to September 2023 by enrolling a total of 56 participants with Down syndrome (DS) after obtaining informed, voluntary assent from the guardians of the participants. Each participant was allocated randomly to the treatment group (n = 28) that received Simulated Equestrian Therapy (SET) and the control group (n = 28) that received Neuro-motor Therapy (NMT) using the envelop method of simple random sampling. The participants and their guardians were blind to the allocations. Participants' blood pressure and heart rate were recorded before and after each session to ensure safety. Each participant was assessed at baseline and after 6th and 12th week of intervention using Bruinink's test of motor proficiency (BOT-2). The data was analyzed using Medcalc software. The results reveal significant findings for improving motor proficiency after 12th week of intervention of SET and NMT. No protocol was found to be superior to another in improvement of the tested parameters. Hence, our study concludes that SET and NMT effectively improve motor proficiency among DS children. However, studies with a follow-up period should be conducted to further evaluate these therapies' long-term benefits.

KEY WORDS: Developmental disabilities, balance, muscle strength, physical therapy techniques, playthings

INTRODUCTION

Down syndrome (DS) has recently emerged as a prevailing condition, with an incidence of 1 in every 300 babies, in low-and middle-income countries occurring due to the triplication of all or some parts of the 21st chromosome (31). Various problems characterize this disability, including a compromised motor skills proficiency (3). Motor proficiency combines strength, coordination, speed and agility, and balance. An individual requires this set of skills to carry out the activities of daily living (13) including walking (28). Various underlying factors and genetic mutations are identified as the cause of motor and ambulatory debilities in children with DS. As a result, laboured task execution and participation restrictions are observed (36). These deficits have been addressed using numerous effective techniques, such as neurodevelopmental therapies (33), strength development (2, 5), balance and vestibular training (34), goal-directed motor learning (4), virtual reality (32) and Equestrian Therapy (24). The focus of this article is Equestrian Therapy.

Equestrian Therapy, also known as equine-assisted therapy or hippotherapy in literature, is a horseback riding technique that uses horses as a modality to treat multiple arrays of physical and mental defects (35). Over the decades, it has advanced and gained significant validation, addressing children, older adults, and individuals with special needs (10, 16) Moreover, it has emerged as a viable approach for treating DS (27). Equestrian Therapy provides a three-dimensional movement depicting the human pelvis rotations while walking. The oscillations provided by horseback riding improve the postural reflex mechanism, balance, and coordination by stimulating neuromuscular responses. It also emphasizes the trunk control of the rider by making it more receptive and forcing them to alter their posture in response to the sequentially fluctuating movements, activating deep agonist muscles and thus improving tone, strength, and flexibility (16). Although the prime goal of equine-assisted Therapy is not to let the rider control the equine, it focuses on the transference of energy and movement, resulting in improved neuronal stimulation and motor responses. However, as equestrian Therapy requires a licensed practitioner, open space, and a high cost, its use in traditional setups remained limited. Moreover, the fear of riding a real horse, specific allergies to its hair or outdoor environments, and the availability of a specially trained equine for the Therapy also remained constrained to its practice (27). Therefore, considering the vast beneficial effects of this approach, Equestrian Therapy simulators were introduced, imitating almost all possible three-dimensional movements provided by the horse, reducing the length of the training process, accessibility, and some of them have reduced the cost of affording and maintaining a real horse (14, 15, 29).

These simulators can be easily placed indoors and provide more safety than riding a real horse, with more reproducibility of effects (7). Evidence stating the beneficial impact of Equestrian Therapy is available for the special needs population, but a scarcity of literature still surfaces regarding the use of simulators and their effects especially for the population suffering from DS. Therefore, this study was aimed to investigate if Simulated Equestrian Therapy is effective in comparison to Neuro-Motor Therapy in improving Motor Proficiency among Down syndrome children.

METHODS

Participants

This double-blinded, randomized-controlled trial was conducted following the CONSORT guidelines in the Department of Rehabilitation of Dar-ul-Sukun Institute and Dr. Ziauddin Hospital, Karachi, after obtaining a prior ethical review from the Ziauddin University ERC committee under reference code 6803223MHREH. A signed informed assent from the guardians of each participant was taken before the enrollment. This research was carried out following the ethical standards of the *International Journal of Exercise Science* (23). It was registered with the

National Clinical Trials registry under trail number NCT05912803. Before the analysis the sample size was estimated using the formula $n = [z2 * p * (1 - p) / e2] / [1 + (z2 * p * (1 - p)/(e2 \bullet N))]$ $z-1.96$, $p = 0.7$, $N = 24.8$, $c = 0.05$ $n = [1.962\ 0.7\ (1-0.7)/0.052] / [1 + (1.962 * 0.7\ (1-0.7)/ (0.052 * 24.8))]$ $n-322.6944/14.0119$ at 80% (power), which gave a sample size of 24 for each group.

A total of 56 participants were recruited for this study and were allocated randomly to the treatment group (n = 28) that received Simulated Equestrian Therapy (SET) and the control group (n = 28) that received Neuro-Motor Therapy (NMT) using the sealed envelope method of simple random sampling technique. The participants and their guardians were blinded to the group allocations. The individuals referred by neurologists with a diagnosis of DS aged 6–12 years with a GMFCS level-I were included in the study, whereas children with DS who already had a similar intervention within the last year or had any atlantoaxial instability, behavioural, cognitive or severe visual impairment were excluded. Details of the recruitment and random assignment are illustrated in Figure 1.

Each participant's blood pressure (BP) and heart rate (HR) were recorded before and after each session to ensure safety. In case of elevated BP and HR, the participants were provided with 10-15 minutes of rest and the readings were repeated. Those participants who failed to achieve normal resting readings or felt uncomfortable, even after rest, were provided with a compensatory session, and their scheduled session was cancelled. During the course of intervention 3 participants have had their sessions rescheduled because of fluctuations in their heartrate and blood pressure readings due to fever. Each participant was assessed at baseline after the 6^{th} and 12^{th} week of intervention using Bruinink's Test of Motor Proficiency (BOT-2). Each group received the treatment thrice a week for three months. Each session's duration was 30-45 minutes on average.

SET was provided in two phases, supervised by an experienced physical therapist, using two horse simulators (mechanical and wooden) depicted in Figure 2 manufactured by Guangzhou Enjoyment Toys.

The mechanical simulator used in this study was an ergonomically designed horse-riding toy. The simulator had an adjustable seat and wheels on the legs. The handles of this simulator are fixed with brakes to stop the horse at any point. The fabric of the simulator is soft and does not contain any sharp ends that injure the child. This simulator can mimic two types of horse gait patterns: Trot and Gallop. This simulator was available in multiple sizes, and the size selection was made according to the age and weight of the child.

Further, it works by active paddling of the child. As the rider holds the handle and pushes the pedal downwards, the legs of the horse fold, and the seat rises, which incorporates the element of galloping. The legs of the horse spread when the paddle is released, propelling the horse in the forward direction and incorporating a trot. On the other hand, the wooden horse simulator has a padded seat and fixed legs on the wooden frame that tilts in an anterior and posterior direction. Handles support the rider as he swings anteriorly and posteriorly on the wooden frame.

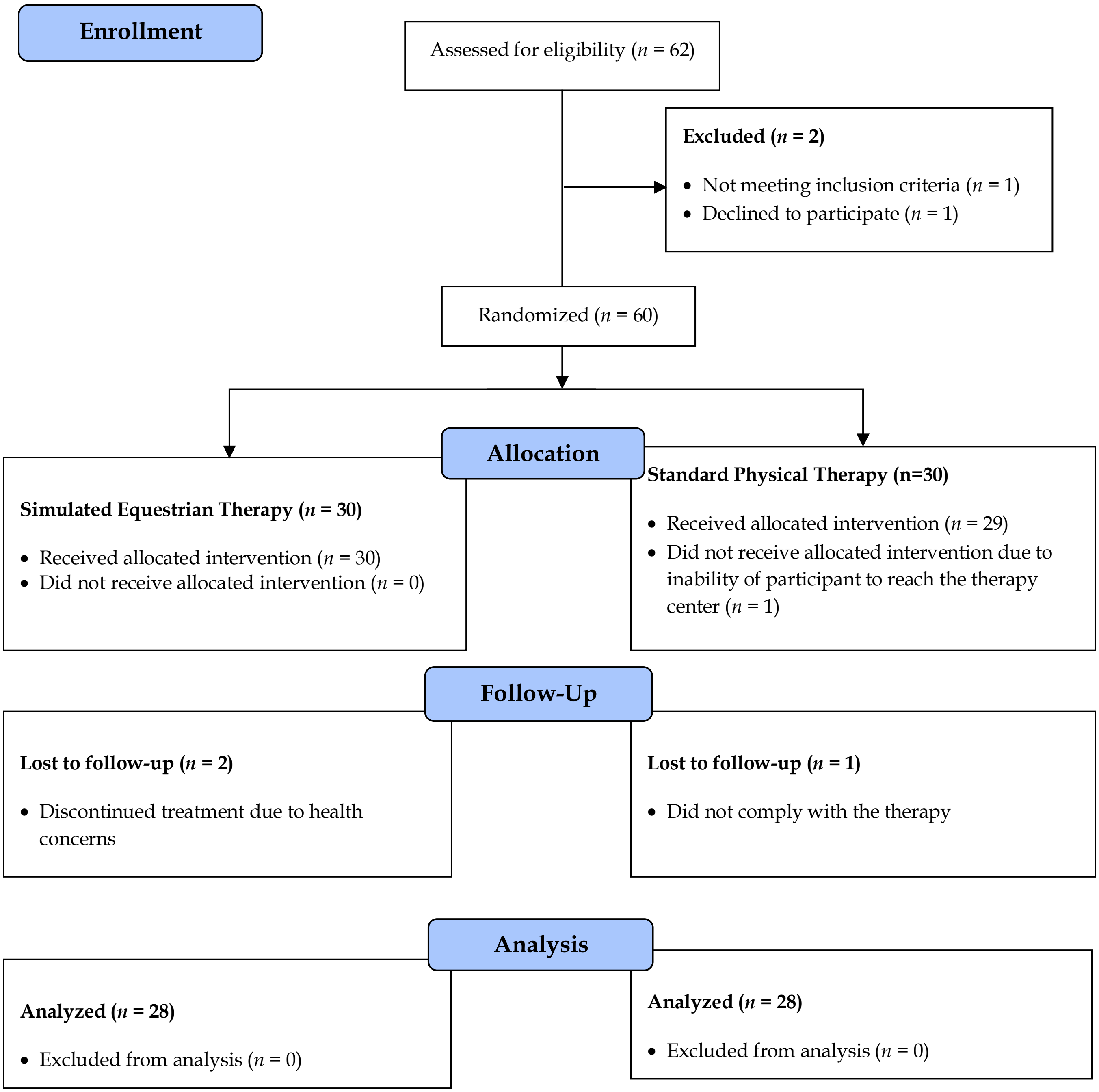

Figure 1. CONSORT flow diagram.

Mechanical Simulator used in phase I of SET

Wooden Simulator used in phase II of SET

Figure 2. Simulators used in simulated equestrian therapy.

Protocol
The Simulated Equestrian Therapy protocol provided to the treatment group begin with warm-up for stimulating the vestibular and proprioceptive senses, the child performed a swinging motion on the wooden rocking horse simulator for 5 minutes in an anterior and posterior direction as a warm-up. This pattern mimicked the rhythmic movement of a horse's pelvis to provide a near-realist experience to the rider.

The warm-up was followed by Phase-I, which aimed to incorporate the horse gait movements of trot and gallop that are experienced while riding a real horse and to stimulate and strengthen the muscles, including the Deltoid, Bicep, Triceps, Hamstrings, Calf, Quadriceps, Latissimus Dorsi, Abdominals, and Back Extensors of the participant. Unlike real Equestrian Therapy settings, the treatment environment was controlled to ensure the child's safety. Using measurement tape and markers, a block 10 feet in length and 5 feet in breadth was constructed in the treatment area for exercising in this phase. The child was asked to complete four rounds around this custom-built block while riding the mechanical walking horse. A rest period of 5 minutes was kept to maintain the participants' energy levels, which they utilized either in between or after this phase.

After this the Phase-II began that targeted the child's motor performance and aimed to stimulate and coordinate his vestibular, proprioceptive and neuro-muscular systems. This phase was adapted from Champagne, Corriveau, and Dugas (6). In this phase, the child rode a wooden rocking horse simulator. Goal-oriented activities were performed, utilizing the equipment of the BOT-2 kit of motor proficiency, with 8–12 repetitions each in a forward, backward and lateral direction. Details of the exercises are listed in Table 1.

In the end there was a Cool-down phase that comprised 5 minutes of anterior and posterior swinging on the wooden simulator and deep breathing exercises.

For the control group that received Neuro-Motor Therapy, the child sat on a therapy ball for 5 minutes and swinging in an anterior and posterior direction was performed to mimic the rhythmic movement of a horse's pelvis the initial warm-up phase.

After the warm-up the training phase began that was adapted from Ghafar and Abdelraouf (1). It included overall stability and body balancing exercises performed in a controlled indoor environment to ensure the safety of the participants, strengthen the core and develop the coordination and balance required for task performance. Each activity was performed in a set of 2–3 with 8–12 repetitions. Details of the exercises are listed in Table 1.

Lastly, the cool-down comprised of 5 minutes of swinging on a therapy ball in an anterior and posterior direction and deep breathing exercises.

Table 1. Weekly progression of exercises in SET and NMT group.

Weeks	Exercise plan for SET (Phase-II)	Exercise Plan for NMT
0–2	- Practicing catching and throwing	- Practicing throwing and catching balls outside of their base of support - Walking on a 5 cm thick balance beam of 1 yard
3–5	- Placing the ball, and rings on the target	- Maintenance of balance over a tilt board during sitting, standing, and squatting positions for 3–5 minutes each
6–8	- Performing target hitting on a game of dart	- Walking up and down stairs to collect objects - Passing over 5 cm obstacles like cones and foam blocks
9–12	- Stretching to the head, feet, and tail of the horse	- Maintenance of stability by unilateral standing, alternatively, with eyes open for 10 seconds to 1 minute - Kicking and jumping activities

SET = Simulated Equestrian Therapy; NET = Neuro-motor Therapy; cm = centimeter.

Outcomes included 4 components of motor proficiency: balance, coordination, strength, speed and agility, which were measured using the Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (BOT-2) by the assessors blinded to the allocation of the participants. Before the incorporation of testing, all the children were oriented from the testing tools to reduce fear, confusion and agitation. Testing was performed in a separate room to eliminate the effects of the environment on the child's performance by incorporating manual-based testing for each component. The details of the data collection procedure on BOT-2 are as follows:

BOT-2 has an excellent reliability (r = 0.9031) and evaluates motor proficiency from a maximum score of 34. The tool comprises four gross motor composites, including balance, coordination, strength, speed and agility, which are tested by performing goal-directed activities mentioned in the BOT testing easel, and a score is given to each component.

Each participant was tested using the tools of the BOT-2 kit, and the scores obtained were compared to the age-equivalent values given in the BOT manual for interpretation.

Statistical Analysis
The data was analyzed using Medcalc software. 'Skewness and Kurtosis Rule of Thumb' was applied to test the normality of the data. Since the data was found to be skewed, 'Friedman's ANOVA' and 'Mann-Whitney U Test' for within and between the groups analysis were applied. Descriptive statistics are reported in terms of mean and standard deviation, whereas continuous variables are displayed as median (25^{th} to 75^{th} percentile, lowest to highest) and *p*-value (< 0.05) considered significant. The intention-to-treat analysis was applied to reduce potential bias in treatment effects due to the attrition rate.

RESULTS

This study entailed 56 children with DS (33 males and 23 females) randomly divided into two groups: SET and NMT. Each component of motor proficiency was analyzed at baseline, after the 6^{th} and the 12^{th} week of intervention. The demographic details of the participants are shown in Table 2.

Friedman's ANOVA test was applied to identify the differences within each group. For each component of motor proficiency (Balance, Coordination, Strength, Speed and Agility), the data set was analyzed at baseline (before intervention), 6^{th} week (during intervention) and 12^{th} week (after intervention).

At baseline, the NMT group had substantially higher scores for balance, coordination, speed and agility than the SET group but the subset of strength was equal for both groups.

From baseline to 6^{th} week in the SET group, the mean ranks in balance and coordination indicated a potential rise in performance. The mean ranks for strength, speed and agility also increased showing significant differences. In the NMT group, balance and strength increased significantly whereas, consistent coordination, speed and agility values exhibited insignificant differences in these subsets at the end of 6^{th} week.

From the 6^{th} to the 12^{th} week, the SET group showed a decline in balance, insignificant differences in coordination and remarkable significant differences in strength, speed and agility. Similarly, a decline in mean rank was observed when comparing the balance of the NMT group. The coordination analysis, on the other hand, revealed relatively stable findings, indicating no consistent increases or declines. The analysis for strength, speed and agility unveiled an exceedingly low p-value indicating pronouncedly significant differences. Details of the analysis are listed in Table 3. Whereas; Table 4 depicts a post-hoc analysis of the variables at different points in time, showing pairwise comparisons and Table 5 indicates between-group comparison of SET and NMT.

Table 2. Demographic details of participants.

Variables	Group	*N*	Mean ± SD
Age (Years)	SET	28	7.89 ± 1.7
	NMT	28	8.07 ± 0.76
Body Mass Index (kg/m²)	SET	28	28.40 ± 1.42
	NMT	28	27.76 ± 3.17
Height (cm)	SET	28	136.50 ± 7.43
	NMT	28	134.25 ± 3.59
Weight (kg)	SET	28	51.21 ± 7.13
	NMT	28	51.14 ± 2.10

N = participants; SD = standard deviation; SET = Simulated Equestrian Therapy; NET = Neuro-motor Therapy.

Table 3. Within-group comparison of SET and NMT.

Variables	25th Percentile		Median		75th Percentile		Mean Rank		*F*		*P*	
	SET	NMT	SET	NMT	SET	NMT	SET	NMT	SET	NMT	SET	NMT
Balance												
Baseline	2.0	3.0	2.5	4.0	4.0	4.0	1.6	1.7				
6th Week	3.0	4.0	4.0	4.0	4.0	4.0	2.4	2.3	6.9	5.5	0.002	0.006
12th Week	3.0	3.0	3.0	3.5	4.0	4.0	1.8	1.8				
Coordination												
Baseline	1.0	2.0	1.0	2.0	2.0	2.0	1.6	-				
6th Week	1.0	2.0	2.0	2.0	2.0	2.5	2.1	-	5.8	1.5	0.005	0.21
12th Week	1.0	2.0	2.0	2.0	2.0	3.0	2.2	-				
Strength												
Baseline	0.0	0.0	0.0	0.0	0.5	0.0	1.3	1.3				
6th Week	0.0	0.0	1.0	0.5	1.0	1.0	1.7	1.6	93.2	223.3	< 0.00001	< 0.00001
12th Week	1.5	2.0	2.0	2.0	2.0	2.0	2.9	3.0				
Speed and Agility												
Baseline	1.0	1.0	1.0	2.0	2.0	2.0	1.2	1.5				
6th Week	1.0	2.0	2.0	2.0	2.0	2.0	1.7	1.5	279.2	82.7	< 0.00001	< 0.00001
12th Week	2.0	3.0	3.0	3.0	3.0	4.0	2.9	2.8				

Due to consistent values of coordination during all the weeks of NMT, calculation of mean ranks was not applicable. SET = Simulated Equestrian Therapy; NET = Neuro-motor Therapy.

Table 4. Post-hoc analysis for SET and NMT.

Variables			Mean rank	Different (*P*)	Minimum required mean rank difference
			Simulated Equestrian Therapy		
	(1)	Baseline	1.6786	(2)	
Balance	(2)	6th Week	2.4286	(1) (3)	0.4166
	(3)	12th Week	1.8929	(2)	
	(1)	Baseline	1.6071	(2) (3)	
Coordination	(2)	6th Week	2.1429	(1)	0.4050
	(3)	12th Week	2.2500	(1)	
	(1)	Baseline	1.3750	(2) (3)	
Strength	(2)	6th Week	1.7143	(1) (3)	0.2369
	(3)	12th Week	2.9107	(1) (2)	
	(1)	Baseline	1.2679	(2) (3)	
Speed and Agility	(2)	6th Week	1.7500	(1) (3)	0.1500
	(3)	12th Week	2.9821	(1) (2)	
			Neuro-Motor Therapy		
	(1)	Baseline	1.7679	(2)	
Balance	(2)	6th Week	2.3571	(1) (3)	0.3788
	(3)	12th Week	1.8750	(2)	
	(1)	Baseline	1.3036	(2) (3)	
Strength	(2)	6th Week	1.6964	(1) (3)	0.1685
	(3)	12th Week	3.0000	(1) (2)	
	(1)	Baseline	0.3788	-	
Speed and Agility	(2)	6th Week	0.3788	-	0.2412
	(3)	12th Week	0.3788	-	

Due to consistent values of coordination during all the weeks of NMT, calculation of mean ranks was not applicable. SET = Simulated Equestrian Therapy; NET = Neuro-motor Therapy.

Table 5. Between-group comparison of SET and NMT.

	Lowest value		Highest value		Median		Hodges-Lehmann Median Difference		Mann-Whitney *U*		Two-Tailed Probability	
	SET	NMT	SET	NMT	SET	NMT	SET	NMT	SET	NMT	SET	NMT
Balance												
	0.0	1.0	4.0	4.0	4.0	2.5	0.0		296.5		*P* = 0.09	
	2.0	2.0	4.0	4.0	4.0	4.0	0.0		337.0		*P* = 0.2	
	1.0	2.0	4.0	4.0	3.0	3.5	0.0		326.5		*P* = 0.2	
Coordination												
	0.0	0.0	3.0	3.0	1.0	2.0	1.0		251.0		*P* = 0.01	
	0.0	1.0	3.0	3.0	2.0	2.0	0.0		291.0		*P* = 0.06	
	1.0	1.0	3.0	3.0	2.0	2.0	0.0		287.0		*P* = 0.06	
Strength												
	0.0	0.0	1.0	1.0	0.0	0.0	0.0		336.0		*P* = 0.1	
	0.0	0.0	4.0	1.0	1.0	0.5	0.0		364.0		*P* = 0.6	
	1.0	1.0	3.0	3.0	2.0	2.0	0.0		327.5		*P* = 0.1	
Speed and Agility												
	0.0	0.0	3.0	3.0	1.0	2.0	0.0		280.5		*P* = 0.04	
	0.0	0.0	3.0	2.0	2.0	2.0	0.0		364.0		*P* = 0.5	
	2.0	2.0	4.0	4.0	3.0	3.0	0.0		300.5		*P* = 0.1	

Due to consistent values of coordination during all the weeks of NMT, calculation of mean ranks was not applicable. SET = Simulated Equestrian Therapy; NET = Neuro-motor Therapy.

DISCUSSION

The early acquisition of motor proficiency is paramount for children diagnosed with DS. In addition to encountering delays in cognitive and psychosocial developmental milestones, children with DS experienced motor skill development delays, affecting their motor skills proficiency. Hence, this study was conducted on 56 children with DS to evaluate the effects of Simulated Equestrian Therapy compared to Neuro-Motor Therapy in improving their motor proficiency. The results analyzed 4 components of motor proficiency (Balance, Coordination, Strength, Speed and Agility) using BOT-2 and exhibited significant differences in baseline and post-term values. However, no therapy was found superior to another.

Our study analyzed participants' performance at three intervals (baseline, 6^{th} and 12^{th} week). Each subset of motor proficiency was separately discussed to highlight the independent impact of SET and NMT on each subset. While searching for comparative literature, the authors identified a substantial gap in the research depository for motor proficiency; however, studies evaluating gross motor skills were available. Our study found a significant improvement in motor proficiency after SET and NMT, which is close to the findings of Jung et al (19), who reported a significant improvement in gross motor parameters of cerebral palsy children after using virtual reality-based SET. Our findings also align with Deutz et al (11), which reported significant results on walking, running and jumping abilities after Equestrian Therapy in children with cerebral palsy. Similarly, our findings are supported by Champagne et al (6) which reported improvement in balance and strength after Equestrian Therapy in cerebral palsy children. These findings advocate Simulated Equestrian Therapy's effectiveness in improving motor proficiency like Equestrian Therapy.

Moreover, our results indicated an increase in balance during the initial 6 weeks of treatment in both SET and NMT groups; however, a performance decline was observed in the later 6 weeks. These findings are surprisingly in opposition to the studies of Jung et al (18) Kanwal et al (19), Known and Kim (20) and Elshafay (12) that reported significant findings in the treatment group. One potential reason can be the population difference, as all authors observed children with cerebral palsy except for Known and Kim, who evaluated DS children. Another reason can be the varying duration of intervention applied to participants. However, this observation can be explained by the hormesis theory (17), which states that "Insufficient physical activity (inactivity), as well as an excessive amount of stress (overtraining), can both contribute to a reduction in physiological functioning leading to a state of overtraining syndrome". Literature also suggests that exercises comprising high intensity can increase the levels of Tumor Necrotic Factor (TNF-α), Inter Leukins (IL-1β, IL-6) and C-reactive protein (CRP). These factors lead to an acute inflammatory response in the body that can produce oxidative stress. While regular exercise (moderate intensity) stimulates the antioxidant system and protects the body against oxidative stress, vigorous exercise or inadequate rest periods can disturb this oxidative balance. However, this evidence is not concrete when applying to other parameters, including strength, speed and agility that showed a significant rise from baseline till the completion of the intervention in the 12th week.

Moreover, it is still unclear if the participants underwent overtraining syndrome. No symptoms were reported by any participant or guardian except one from the NMT group, where the guardian observed a disturbed sleeping pattern at the beginning of 5th week. However, the complaint lasted for a week. Despite the perplexing conclusion, performance decline in both groups during a specific intervention period is an area of future exploration.

The analysis for coordination also exhibited a compelling revelation where the SET group showed improvements in the initial 6 weeks of intervention, but a performance plateau was observed in the later 6 weeks, which is in opposition to the findings of Costa et al. (8) that found improvements in global motor coordination of children with DS after Equestrian Therapy. Moreover, in the NMT group, unchanged statistics were observed, pointing to two potential reasons. One among them can be the nature of interventions and their prime focus. Another can be a small cerebellar size in the DS population that can impact the intervention's efficacy and success, as the cerebellum plays a vital role in coordination activities. As stated by Noriyuki Koibuch, this cerebellar size is influenced by fluctuating levels of circulating hormones, including steroids (corticosteroids, progesterone, androgens, and estrogens) and thyroid hormone as they can affect the development and adaptability of the cerebellum (30). Since coordination takes time to develop, longer intervention duration could have improved it by developing sub-regional plasticity of the cerebellum, which was also advocated by Park et al.

after comparing the cerebellar vermis of skilled basketball players and sedentary individuals (26).

On the other hand, strength, speed and agility greatly improved in both SET and NMT groups, with no reported performance plateaus and declines at evaluation that is in line with Champagne et al. (6), who reported improvement in strength after Equestrian Therapy in cerebral palsy children. One reason for the improvement in strength can be understood by the explanation that two main processes contribute to a gain in muscle strength after exercise: hypertrophy (cell enlargement) and neural adaptations that enhance nerve-muscle interaction. In the initial stages of strength training, substantial increases are observed mainly due to neural adaptations, while hypertrophy is a slower process requiring new muscle protein synthesis; hence, it takes time. However, repeated exercise stress contributes to both neural and muscular enhancements, increasing muscle strength and this claim is also evident from the study of Moritani, who argues that strength is measured not only by cross-sectional area, muscle fiber type and muscle mass but also by the neuronal factors involved, which explains the strength improvement in our study despite the presence of joint laxity in DS (22). These claims are also supported by a phenomenon known as the "cross-over effect," which states that muscle growth is not necessary for changes in muscle strength. If an untrained limb is compared to a contralateral trained limb, strength improvement will be observed in both due to neural adaptations. Neural adaptation and strength have also been linked to the basis of agility development; hence, improvement in one parameter resulted in improvement of another (9).

Moreover, the surfacing literature mentioning growth curves in DS advocates that these children attain motor function at a slower pace than their age-matched typically developing peers, which can lead to complications with progressing age. However, early interventions can combat this problem and significantly contribute to DS age-appropriate motor growth (25).

Previous studies have been conducted on youth and adolescents with DS using Simulated Equestrian Therapy; to the author's knowledge, no study on DS children was conducted; hence, our study is the first of its kind in evaluating motor proficiency among DS children, which adds up to the scarce literature. It will also serve as a basis for future research where this protocol can be generalized to a more significant sample, and a comparison between genders and age groups could be made. Despite the rigour, it has some limitations, too, including the absence of a follow-up period, which could have provided valuable insight into the long-term effectiveness of the protocols. Moreover, this study did not evaluate changes on the cellular level, which are essential to note in conditions like DS to contribute to the betterment of this community significantly. Furthermore, the induction of children with DS without stratification of its types could also raise a question on the application of this intervention, as the effectiveness can vary with the type of DS.

This study concludes that SET and NMT both are effective in improvement of motor proficiency and Gait Parameters among DS children. However, studies with a follow-up period should be conducted to further evaluate the long-term benefits of these therapies.

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